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# Analysis of the key factors affecting beneficiation in South Africa

**Tom, Zonwabele Zweli**

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# Analysis of the key factors affecting beneficiation in South Africa

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

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28 October 2015

## DECLARATION

I, Zonwabele Zweli Tom, declare that this research report is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Science in Engineering at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University. I further declare that I obtained the necessary authorisation and consent to carry out this study

Zonwabele Zweli Tom

_____ _____

Signature Date

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*What must I give you, LORD, for being so good to me?*

Ps. 116:12

## ABSTRACT

South Africa has the wealthiest mining jurisdiction in the world with mineral resources valued at $2.5 trillion. Despite these assets, the level of value added mineral beneficiation undertaken in South Africa is low, with activities in the mining industry dominated by primary production and exports of raw or partially processed minerals.

This study undertook to determine, evaluate and analyse the constraints to mineral beneficiation and downstream operation in South Africa. The study also considered the key drivers of mineral beneficiation.

Downstream mineral beneficiation is defined as the transformation of a mineral or a combination of minerals to a higher value product which can either be consumed locally or exported to international markets.

Primary data was collected by a combination of quantitative and qualitative method using a questionnaire. The questionnaire was purposefully distributed to stakeholders considered to have expert knowledge in the mining and manufacturing sectors. Data was tested for reliability and validity before it was analysed and specific constructs were developed from the questionnaire.

The study found that mining industry will continue to play a vital role in the economy of the country. The level of mineral beneficiation was found to be dismally low considering the country's mineral endowment and this resulted in the country missing out on the opportunity to earn more from exports of finished products, create employment, and address the problems of inequality and poverty. Amongst the factors found to constrain beneficiation were the country's labour laws, lack of adequate skills, corruption, unstable labour force, research and development, the lack of entrepreneurship activity, inadequate infrastructure, and energy problems. In addition the study provided practical recommendations to help policy makers make informed decisions that will support the beneficiation programme.

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## LIST OF ACRONYMS

| | |
|---|---|
| AMCOR: | African Metals Corporation |
| AMCU: | Association of Mineworkers and Construction Union |
| Amplats: | Anglo American Platinum |
| ANC: | African National Congress |
| CTL: | Coal-to-Liquid |
| DPF: | Diesel Particulate Filter |
| DME: | Department of Minerals and Energy |
| DMR: | Department of Mineral Resources |
| DTI: | Department of Trade and Industry |
| FDI: | Foreign Direct Investment |
| GDP: | Gross Domestic Product |
| IDC: | Industrial Development Corporation |
| Implats: | Impala Platinum |
| MPRDA: | Minerals and Petroleum Resources Development Act |
| MQA: | Mining Qualification Authority |
| NUM: | National Union of Mineworkers |
| NUMSA: | National Union of Metal Workers of South Africa |
| PGM: | Platinum Group Metals |
| SAIRR: | South African Institute of Race Relations |
| SEDA: | Small Enterprise Development Agency |
| SETA: | Sector Education and Training Authority |
| SLP: | Social and Labour Plan |
| WEF: | World Economic Forum |

## DEFINITION OF TERMS

| | |
|---|---|
| Beneficiation | Transformation of a mineral (or a combination of minerals) to a higher value product which can either be consumed locally or exported |
| Down-stream | Involves a range of activities including large scale capital-intensive activities such as smelting and refining as well as labour-intensive activities such as craft jewellery and metal fabrication |
| Economic Linkages | Linkages that arise when economic activities in one industry lead to economic growth in another industries and / the emergence of new industries |
| Manufacturing | The process of converting raw materials, components or parts into finished goods that meet a customer's expectation or specification |
| Mining | The science, technique and business of mineral discovery and exploitation |
| Side-stream | Refers to inputs, namely capital goods, consumables and services, into the value chain |

# CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

## 1.1 Context of the Study

For over a century, South Africa has been a resource economy. Its mineral resources are valued at $2.5 trillion, making the country the wealthiest mining jurisdiction in the world (Department of Mineral Resources, 2011). The sustainable economic growth and development of the country is, therefore, premised on this abundance of resources. These mineral resources have contributed significantly to South Africa's economic performance, through the exports of minerals, but their impact on sustainable economic growth and development has been limited due to the fact that most of South Africa's mineral resources are exported as raw ores or only partially processed.

According to Gonzalez (2004) the countries, regions and localities where mining activity takes place, should have direct share in the wealth created by mineral exploitation in their jurisdictions, in a way that translates into an improvement in their inhabitants' quality of life and level of well-being.

The South African Government adopted a developmental policy known as "The New Growth Path", which seeks to place the national economy on a production-led growth trajectory in order to tackle the country's developmental challenges of unemployment, inequality and poverty (Department of Mineral Resources, 2011). The government places focus on ensuring greater local processing of the country's abundant natural resources. This policy framework prioritises mining value chain, which includes mineral beneficiation as one of the key economic activities that present the highest value proposition towards the objective of eradicating unemployment, inequality and poverty.

Beneficiation or value-added processing involves the transformation of the raw material (through the production process) using local resources (labour or capital) to a more finished product that has a higher value than the raw material for export market (Department of Mineral Resources, 2011). The finished products are marketable to a much wider range of customers, both locally and internationally, this is confirmed by a study conducted by (Mintek, 2000) which established that a ton of stainless steel containing chromium was worth 147 times more than a ton of chromium in chromite ore, and the

value of polished diamonds was between 30 and 173 times more than that of rough diamonds depending on where they were on the value chain and subject to size, clarity and cut.

According to Creamer (2010) the statement by Citibank, that South Africa's known in-situ mineral resources were worth $2.5 trillion, the largest in the world (see figure 1) is viewed by some analysts as an opportunity for South Africa to come up with a long term plan for mineral beneficiation.

Lundall *et al.* (2008) argue that the abundant supply of coal and cheap electricity present South Africa with a considerable competitive advantage in minerals beneficiation. The country possesses some strength that favours undertaking local beneficiation of minerals and these strengths include: a natural monopoly on certain mineral reserves, competitive advantages in some mining and smelting activities, experience in the beneficiation of certain minerals at the firm level, and a range of research and development programmes focused on the mining sector (Soko & Balchin, 2012).

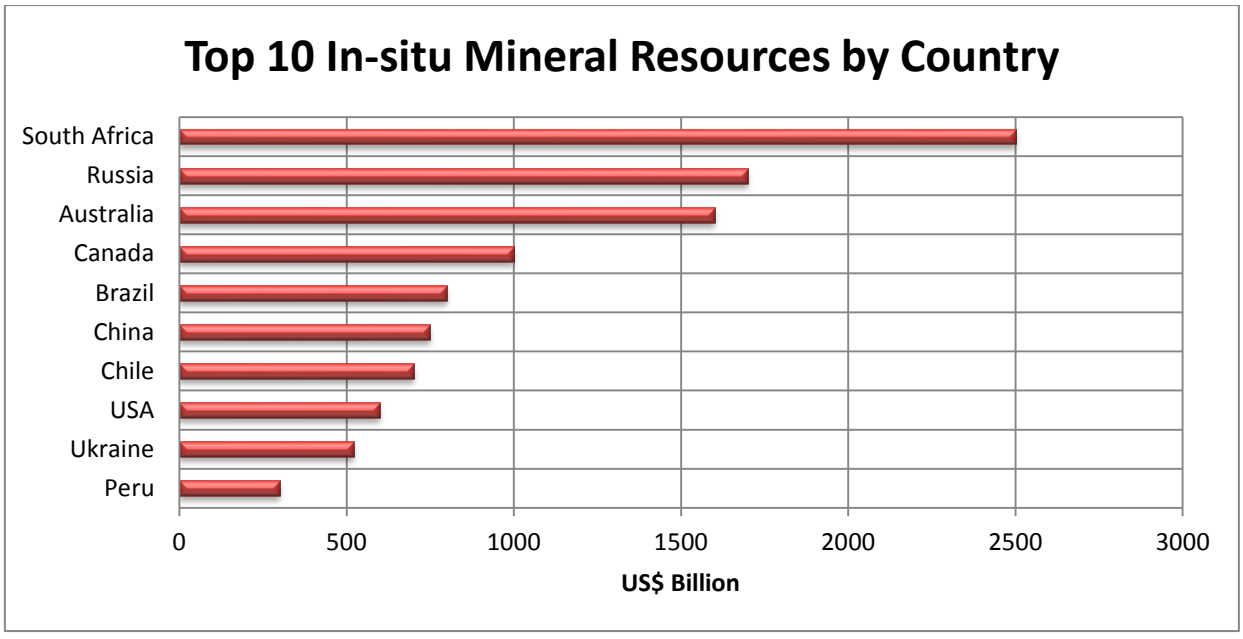



**Figure 1:** Top 10 In-situ mineral resources by Country (Baxter, 2005)

Figure 1 indicates that South Africa is exceptionally well-endowed with mineral resources. These include the largest reserves of the platinum group metals (PGMs), gold, chromite, manganese, vanadium and refractory minerals (alumina-silicate). Russia and Australia are

the next wealthiest mining jurisdiction with mineral wealth estimated at $1.6 trillion each. South Africa also has large resources of coal, iron ore, titanium, zirconium, nickel, vermiculite, phosphate and many other minerals (see Table 1).

Table 1 indicates South Africa's mineral reserves at 2009 production rates, the world ranking and the nominal life (assuming no further reserves) as at 2009. At 2009 production rates the reserves for all minerals will last for several hundred years, if no further resources are delineated, except for gold (terminal decline), lead and zirconium (heavy mineral sands).

Table 1: South Africa's Mineral Reserves, World Ranking, 2009 Production and Nominal Life

| MINERAL | UNIT | RESERVES | | | PRODUCTION 2009 | | | LIFE |
|---|---|---|---|---|---|---|---|---|
| | | Mass | %World | Rank | Mass | %World | Rank | Years |
| Alumino-silicates | Mt | 51 | * | * | 0.265 | 60.2 | 1 | 192 |
| Antimony | kt | 350 | 16.7 | 3 | 3 | 1.6 | 3 | 117 |
| Chromium Ore | Mt | 5500 | 72.4 | 1 | 6.762 | * | 1 | 813 |
| Coal | Mt | 30408 | 7.46 | 6 | 250.6 | 3.6 | 7 | 121 |
| Copper | Mt | 13 | 2.4 | 6 | 0.089 | * | 8 | 146 |
| Flourspar | Mt | 80 | 17 | 2 | 0.18 | 3.5 | 5 | 444 |
| Gold | t | 6000 | 12.7 | 1 | 197 | 7.8 | 5 | 30 |
| Iron Ore | Mt | 1500 | 0.8 | 13 | 55.4 | 3.5 | 6 | 27 |
| Iron Ore – *including BC* | Mt | 25000 | ~10 | 8 | 55.4 | 3.5 | 6 | 451 |
| Lead | kt | 3000 | 2.1 | 6 | 49 | 1.2 | 10 | 61 |
| Manganese Ore | Mt | 4000 | 80 | 1 | 4.576 | 17.1 | 2 | 874 |
| Nickel | Mt | 3.7 | 5.2 | 8 | 0.035 | 2.4 | 12 | 107 |
| PGMs | t | 70000 | 87.7 | 1 | 271 | 58.7 | 1 | 258 |
| Phosphate Rock | Mt | 2500 | 5.3 | 4 | 2.237 | 1.4 | 11 | 1118 |
| Titanium Minerals | Mt | 71 | 9.8 | 2 | 1.1 | 19.2 | 2 | 65 |
| Titanium – *including BC* | Mt | 400 | 65 | 1 | 1.1 | 19.2 | 2 | 364 |
| Uranium | kt | 435 | 8 | 4 | 0.623 | 1.3 | 10 | 698 |
| Vanadium | kt | 12000 | 32 | 2 | 11.6 | 25.4 | 1 | 1034 |
| Vermiculite | Mt | 80 | 40 | 2 | 0.1943 | 35 | 1 | 412 |
| Zinc | Mt | 15 | 3.3 | 8 | 0.029 | 0.2 | 25 | 517 |
| Zirconium | Mt | 14 | 25 | 2 | 0.395 | 32 | 2 | 35 |

Source: (Department of Mineral Resources, 2011)

Table 1 also indicates that South Africa ranks high compared to other countries with mineral reserves. It is important to note that the life of most minerals exceed 100 years, meaning that the country will benefit from these minerals for years still to come.

The advantages and benefits of the existence of mining and mineral processing facilities within a country in terms of job creation, provision of opportunities for the development of domestic skills, encouragement of the creation of associated industries thereby boosting the manufacturing sector, and provision of other beneficial side effects or linkages for the local economy cannot be overemphasised (Tilton, 1992).

The core issue, therefore, relates to how South Africa uses this exceptional endowment to improve the lives of its people, and how it maximises the developmental impact on its substantial mineral assets whilst extant. This study believes that the answer lies in the optimal value added mineral beneficiation.

It is important to note that the concept of beneficiation is not new in South Africa. For example, the bulk of South Africa's electricity is generated from coal power stations, which consume more than 50% of the country's annual coal production (Department of Mineral Resources, 2011). The Coal-to-Liquid (CTL) technology in South Africa (Creamer, 2014) is another example of successful beneficiation of local mineral resources for the benefit of the country.

The Industrial Development Corporation (IDC) is of the view that undertaking greater levels of downstream beneficiation can foster the development of backward, forward and even horizontal linkages, thereby creating employment, facilitating skills development and technological innovation, and boosting industrial growth (Industrial Development Corporation, 2012). Economic linkages refers to a situation whereby economic activities in one industry lead to economic growth in another industry and / or the emergence of new industries. Mtegha (2009) supports this view of beneficiation stating that by beneficiating more minerals along the mining value chain, the country would not only generate more tax revenue from the growth in value of beneficiated minerals but also create more job opportunities when new companies are established to provide products and services to the mineral sector along the entire value chain.

However, South Africa is faced with number of obstacles to beneficiation (Creamer, 2013). This has led to some sceptics questioning the assumption that resource-rich countries automatically possess the competitive advantages required to process minerals competitively into finished products (Creamer, 2013).

The main focus of this research is to analyse the factors affecting downstream beneficiation in South Africa. There is need to assess the viability of further mineral exploitation by mining companies to move down the value chain to become refiners, and also assess the readiness of existing manufacturing companies to conduct mineral beneficiation and determine whether they will enjoy support from the mining companies. To be able to make an assessment, the requirements for value added beneficiation need to be determined.

## 1.2 Problem Statement

South Africa has the world's largest reported reserves of gold, platinum group metals (PGM), chrome ore and manganese ore, and the second largest reserves of zirconium, vanadium and titanium (Erasmus, 2013).

Despite these assets, the level of value added mineral beneficiation undertaken in South Africa is low, with activities in the mining sector dominated by primary production and exports of raw or partially processed minerals. On the contrary, South Africa imports a variety of finished products that have been processed from its own minerals.

As a result there is significant opportunity lost in export revenue and employment creation due to low beneficiation activity. There is, therefore a need to evaluate the challenges constraining South African companies from engaging in high levels of beneficiation with a view to help policy makers make informed decisions.

## 1.3 Research Aim

The principal aim of the research is to determine, evaluate and analyse the constraints to sustainable mineral beneficiation and downstream operations in selected mineral sectors from the perspectives of the stakeholders in the mining value chain in South Africa. This

will provide the basis to help unlock the constraints to sustainable mineral beneficiation in the mining value chain in South Africa.

## 1.4 Research Objectives

In order to meet the research aim, address the problem statement and provide answers to the research question, stakeholders in the beneficiation value chain are the key focus for this study. Therefore the objectives of this research are:

(i) to establish from stakeholders the reasons for low levels of mineral beneficiation in South Africa; and

(ii) to ascertain if respondents from mining, manufacturing, academic institutions, consulting firms and non-governmental organisation feel that there is a need for mineral beneficiation in South Africa as opposed to direct exports of raw ores to generate revenue.

## 1.5 Research Question

What are the constraints to establishing high levels of beneficiation as an economic activity in South Africa?

### 1.5.1 Research Propositions

To address the research question, the study proposes and considers the following propositions:

(i) Proposition 1: South Africa's labour laws are the main constraints to sustainable beneficiation.

(ii) Proposition 2: Beneficiation does not add significant economic value to South Africa and its export market

(iii) Proposition 3: Skills shortage and lack of research and development activities are the main causes of low beneficiation levels in South Africa.

## 1.6 Importance of the Study

The study aims to fill the gap in that there is currently no significant academic research that addresses the lack of high levels of downstream mineral beneficiation in South Africa.

## 1.7 Scope of the Study

Due to the size and complexity of South Africa's mining industry, the literature survey is confined to selected South African mineral sectors, namely, the precious metals and minerals with specific focus on platinum, gold and diamond sectors. Primary data collected however included all mineral sectors so that the results of the study are applicable to all other mineral sectors.

## 1.8 Assumptions

A key assumption has been made in the study that there is low level of mineral beneficiation towards high value finished products in South Africa. This is valid and reasonable given that the country exports most of its minerals as raw ores or partially beneficiated ores (Creamer, 2014; Department of Mineral Resources, 2011; Eunomix, 2012).

## 1.9 Structure of the Report

Chapter 1: Introduction and Problem Statement - This chapter introduces the research by providing the background on the subject matter. The aims and objectives of the study are presented, and the problem statement and research question with associated propositions are defined.

Chapter 2: Literature Review - This chapter contains a comprehensive review of South African mining industry. The history and current state of the industry are discussed, and challenges and opportunities facing this industry are reviewed. This chapter provides a definition of mineral beneficiation and evaluates the current state of mineral beneficiation in South Africa.

Chapter 3: Research Methodology - This chapter outlines the methodology used to conduct the research, which includes the research design and research instruments used, the approach taken for data collection, and analysis and a discussion on the validity and reliability of the study.

Chapter 4: Results and Analysis - The chapter presents and analyses data collected

Chapter 5: Discussion of Research Findings – This chapter discusses the findings of the study

Chapter 6: Conclusion and Recommendations - This chapter contains the final conclusion of the research and recommendation on possible further work.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

This chapter considers several aspects of beneficiation relevant to South Africa that are drawn from the literature and linked together to portray the unique setting in the country. The chapter defines downstream mineral beneficiation including its stages, history, opportunities and the current state of beneficiation in South Africa; the scope for economic value addition by precious minerals with specific focus on platinum group metals, gold and diamond sectors; South Africa's general competitiveness as surveyed by the World Economic Forum (WEF) and implications for manufacturing competitiveness; constraints to beneficiation; and South Africa's mining industry, its linkages to manufacturing and other sectors of the economy and the challenges it faces.

## 2.2 Mineral Beneficiation

Beneficiation can be classified into three types, which are upstream beneficiation, side-stream beneficiation, and downstream beneficiation.

For the purpose of this study, only downstream beneficiation, which refers to the transformation of a mineral (or a combination of minerals) to a higher value product which can either be consumed locally or exported, is considered. The next section provides a detailed explanation on downstream beneficiation.

### 2.2.1 Beneficiation Defined

Beneficiation is defined in the South African Minerals Policy White Paper (1998) as the successive processes of adding value to raw materials from their extraction through to the sale of finished products to consumers, covering a wide range of very different activities. It involves the transformation of primary material (produced by mining and extraction processes) to a more finished product, which has a higher sales value (Department of Mineral Resources, 2011). This is supported by Baxter (2005) who defines beneficiation as the process of adding value from mining right through to the final fabrication of a consumer branded product.

According to the Department of Mineral Resources (2011) beneficiation involves a range of different activities which include the following successive levels of processing: Smelting characterised by large-scale, capital-intensive activities; refining characterised by sophisticated refinery plants; and final processing characterised by labour-intensive processes, such as craft jewellery, metal fabrication and ceramic pottery.

All these successive levels of processing add value at each stage and allow the product to be sold at a higher price than the previous intermediate product or original raw material.

According to Munghoshi (2011) the net beneficiation of minerals is maximised by a combination of down-stream and side-stream linkages. Some sources have suggested that there should be recognition of the significant contribution of side-stream linkages into the value chain and proposed the term “side-stream beneficiation” (Baxter, 2005; Leeuw, 2012).

Downstream value addition of minerals involves a range of activities indicated above including large-scale capital intensive activities such as smelting and refining as well as labour-intensive activities such as craft jewellery and metal fabrication. Side-stream beneficiation (commonly referred to side-stream linkages) refers to inputs, namely capital goods, consumables and services, electricity supply and the infrastructure into the value chain. According to the Department of Mineral Resources (2011, p.17) side-stream beneficiation is an integral part of the downstream pipeline because it increases local value added in the final beneficiated product. It also refers to the spill over effects of downstream beneficiation such as establishment of industries vital for the operation of full mineral production. For the purpose of this study, side-stream beneficiation is not considered any further.

Hausmann et al (2008) refer to beneficiation as vertical relationships in production chains, known as linkages which have a profound impact on the economic policy in developing countries, geared towards stimulating structural transformation. They postulate that such policies have been termed differently, such as promoting downstream processing; completing value chains; increasing value-added; and beneficiation, but they are all based on the same idea. They further observed that it is a logical and natural progression for countries exporting raw minerals to move into the processing of such minerals, and

therefore policies that encourage that progression can accelerate economic growth (Hausmann, et al., 2008). This view is supported by Zoghby and Olivier (2013) who argue that mineral beneficiation should be a priority for governments of resource rich countries that would like to leverage the potential of mineral beneficiation to create local employment and drive economic growth.

Mineral beneficiation is a process that occurs in stages and in order to fully understand beneficiation it is important that all its stages are explained. The next section explains the stages of mineral beneficiation.

### 2.2.2 Beneficiation Stages

There are generally four stages involved in downstream mineral beneficiation which are the following (Baxter, 2005):

- Stage 1 – the primary action of mining and producing an ore and concentrate. This stage is relatively labour and capital intensive.

- Stage 2 – converting a concentrate into a bulk tonnage intermediate product, such as metal or alloy. The production of intermediate products usually takes place in capital-intensive, energy-intensive smelters and refineries. The value added to the original ore at this stage increases significantly but the broader economic advantages are constrained by the high level of skills needed and low levels of employment required.

- Stage 3 – transforming an intermediate material into a refined, semi-fabricated product suitable for purchase by both small and sophisticated industries. Such activities take place in foundries using heat-treating and / or cold forming / finishing processes. Employment levels are greater at this stage and the degree of value added increases substantially due to the inclusion of other resources and inputs required in the process.

- Stage 4 – the converted material is further transformed into a finished product for sale (fabrication) and subsequent inclusion in a variety of different applications. The

level of employment is significantly greater at this stage and firms include small and medium-sized as well as large manufacturers.

Another classification of the stages of beneficiation is provided by Leeuw (2012) who states that the four stages of beneficiation are primary, secondary, tertiary and final stage. The primary stage comprises of activities such as mining, recovery, reduction and smelting with the purpose of converting of raw minerals into concentrates. The secondary stage is a transition stage between the mining sector and industrial sector, and is largely concerned with the conversion of mineral concentrates into intermediate products. The tertiary stage involves refinement of intermediate products to produce high-value products. Lastly the final stage involves manufacturing of high-value final products ready for consumers.

Leeuw's (2012) approach to the classification of stages of beneficiation is illustrated with an example in table 2 which indicates that the tertiary and final stages are most likely to take place in the manufacturing industry; that the tertiary stage is capital intensive and requires low labour intensity while the final stage requires medium to high levels of labour and capital investments. This therefore means that the final stages of beneficiation require manufacturing competence.

Table 2: An Example of beneficiation stages in South Africa

| Stages of Beneficiation | Example of Metals | Industrial Mineral | Labour Intensity | Capital Intensity | Industry Cluster |
|---|---|---|---|---|---|
| **Primary** | Sealable smelted products (copper cathode) | Processed raw material (granite blocks) | High | High | Mining |
| **Secondary** | Fabricated alloys and metals (copper tubes) | Basic final products (granite slabs) | Low | High | Mining |
| **Tertiary** | Semi-manufactured articles (armatures) | Refined products (polished granite tops) | Low | High | Refining / Manufacturing |
| **Final** | Fabricated articles (electric motors) | Fabricated articles (granite workstations) | Medium to High | Medium to High | Manufacturing |

Sources: adapted from (Baxter, 2005; Leeuw, 2012)

By this classification, all mining companies in South Africa are actively involved with the primary stage of beneficiation. Leeuw (2012) is of the view that the debate on mineral beneficiation in South Africa should revolve around secondary, tertiary and final stages. These are the stages where industrial competency has an upper hand in relation to mining. This view is supported by Baxter (2005) who states that stage 1 and stage 2 (mining and processing) tend to be concentrated on mining, and the mining sector has the skills and aptitudes to tackle issues in these stages. Stage 3 and stage 4 is more related to the manufacturing sector, and is where the manufacturing sector has the skills and competencies.

It is, however important to note that latter stages of beneficiation cannot occur in isolation from the earlier stages. It is reasonable to assume that beneficiation requires close cooperation between the mining and manufacturing sectors, for example in order to sustainably beneficiate, the manufacturing companies will most likely need the sustainable supply of raw minerals at competitive prices from the mining companies.

To understand how beneficiation has taken place in South Africa it is important to look at the history of beneficiation and this is considered in the next section.

### 2.2.3 History of Mineral Beneficiation in South Africa

In South Africa beneficiation has partly been a product of market dynamics and partly a product of extensive government intervention (Eunomix, 2012). This view is supported by the Department of Mineral Resources (2011) which states that the concept of beneficiation is not new in South Africa – citing the generation of electricity and the conversion of coal-to-liquid by South African companies. The report further states that beneficiation often started in response to the needs of the mining industry, and has usually involved the use of by-products resulting from primary processing of mineral resources, sometimes used as production entrants in the mining process and sometimes used as a product for final or intermediary consumption. The examples of early beneficiation include (Eunomix, 2012):

- Dynamite production: pyrite, a by-product of gold, was used to produce sulphuric acid. All other raw materials from manufacturing dynamite were imported. A dynamite factory was established in 1984.

- Drilling: drill bits were required for gold mining. Large quantities of low-grade diamonds were produced by the diamond industry in Democratic Republic of Congo (formerly known as Zaire). In partnership with the Minerals research institute, a range of uses for industrial diamonds was developed, including diamond drill bits. Boart International, a mining technology and equipment company, was formed in 1936 to develop the uses of industrial diamonds in three areas: (1) industrial diamonds and their uses; (2) diamond drilling; and (3) hard-metal drilling tools and parts. After the World War II, De Beers replaced the jigging plant with a dense-medium separation system. This proved successful and led to the establishment of a Ferrosilicon plant by African Metals Corporation (AMCOR) in 1949.

From the 1950s onwards the South African government sought to leverage the country's mineral resources to advance upstream and downstream industrialisation. This industrialisation was motivated by the then eminent sanctions, and was aimed at protecting the Afrikaner-led government. The examples of these included (Eunomix, 2012):

- South Africa's need for petroleum, particularly under sanctions which reduced its ability to import fuel and export coal, led to the establishment of Sasol in 1950 to produce petrochemicals from coal.
- In 1964, Rand Mines, the largest holder of chromium ore reserves, researched the conversion of chromium ore to ferrochromium and formed RMB Alloys to build a production plant in Middelburg. This resulted in the formation of Southern Cross Stainless Steel Company and the construction of a stainless steel plant in 1966. The domestic market was too small to support the factory as a profitable company - this led to a merger of RMB Alloys and Palmiet Chrome to form Middleburg Steel & Alloys (MS&A) in 1969. The factory was expanded in 1980 and MS&A actively encouraged domestic fabricators to manufacture products previously imported, thus increasing domestic consumption.
- A ferrochrome industry was established in 1960 and in the mid-1990s platinum group metals (PGM) were used to produce auto catalyst – producing 20% of global supply.

In 1934 the South African Iron and Steel Industrial Corporation (Iscor) was established with the purpose of producing iron and creating employment opportunities. This was motivated by the wartime needs for steel and the local manufacture of numerous necessities (ArcelorMittal, 2010).

In 1923 the electricity supply commission (ESCOM) was established with the purpose of generating electricity from South Africa's coal and distributing it to industrial, mining, commercial, agricultural and residential customers.

According to Eunomix (2012) the beneficiation term has applied to the downstream transformation of imported mineral resources, as in the case of the country's aluminium industry. An example of this is that of Alcan Aluminium, a Canadian company, which promoted the use of aluminium in South Africa in the 1930s and established a fabricating plant in 1948, importing aluminium billets from Canada. The Industrial Development Corporation backed the establishment of an aluminium smelter and the Alusaf plant was opened in 1969 in Pietermaritzburg. A smelter to supply aluminium ingots was later built at Richards Bay. Hulett Aluminium has four fabricating plants producing semi-finished aluminium products.

Having noted the history of beneficiation, the opportunities and the current state of beneficiation in South Africa is next considered.

### 2.2.4 Opportunities and the Current State of Beneficiation in South Africa

According to then Minister of Mineral Resources (Eunomix, 2012) beneficiated products are key to unlocking social and economic development, to create local jobs thereby expanding the local skills base. Exports of raw minerals versus beneficiated products resulted in South Africa losing up to 89% of the potential value of such minerals (Department of Mineral Resources, 2011). The DMR report further states that in 2008 only 11% of the country's minerals were processed, yet this small amount created added value worth R86 billion. In 2010, total primary mineral sales export increased by 26.8% to a total of R224.2 billion. This is a strong indication that beneficiation has the potential to increase export revenue and therefore lead to employment opportunities and economic growth.

Government's beneficiation strategy and policies seek to translate South Africa's comparative advantage inherited from mineral resources endowment to a national competitive advantage (Department of Mineral Resources, 2011). South Africa's cabinet approved the beneficiation strategy, which targets adding value to the country's gold, platinum, diamonds, iron-ore, chromium, manganese, vanadium, nickel and titanium, energy coal and uranium endowments (Creamer, 2014). The five pilot value chains had been identified as energy, steel and stainless steel, pigment production, auto catalyst and diesel-particulate filters, diamond processing and jewellery, and Section 26 of the Mineral and Petroleum Resources Development Act Amendment Bill would require a proportion of mineral output to be reserved for use in local value-adding activities and sold locally at a development price (Mineral and Petroleum Resources Amendment Bill, 2013).

The South African White Paper (1998) also noted that the beneficiation policy would develop South Africa's mineral wealth to its full potential and to the maximum benefit of the entire population (Department of Mineral Resources, 2011) and it has been established that this would be achieved through the promotion of secondary and tertiary mineral-based industries aimed at adding maximum value to raw minerals.

Table 3 indicates that there is a gap between export quantities and local usage of minerals. According to Leeuw (2012) this gap represents opportunities that can be filled by beneficiation activities through increased participation of small, medium and large enterprises in the manufacturing sector.

Table 3: South Africa's production of selected minerals and metals in 2009

| Mineral / Metal | Global Resource Ranking | Production (t) | Export Quantity (t) | Local Usage (t) | Export (%) | Local (%) |
|---|---|---|---|---|---|---|
| Chrome Ore | 1 | 9 683000 | 762 000 | 8 921 000 | 8 | 92 |
| Manganese | 1 | 5 589 000 | 3 572 000 | 2 017 000 | 64 | 36 |
| PGMs | 1 | 276 | 223 | 53 | 81 | 19 |
| Gold | 1 | 213 | 190 | 23 | 89 | 11 |
| Flourspar | 2 | 299 000 | 276 000 | 23 000 | 92 | 8 |
| Vanadium | 2 | 20 300 | 12 100 | 8 200 | 60 | 40 |

| Mineral / Metal | Global Resource Ranking | Production (t) | Export Quantity (t) | Local Usage (t) | Export (%) | Local (%) |
|---|---|---|---|---|---|---|
| Vermiculite | 2 | 200 000 | 205 000 | - | 103 | 0 |
| Titanium | 2 | 1 211 000 | 1 211 000 | - | 100 | 0 |
| Phosphate | 4 | 2 287 000 | - | 2 287 000 | 0 | 100 |
| Nickel | 5 | 32 000 | 22 200 | 9 800 | 69 | 31 |
| Coal | 8 | 250 200 000 | 57 900 000 | 192 300 000 | 23 | 77 |
| Zinc | 8 | 31 400 | - | 31 400 | 0 | 100 |
| Iron Ore | 9 | 41 300 000 | 3 300 000 | 1 000 000 | 73 | 27 |
| Copper | 14 | 93 000 | 27 000 | 66 000 | 29 | 71 |

Source: adapted from (Leeuw, 2012, p. 104; Department of Mineral Resources, 2011)

Table 3 indicates that South Africa ranks at the top globally with the majority of mineral resource base and that the lower percentages of produced minerals are refined locally with most minerals exported as raw ores to international markets. The table shows that only 11% of South Africa's mined gold was beneficiated locally and 89% was exported as raw ores, and only 19% of the platinum group metals were beneficiated locally as opposed to 81% which were exported as raw ores.

This and the fact of physical proximity to raw minerals should, therefore provide local downstream processors with a great opportunity. Having considered the opportunities, it is also useful to consider the scope of this opportunity by looking at value addition through selected precious minerals.

Though the South African government has singled out 10 minerals which it believes have the greatest potential for value through beneficiation, the following section discusses selected precious minerals, namely, platinum group metals, gold and diamond sectors, their uses and the scope for beneficiation.

## 2.3 The Scope for Economic Value Addition by Precious Minerals

Adequate supplies of raw materials of which minerals are part, are essential for manufacturing and thus for the sustainable development of the modern economy (Kitange, 2012).

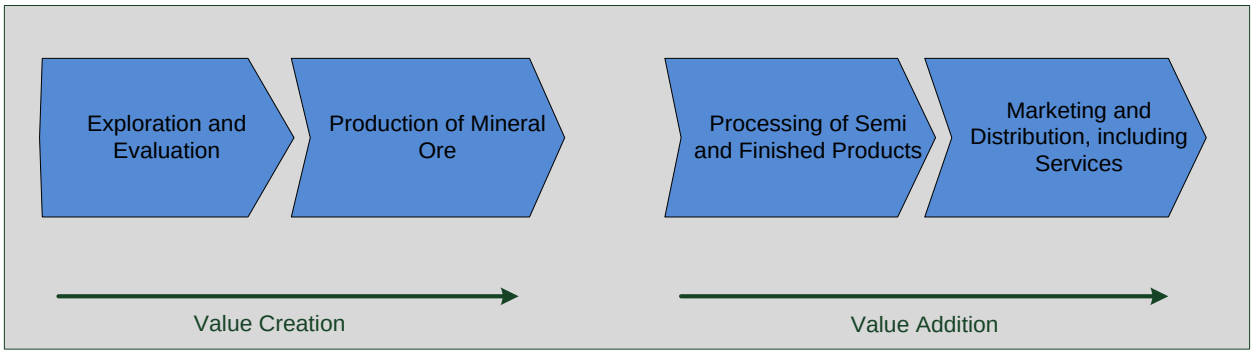



**Figure 2:** Mineral value chain-value creation and addition (Kitange, 2012)

As noted in Chapter 1 the bulk of minerals are exported as ores in semi-processed form with little or no value added, resulting in beneficiation taking place elsewhere and a lower revenue stream for South Africa than its likely potential if beneficiated locally.

Kitange (2012) alluded that value is created at the upstream stages and value addition happens at the downstream stage of the mineral value chain. As illustrated in Figure 2 it is therefore useful to consider the opportunity available for value addition in the precious minerals sector through beneficiation.

The following sections explain the uses and benefits of selected minerals namely platinum group metals, gold and diamond and indicates the opportunity for South Africa to beneficiate them.

### 2.3.1 Platinum Group Metals (PGMs) Industry

South Africa is the largest producer of platinum in the world, and accounts for 78% of the world's platinum (Chamber of Mines, 2013). The Chamber of Mines further states that the platinum mining in South Africa is a valuable industry for the country as it creates many jobs both directly and indirectly, and uplifts the communities in the process. According to the Department of Mineral Resources (2011) South Africa's production of the major PGMs has risen by an average of 4.5% per annum since 1985.

The uses and benefits of platinum, it's value chain, market trends and beneficiation potential are next discussed below.

### 2.3.1.1 Platinum Uses and Benefits

Platinum group metals are essential to a wide range of industries and do not have any substitutes in their main applications, in particular the automotive catalytic converters or auto catalyst (Pallinghurst, 2014). Figure 3 below illustrates some of the uses of platinum.

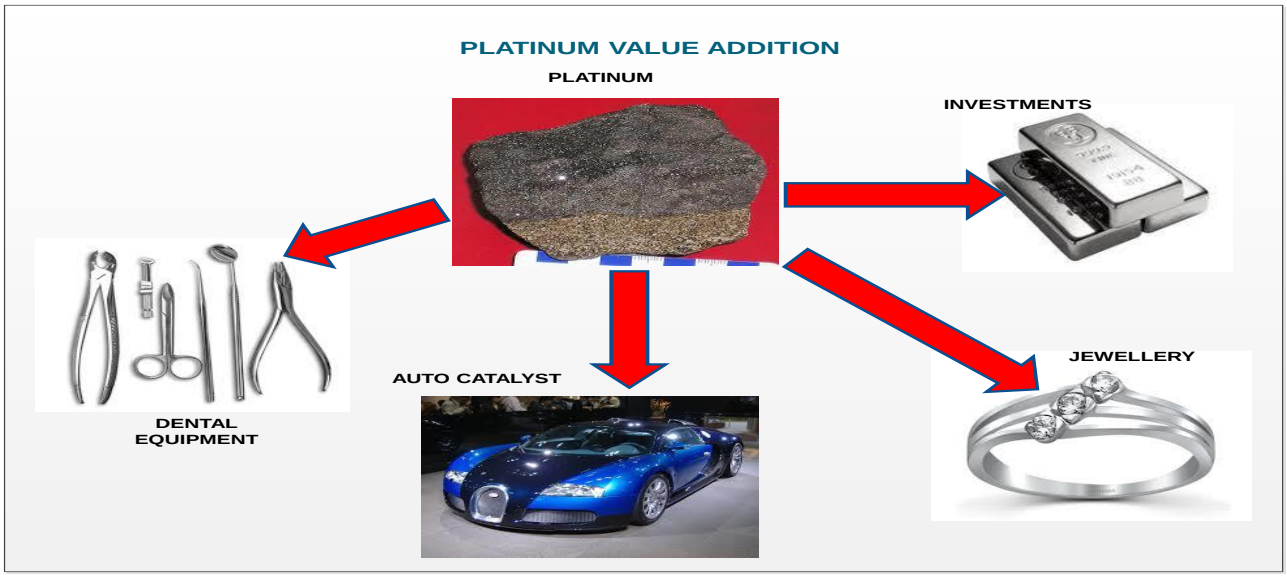



**Figure 3:** Mineral Value Added – PGMs (Anon, 2014)

The catalytic converters are used for vehicular emission control which limits the emission of major air pollutants such as carbon monoxide (CO) and oxides of nitrogen gasses (NOx) in line with the strict international controls on the emissions of particulate matter and greenhouse gasses (Department of Mineral Resources, 2011).

Pallinghurst (2014) estimated that 20% of consumer products either contain PGMs or use them during their manufacturing process. The demand for PGMs is also driven by their use in high-end jewellery, investments in physical metals and Exchange Trade Funds as shown in figure 3 (Anon, 2014). This view is supported by Saurat and Bringezu (2008, p. 755) who state that there are seven industrial sectors and product groups which are the main users of PGMs, and comprise of the chemical, petroleum and glass industries; jewellery, dentistry, electronic equipment and car catalysts.

The high price of the PGMs led to intensive research to find substitutes for them, but to date there is no cheaper material available that offers similar properties for the catalytic reactions (Rumpold & Antrekowitsch, 2012). This view is shared by Dewar (2012) who states that the global auto catalyst production remains the largest consumer of PGMs and that South Africa provided 59% of platinum, 29% of palladium, and 72% of rhodium, as well as over 50% of the global chromium demand. The author further states that South Africa beneficiated only 15% of locally mined PGMs towards the production of catalytic converters.

Based on this and the fact that every new car that is produced has to be equipped with a catalytic converter (Dewar, 2012) and that the number of car registrations is increasing globally, the demand for PGMs and in particular catalytic converters is expected to continue to grow.

#### 2.3.1.2 The PGM Value Chain, Market Trends and Beneficiation Potential

Although the majority of PGMs are refined to the highest level of purity at local PGM refineries, the major manufacturing offtake from PGMs – the auto catalyst market, benefits from only 10% of the platinum produced (Department of Minerals and Energy, 2008).

According to the Department of Minerals and Energy (2008) some of the main factors influencing the PGM sector in South Africa are the increasing global demand, exploration potential, and resource leverage. The DME further states that platinum beneficiation is necessary in the growth of South Africa's mineral industry. The factors that make beneficiation important include the country's platinum production, the world demand of platinum and the price of platinum.

According to Dewar (2012, p. 900) projections are that the demand for auto catalysts and diesel particle filters will more than double over the next two decades. South Africa has a world-class industry that is already beneficiating more than 95% of all locally consumed PGMs (10% of South Africa's produced PGMs) and has the opportunity to develop substantially (Dewar, 2012).

The future of the catalytic converters is a promising growth because of the following factors mentioned by Dewar (2012, p. 900):

- Regulatory controls on auto emissions are being tightened further in developed countries and introduced increasingly in the emerging economies such as China, India and Brazil. This has a potential to result in a continual and increasing demand for catalytic converters for vehicles. Dewar (2012) further predicts that global vehicle sales with grow by 50% by the year 2020.
- European legislation restricts the emission of soot particles from diesel engines, which has resulted in increased requirement for fitment of diesel particulate filters (DPFs)

The fact that South Africa has 88% of the PGMs world reserves (Department of Mineral Resources, 2011) and that only a limited amount is being beneficiated presents an opportunity for increased beneficiation.

### 2.3.2 Gold Industry

The discovery of the Witwatersrand Goldfields in 1886 led to the development of South Africa's world-class mining industry, which has dominated the global gold mining industry for 120 years (Gold in South Africa, 2005). The report states that the South African gold mining sector has, from 1884 (when records of production were first collected) to 2004, produced 50,055tons of gold which accounts for some 33% of all the gold estimated above the world's surface.

Three of the six largest gold mining companies are South African (Gold in South Africa, 2005). The South African gold mining industry could be divided into four sub-sectors (Gold in South Africa, 2005): Large, publicly-listed gold mining companies; Companies producing gold as a by-product of the other metal mining (largely PGM producers); Tailings retreatment operations (operated either by the large listed companies or by small-scale companies); and Junior or small-scale miners.

The uses and benefits of gold, its value chain, market trends and beneficiation potential are discussed below.

### 2.3.2.1 Gold Uses and Benefits

Figure 4 below indicates some of the uses of gold.

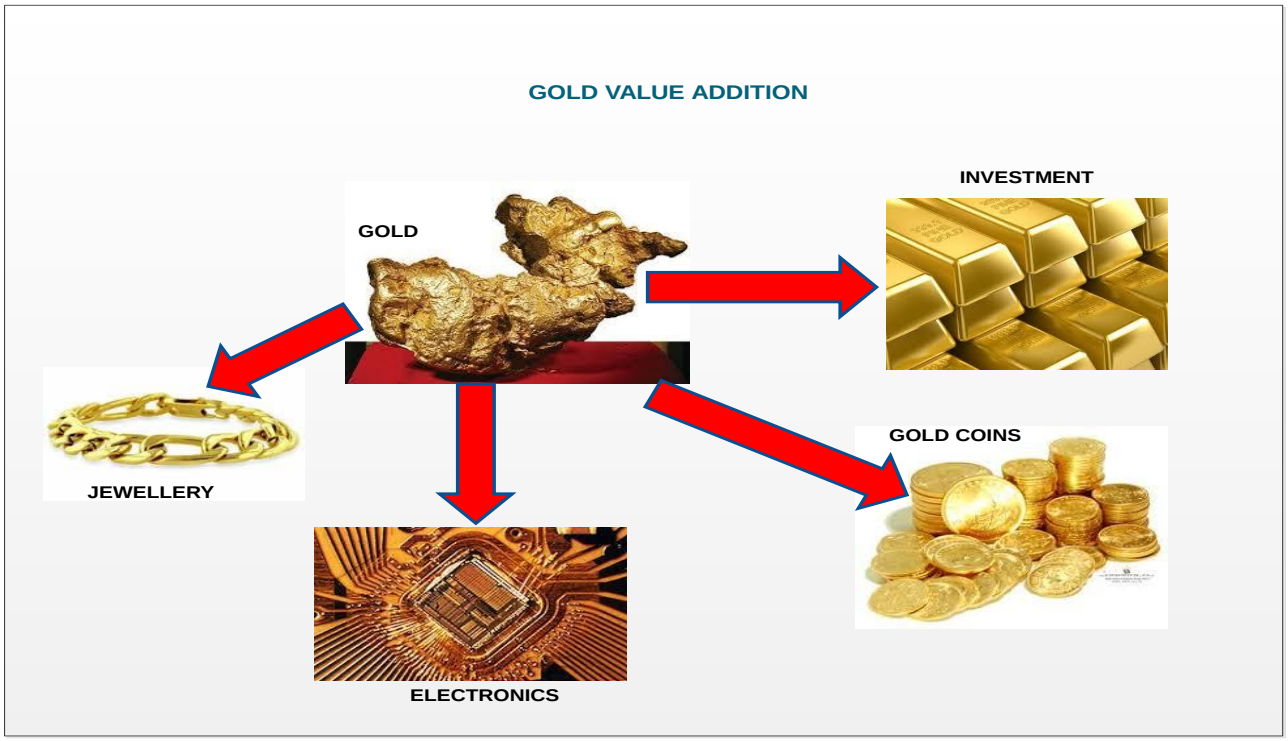



**Figure 4:** Mineral Value Added – Gold (Anon, 2014)

According to Scottsdale Bullion and Coin (2012) the top 6 common uses of gold in the world are:

Jewellery:

About 78% of gold consumed every year is made into jewellery. Jewellery is the most common way gold reaches consumers, and has been a primary use for the metal in various cultures. Because of its beautiful and durable properties, gold jewellery is an adornment that is both ethereal and revered.

Finance and Investing:

Because gold is so rare and highly valued, this precious metal makes a natural currency, and has been for at least 6,000 years. The USA used to hold all its monetary currency to a gold standard, and since the turn of the millennium, gold value has been on the rise in the stock market. In an uncertain economy, gold has emerged as a possible financial staple.

One of the most common ways to hold or invest in gold is in gold coins, gold bars, and gold bullion.

Electronics and Computers:

Gold is a highly efficient conductor that is able to carry tiny electrical charges, and because of this property a small amount is found in almost all electronic devices, including cell phones, televisions, GPS units and more. Because gold is such an efficient conductor of electrical charges, it is also often found in desktop and laptop computers to transfer information quickly.

Dentistry and Medicine:

Gold makes for the best fillings, crowns, bridges and orthodontic appliances because the metal is chemically inert, easy to insert and non-allergenic. Gold has been used in dentistry since 700 B.C. and will probably continue to be the best option for replacing broken or missing teeth. In the medical field, small amounts of gold isotopes are used in certain radiation treatments and diagnosis.

Aerospace:

In the aerospace industry where reliable and effective technologies are key to survival, gold plays an essential role. Gold is used to lubricate mechanical parts, conduct electricity and coat the insides of space vehicles to protect people inside from infrared radiation and heat.

Medals and Awards:

As a highly esteemed precious metal, gold makes a natural appearance in crowns, awards and religious statues. Because of its unparalleled beautiful qualities and rarity, gold is one of the highest status symbols. In everything from Academy Awards to Olympic medals, gold is recognized for its admirable qualities and it holds a permanent place of value in humanity's eyes.

#### 2.3.2.2 The Gold Value Chain, Market Trends and Beneficiation Potential

The South African gold industry has seen a significant amount of consolidation since 1998, with over 50 listed gold companies being consolidated, mostly within their mining house groups and through mergers and acquisitions (Chamber of Mines, 2013). Gold has also moved from being the top earner to a third position with sales of R19.3 billion, having been overtaken by the PGMs with sales of R33.5 billion and coal with sales of R20.2 billion (Department of Mineral Resources, 2011).

According to the Department of Minerals and Energy (2008, p.30) there are a number of reasons for the sharp decline in South Africa's gold production profile:

- Declining average grade – this is a result of mining and more distal deposits within the Witwatersrand, and the lack of any new high grade deposits being discovered recently.
- Declining amount of available tonnage – as mining progresses deeper and further away from shafts, the economic amounts of material available become scarcer.
- Mining costs – most companies are affected by the volatile economic conditions.
- Labour and social costs – labour costs and related social development costs are a major part of the operating costs of any company, and especially mines which are also required to provide substantial funding for rehabilitation, environmental monitoring, and skills development and training.

Beneficiation in the gold industry has been under debate for a number of years. The debate is based on the argument that the South African beneficiation of gold is only 2% of current mine production and the country is not exploiting any comparative advantage of its large natural resource base (Mogotsi, nd). This suggests that there is a huge opportunity for beneficiation of gold in South Africa.

### 2.3.3 Diamond Industry

Diamonds are one of the worlds, and specifically Africa's major natural resources. An estimated US$13 billion worth of diamonds are produced per year of which approximately US$8.5 billion are from Africa (World Diamond Council, 2013). The council further states that global diamond jewellery sales continue to grow, increasing three-fold in the past 25

years, and are currently worth in excess of US$72 billion every year. This fact is corroborated by a study conducted by Gawanab (2010, p.11) which states that the global diamond industry is a multi-billion dollar industry.

The uses and benefits of diamond, and the value chain are discussed below.

#### 2.3.3.1 Diamond Uses and Benefits

According to the World Diamond Council (2013), diamonds have two main uses: in jewellery – due to their rarity and beautiful appearance, and in industry- due to their unique molecular properties. About 30% of diamonds are of gem quality and are distributed to experts for cutting, polishing and jewellery manufacture and the remaining 70% are used for industrial applications such as drilling, cutting, grinding and polishing.

The diamond trade contributes approximately US$8.5 billion a year to Africa and helps the continent in the following four key ways (World Diamond Council, 2013):

- Financial: diamonds provide a significant economic contribution to the countries in which they are found, for example, they represent 33% of the GDP of Botswana.
- Health: diamonds play a significant role in helping tackle the HIV pandemic in Southern Africa through the funding of counselling, testing, education, treatment programs and clinics.
- Education: Southern African countries are using the revenue from diamonds to help educate more children.
- Employment: The diamond industry employs more than 38 000 people in the Southern Africa region.

#### 2.3.3.2 Diamond Value Chains

All the role players in the diamond industry are strategically included in the value chain shown in figure 5. This value chain traces diamond production all the way from the mine to retail customers.

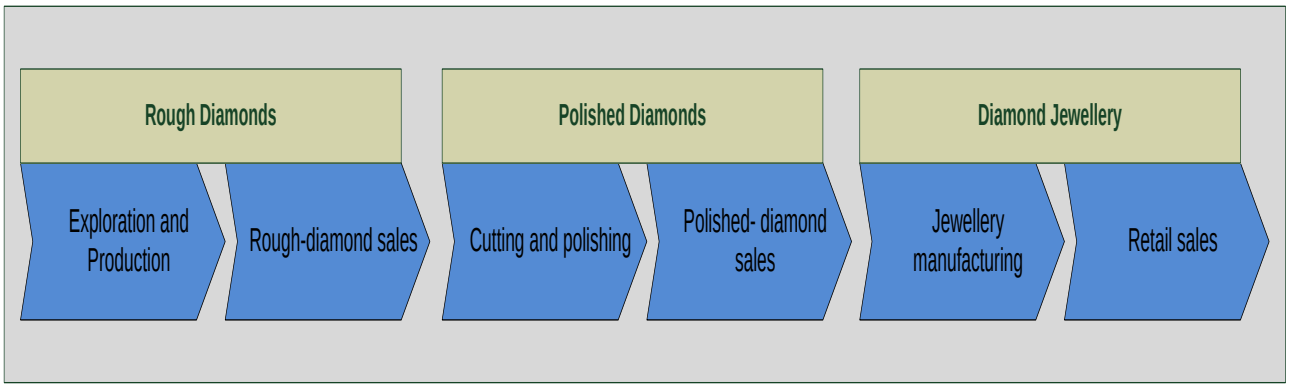



**Figure 5:** Typical Diamond Pipeline (Gawanab, 2010; Bain & Company, 2013)

The value chain steps are discussed as follows, based on the study conducted by Gawanab (2010, p. 11):

Exploration:

Exploration refers to the discovery of new deposits of diamondiferous kimberlite, which can be mined economically. Modern exploration uses highly sophisticated technologies to determine the economic viability of deposit (e.g. airborne surveys).

Diamonds are found in many countries around the world, and majority (approximately 65%) are found in Africa (World Diamond Council, 2013). Table 4 indicates the major producing countries and shows that South Africa ranked fifth in 2012 amongst the world's diamond producing companies.

Table 4: Major diamond producing countries in 2012

| Country | | Value, US$ billion | Volume, cts | US$ / cts |
|---|---|---|---|---|
| 1 | Botswana | 2.979 | 20,544,928.45 | $144.95 |
| 2 | Russia Federation | 2.873 | 34,927,650.00 | $82.28 |
| 3 | Canada | 2.007 | 10,450,618 | $192.07 |
| 4 | Angola | 1.110 | 8,330,995,68 | $133.26 |
| 5 | South Africa | 1.027 | 7,077,431.00 | $145.13 |
| 6 | Namibia | 0.900 | 1,628,779.80 | $552.87 |
| 7 | Zimbabwe | 0.644 | 12,060,162.70 | $53.4 |
| 8 | Lesotho | 0.301 | 478,926.19 | $629.43 |
| 9 | Democratic Republic of Congo | 0.183 | 21,524,266.19 | $8.51 |

Source: (Kimberly Process Certification Scheme, 2013)

Mining and ore extraction:

Once diamonds are detected, there are different types of mining operations used to extract them depending on the environment in which they are found. This includes the extraction of ore from open-cast, underground, alluvial and seabed mining and the processing of the ore into rough diamonds ready for sorting.

Sorting and distribution:

Rough diamonds are sorted into 13 000 different categories based on characteristics such as shape, size, colour, cut-ability and quality and sold to wholesalers.

Cutting and polishing:

This process takes place in over 30 countries, but is concentrated in 5 locations: Antwerp, Johannesburg, Mumbai, New York and Tel Aviv. India processes 55% by value of the world's diamonds.

Jewellery manufacturing:

This activity involves the crafting of diamonds into jewellery. Manufacturers are located close to consumer markets, with about 40% based in the United States of America, 15% in Japan and the rest spread across Africa, Asia and Europe.

Marketing and retail of jewellery:

There are about 200 000 diamond jewellery retail outlets worldwide. Globally, 45% of jewellery is sold in the USA, 33% in Asia, and 11% in Europe. In a study conducted by Bain & Company (2013) it was found that the value of diamond increases significantly as they travel through the value chain from the mine to the final market, nearly quintupling at the end of the value chain. The greatest value, $25 billion or more in both cases is added at the jewellery manufacturing and retail stages.

A study conducted by Gawanab (2010, p.14) found that value-adding activities are dominated by India and China, who do not produce a single diamond from their local soil. This is consistent with the study conducted by Kaiser Associates (2005) which states that

the USA jewellery market was the largest in the world and was worth approximately UD$29.1bn in 2003, which accounted for 55% of the world diamond jewellery consumption.

Figure 6 indicates that rough-diamonds production generates revenues of $14.8 billion. The revenue grows to $47.2 billion when the diamonds are manufactured into jewellery and grow again to $72.1 billion when the jewellery is sold at retail.

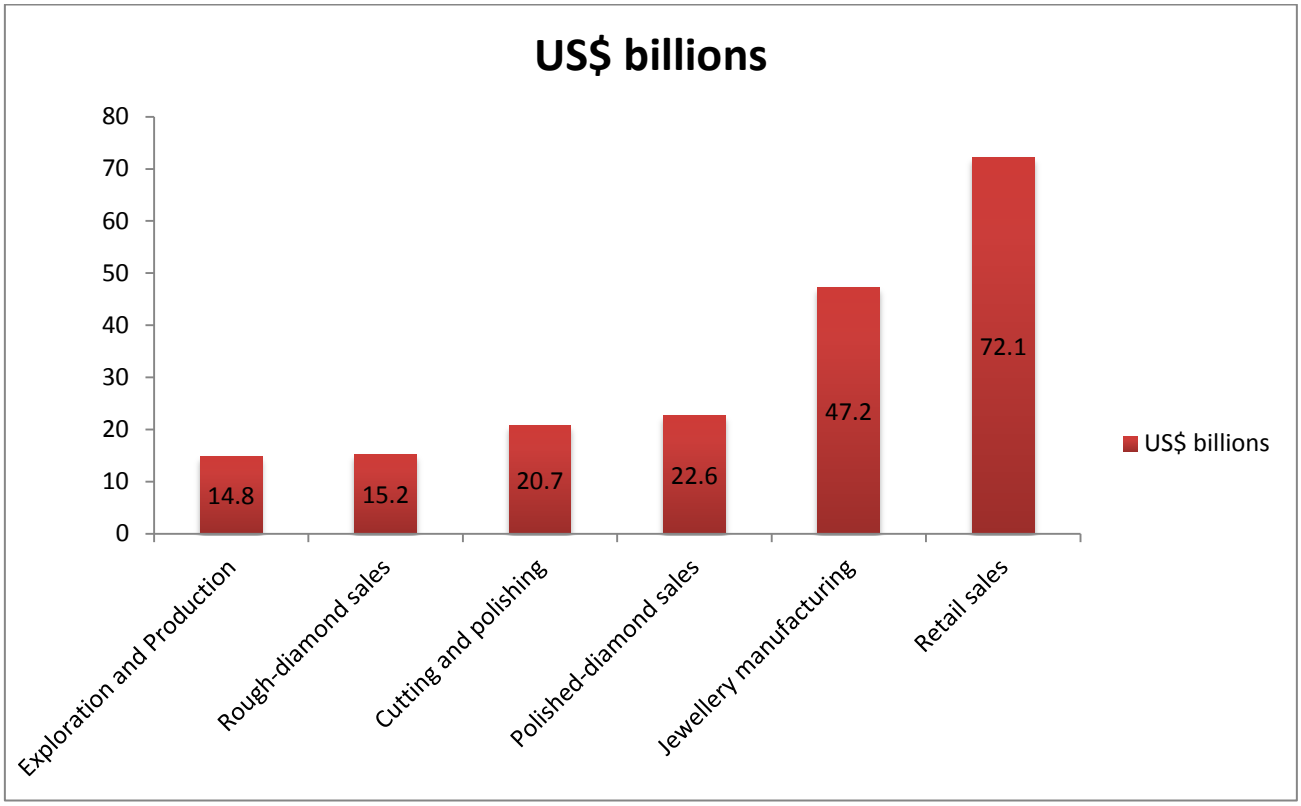



**Figure 6:** Global revenue by value chain segments in 2012 (Bain & Company, 2013)

It is interesting to note that the USA is not among the top 10 diamond producing countries in the world (see Table 8) and yet it is the main diamond jewellery retailer (see Table 5 below).

Table 5 below provides the top 9 list of diamond jewellery retailing countries as of 2006.

Table 5: Major diamond jewellery retailing countries

| Country | | Retail sales value (US$) | % Share |
|---|---|---|---|
| 1 | United States of America | 29.10bn | 55 |
| 2 | Canada | 0.70bn | 2 |
| 3 | Japan | 20bn | 16 |
| 4 | Hong Kong | 0.77bn | - |
| 5 | China | 1.21bn | - |
| 6 | India | 0.80bn | - |
| 7 | Europe | 7.70bn | - |
| 8 | Israel | 0.99bn | - |
| 9 | South Africa | 0.15bn | - |

Sources: (Kaiser Associates, 2005; Global Witness, 2006)

From Table 5 it can be seen that only South Africa within Africa makes the top 10 list of diamond jewellery retailing countries, coming only at number 9. The research conducted by Global Witness (2006) show that South Africa and Europe combined only contributed 13% of global retail sales of diamond jewellery in 2005.

The logical expectation is that South Africa, as one of the major producers of diamond in the world, like Canada should be sitting among the top of the list of countries that retail in diamond jewellery and benefitting greatly from the value-added by this important stage of the diamond value chain.

#### 2.3.3.3 Value Addition by Diamonds in South Africa

Downstream value added and beneficiation in the diamond industry has become an important issue for the South African government in recent years (Hazleton, 2002). In 2000, a major study was undertaken with the purpose of identifying opportunities in the jewellery sector for improved foreign exchange earnings and job creation (Hazleton, 2002).

The South African Jewellery Cluster Study, released in 2001 recommended that the country should do the following (Kaiser Associates, 2005):

- Migrate towards increased cutting and polishing activities to generate further revenue from rough diamonds;
- Concentrate its efforts in the mid-range of the cutting and polishing diamonds spectrum;

- Create or expand a diamond exchange (and include other gemstones) to take full advantage of the natural abundance of raw materials in the region.

From the information provided above it is apparent that there exist opportunities for South Africa to benefit from future beneficiation of its diamond resources.

### 2.3.4 Integrated Precious Minerals Strategy Outcomes

According to the Department of Minerals and Energy (2008, p.19) the beneficiation of gold and diamonds require the establishment of integrated jewellery hubs throughout South Africa. The jewellery hubs may also integrate the specialised platinum jewellery facilities.

The high value and low bulk of gold, platinum and diamond jewellery makes them attractive for export in particular to export markets such as the United States of America, Japan and Europe. This can provide an opportunity for local beneficiating companies to grow their markets internationally.

Figure 7 below indicates the precious minerals strategy outcome developed by DME.

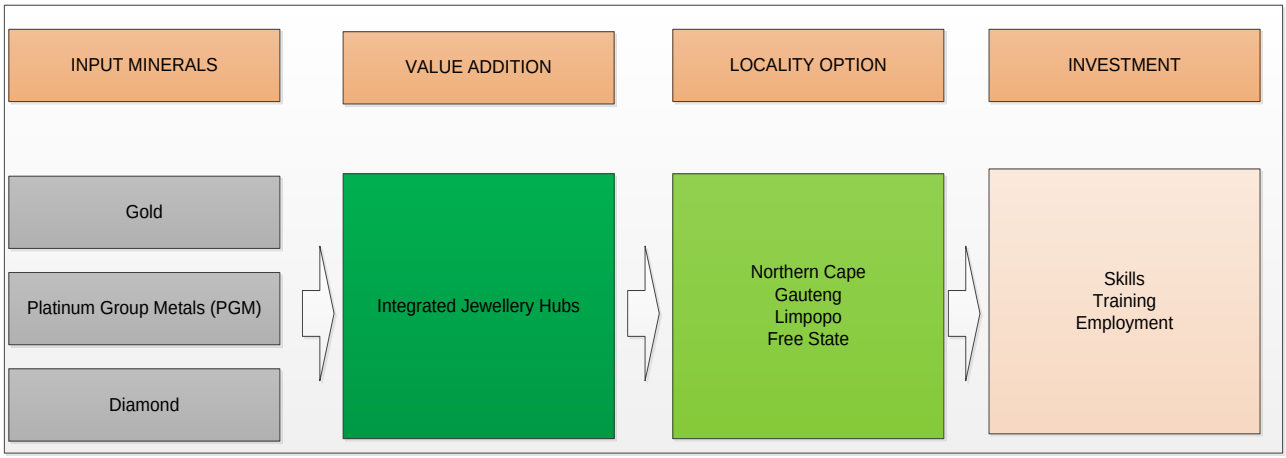



**Figure 7:** Precious Minerals Strategic Outcomes (Department of Minerals and Energy, 2008)

According to the Department of Minerals and Energy (2008) the key action plans for jewellery could include: (1) the establishment of an applicable and effective metal advance scheme aimed at ensuring local metal or mineral access for value addition; (2) a structured training programme which takes into consideration current specific demands and the expansion of the jewellery industry could be developed in collaboration with the Mining

Qualification Authority (MQA) and relevant Sector Education and Training Authorities (SETA's); (3) jewellery investment promotion, including the promotion of existing incentives in the jewellery sector. The development of jewellery hubs in industrial development zones would also put South African companies at almost the same level as their competitors in other countries; and (4) second economy interventions such as the Kgabane Jewellery Project, the Olifantsfontein Jewellery Training and Manufacturing facility, the Small Enterprise Development Agency (SEDA) platinum Incubator, as well as all private sector initiatives could contribute significantly towards furthering the objectives of a strategy towards jewellery manufacturing.

In order to fully understand the mineral beneficiation dynamics, it is important to consider both the mining and manufacturing industries concurrently, for the two are closely linked as indicated earlier, their contribution to downstream value chain and the challenges they face. To do this, one needs to look at available literature on South Africa's manufacturing competitiveness which provides useful key indicators and their current status. A survey of the literature found that the most recent data on South Africa's generic competitiveness is the information available and is obtained from the World Economic Forum (2013). From this generic competitiveness, elements which apply to manufacturing e.g. labour related elements are considered for insight on manufacturing competitiveness in South Africa. The sections that follow below discuss manufacturing competitiveness and the mining industry.

## 2.4 South Africa's Manufacturing Competitiveness

The manufacturing sector is crucial in the support of the country's mineral beneficiation programme due to its ability to upgrade and innovate which according to Porter (1990) are essential elements in creating an export market potential.

According to Pan-African Investment & Research Services (2011, p. 8), South African manufacturing competitiveness has eroded over the past decade, due to a number of structural impediments, including rising input costs, inadequate infrastructure, energy shortages and most importantly the sector's long term competitiveness has not received the necessary attention, as in the case for the country's peer economies. The report states that this could be attributable to the fact that the key driver for the domestic economy's growth over the decade has been consumption, on the back of the liquidity boom and as a

result, the production side of the economy was neglected (Pan-African Investment & Research Services, 2011).

Figure 8 below ranks South Africa's competitiveness out of 148 surveyed countries. The figure shows that South Africa ranks number 1 on the strength of auditing standards, efficacy of corporate boards and the protection of minority shareholder interest. This indicates the strength of the country's institutions. Figure 8 also indicates South Africa's excellent performance on financial market development in that the country was ranked first on the regulation of securities exchanges, and the legal rights index, second on the availability of financial services and local equity market development, and third on the soundness of banks.

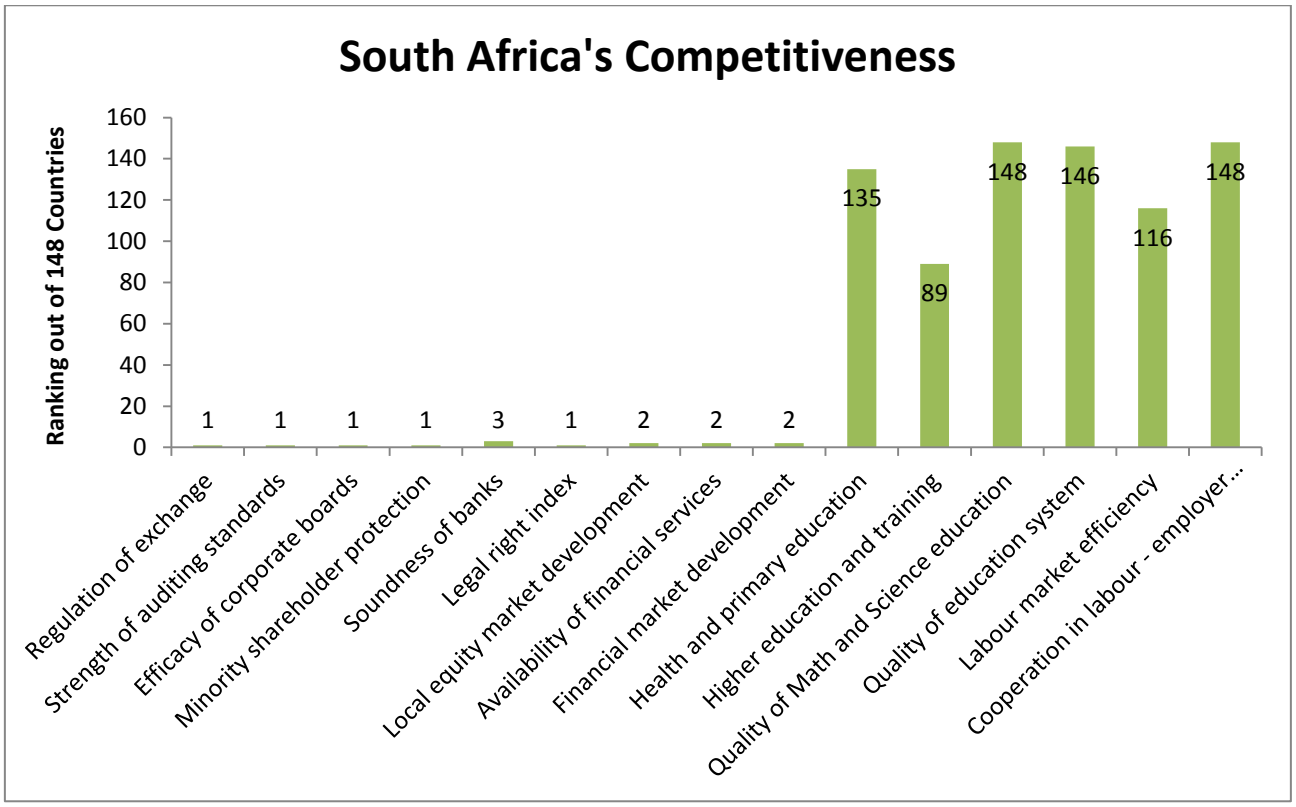



**Figure 8:** South Africa's Competitiveness (World Economic Forum, 2013)

South Africa displayed dismal performance on the quality of health and primary education, ranking number 133 out of 148 countries on the quality of primary education and 122 on the primary education enrolments.

The country ranks number 89 on higher education and training, ranking last on the quality of math and science education, 146 on the quality of education in general, 116 on internet access in schools, and 108 on the availability of scientists and engineers. The country, however, performed well on the quality of management schools and the extent on staff training.

On labour market efficiency, South Africa displayed a concerning ranking of 116 out of 148 countries. It was ranked last on the co-operation in labour and employer relation, 147 on hiring and firing practices, 144 on the flexibility of wage determination, and 142 on the ratio of pay and productivity. This is an indication that the country's labour laws are not friendly towards business.

Figure 9 below indicates the scores measured on the three drivers of competitiveness as measured by World Economic Forum (2013). South Africa obtained an overall ranking of 95 out of 148 countries on the basic requirements and this was obtained from the rankings of the following four pillars: Institutions (rank 41); Infrastructure (rank 66); Macroeconomic environment (rank 95); and Health and primary education (rank 135)

An overall ranking of 34 out of 148 countries was obtained on efficiency enhancers, and the ranking was obtained from the following pillars: Higher education and training (rank – 89); Goods market efficiency (rank 28); Labour market efficiency (rank 116); Financial market efficiency (rank 3); Technological readiness (rank 62); and Market size (rank 25).

The country is ranked number 37 on innovation and sophistication factors, business sophistication (rank 35); and innovation (rank 39).

According to World Economic Forum (2013, p. 16) South Africa ranks number 53 out of 148 countries on the overall global competitiveness index.

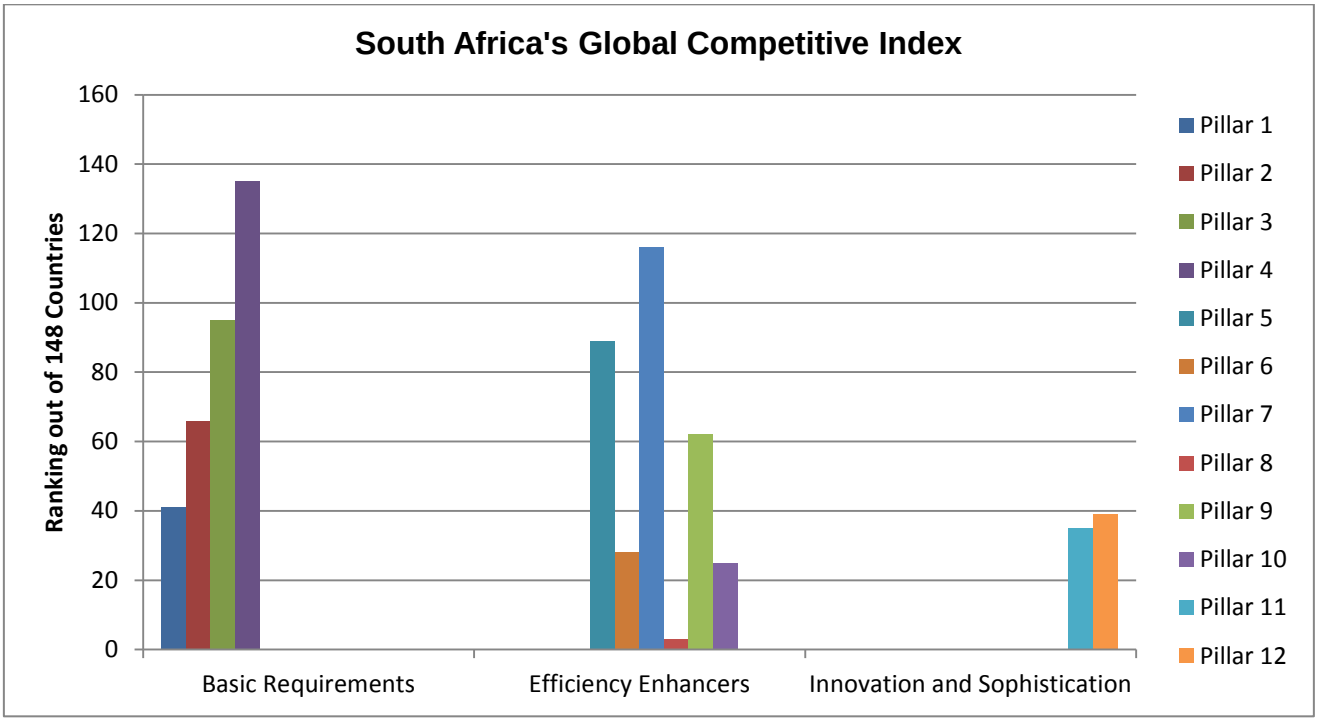



**Figure 9:** South Africa's Competitiveness Index (World Economic Forum, 2013)

It is the author's view that for South Africa to be competitive and achieve success in the beneficiation programme, the study by World Economic Forum (2013) indicates that more attention should be focused on the basic requirements of competitiveness, and specific focus should be placed on the macroeconomic environment and the quality of health and primary education. To be efficient the country must put resources to improve the quality of higher education and training, research and development, and technology.

According to Edwards and Lawrence (2012, p. 19) South Africa needs to be positioned for a continuation of the commodity cycle, and to exploit emerging economies fully.

It is, therefore important for South Africa to develop policies to spur labour-intensive services and manufacturing exports as these will be needed if the commodity markets are less robust and because of their employment creating potential.

It is the researcher's view that manufacturing competitiveness is important for the sustainability of the beneficiation programme. It is therefore assumed that the challenges affecting manufacturing competitiveness will also affect beneficiation. The next section presents the constraints to beneficiation obtained from the literature.

### 2.4.1 South Africa's Constraints to Beneficiation

According to Hausmann *et al*. (2008) there is no reason for countries like South Africa to focus attention on beneficiation at the expense of policies that would allow for other export sectors to emerge. The authors further state that South Africa should not pay special attention to beneficiation at the expense of missed opportunities from the entire set of 'lateral' sectors that don't currently exist, as it will be a wrong approach in trying to address the problems of unemployment and inequality.

This view can be supported by a comparative analysis with Indonesia. According to Vecchiatto (2014) Indonesia is rapidly losing its status as the world's largest nickel producer because of its policy of insisting that all raw materials are processed before export. Since the Indonesian government's law came into effect, that country's exports of nickel have been reduced drastically and there is also a build-up of stock (Vecchiatto, 2014). The high inventory levels according to Vecchiatto (2014) may be due to limited or non-existent access to international markets for beneficiated products.

According to Edwards and Lawrence (2012, p.29) there is little international evidence in support of the view that production of raw materials automatically gives a country a competitive advantage in beneficiation activities. The authors further give an example that South Africa faces significant disadvantages in the beneficiation of iron ore: it does not have sufficient local demand for scale; is not close to major foreign demand centres, the location of mills are not on the coast; and profitability is adversely affected by high costs of significant factors (capital, labour and energy) and high cost of imported and coking coal (Anglo American Kumba Iron Ore, 2011)

Edinger (2014) states that beneficiation is driven by competitive advantage issues (production, skills, craftsmanship etc.) and not necessarily by the availability of raw materials. Competitiveness is defined by World Economic Forum (2013) as the set of institutions policies and factors that determine the level of productivity of a country. "The level of productivity sets the level of prosperity that can be reached by an economy and also determines the rate of return obtained by investment in an economy, which in turn are the fundamental drivers of its growth rates" (World Economic Forum, 2013, p. 4).

In a survey by the WEF, the respondents were asked to select the five most problematic factors for doing business in South Africa (World Economic Forum, 2013, p. 346). Figure 10 indicates the results of the survey.

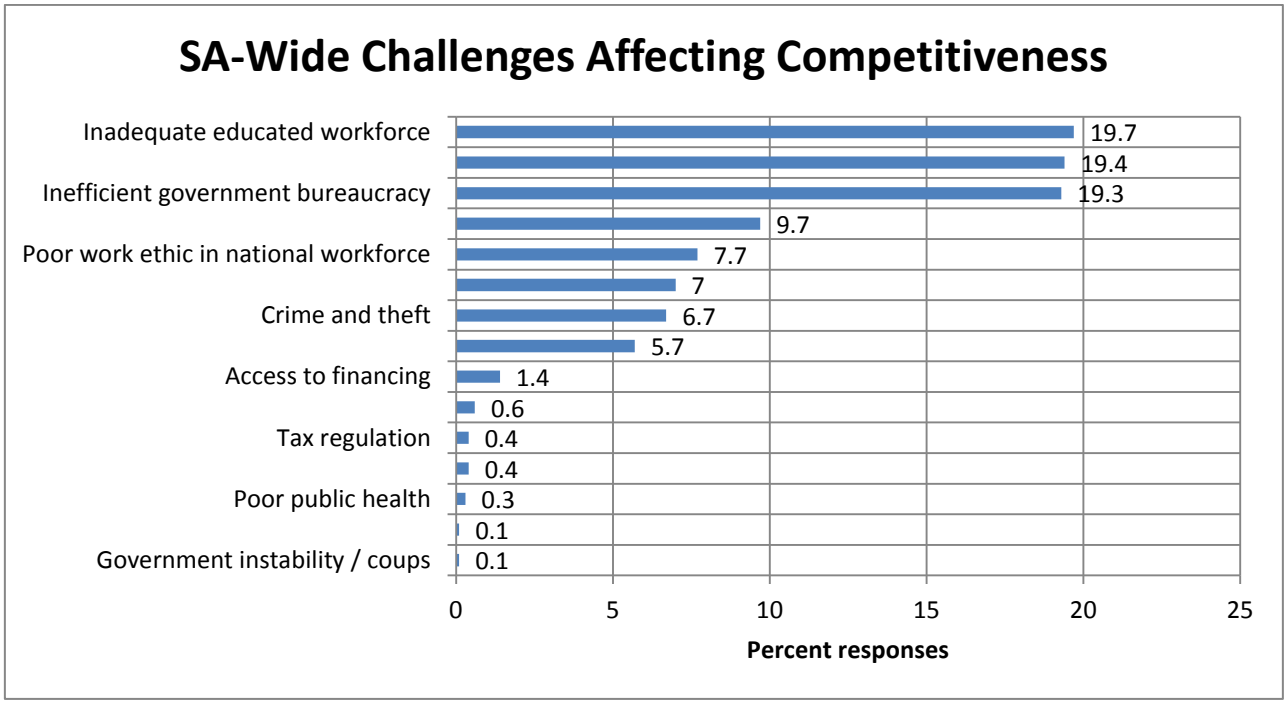



**Figure 10:** Challenges facing South Africa's Competitiveness (World Economic Forum, 2013)

The Global Competitive Report (see figure 10), indicates that the five greatest obstacles to doing business in South Africa are: i) inadequately educated labour force; ii) restrictive labour regulation; iii) inefficient government bureaucracy; iv) corruption; and v) poor work ethic in the national workforce.

The challenge of inadequately educated labour force may be partly attributed to the poor quality of primary and higher education and training.

According to Oliphant (2014, p. 4), While the labour legislation should certainly be supportive of the economic growth and employment, it is important to recognise that our law is not focused on securing employment for the citizens of the country. Labour legislation is principally concerned with providing the employed with basic protection against unfair labour practices, unsafe working conditions and decent living wage.

Over the past three years, South Africa has experienced an increase in labour strikes and especially in the number of workdays lost due to strike actions. The average loss of workdays due to strike actions have been 3 million over the 2011 to 2012 period (Oliphant, 2013).

There is also a critique that South Africa cannot be able to compete on the basis of labour costs. In a study conducted in 2010, Edwards and Lawrence (2012, p. 26) compared the labour costs across various countries and the results are presented in table 6 below.

Table 6: Comparison of labour cost competitiveness in manufacturing, 2010

| | **Unit Labour Cost (US=100)** | **Hourly wages ($)** |
|---|---|---|
| South Africa | 105 | 7.1 |
| India | 118 | 3 |
| China | 85 | 1.9 (was 0.9 in 2006) |
| Brazil | 95 | 8.2 |
| Peru | 84 | 4.5 |
| United States of America | 100 | 33.7 |

Source: (Edwards & Lawrence, 2012)

According to Edwards and Lawrence (2012, p. 26) South Africa cannot compete with China and other emerging economies on the basis of average current manufacturing wages. Table 6 above shows that South African companies firms face a wage cost disadvantage relative to China and India, as the average manufacturing wages in South Africa (at $7.1 an hour in 2010) were over three times those in China.

Among the cross-cutting challenges to effective beneficiation identified by Eunomix (2012) and Department of Minerals and Energy (2011) are: (1) the availability of energy to power new large scale mineral beneficiation operations. Most beneficiation programs require large and uninterrupted supply of energy and the recent unprecedented levels of electricity demand, compounded by lack of investment in power generation resulted in deficit energy supply from the first quarter of 2008; (2) infrastructure constraints, in the form of lack of

capacity and rapid cost escalation, which are limiting export access to imported inputs, export markets and effective domestic production logistics; (3) labour cost inflation, now largely exceeding inflation and productivity gains, has been cited by primary and secondary producers as a major constraint to investment in transformation; (4) the quality of school education and its ability to produce the necessary skills along the value chain. Supporting this point, Deloitte (2014) affirms that South Africa has a widely recognised skills shortage, largely due to mismatch of the skills in demand versus those in supply; (5) limited access to raw material for beneficiation. According to the DME report this constraint is resultant from the current structural arrangement in the mining industry, which remains geared towards export orientation of raw material, with the bulk of current producers tied to long term contracts with their international clients; and (6) Research and Development constraints. The DME report found South Africa's limited exposure to break though research and development programs to be limiting the prospects of innovation and creativity in creating products for beneficiation.

These factors clearly demonstrate that having natural resource does not automatically translate to downstream beneficiation, unless there are dedicated interventions to address constraints and realise competitive advantage for the mineral beneficiation industries.

Having considered the manufacturing sector, the mining industry is next considered as it supplies minerals to the manufacturing sector.

## 2.5 South Africa's Mining Industry

Since the late 19$^{th}$ century, South Africa's economy has been based on the production and export of minerals, which, in turn have contributed significantly to the country's industrial development (Technology Innovation Agency, 2012). South Africa's mining industry, which is the fifth largest in the world (Department of Mineral Resources, 2011), plays an important role in the country's economy. In 2012 the mining sector contributed over 8.3% to gross domestic product (GDP), generating more than 40% of the country's exports and significantly contributing to corporate tax revenues (South African Institute of Race and Relations, 2013). According to the Industrial Development Corporation (2012) the mining industry generated R262 billion worth of value added (GDP), with new capital investments

amounting to R50 billion to R232 billion of foreign exchange earnings (measured by total export value).

The mining industry is one of the largest employers in South Africa, second only to the agricultural sector (Coetzee & Horn, 2006). The authors further state that the mining sector as an industry, and the precious metals mining in particular, is therefore of strategic importance for the development and sustainable growth of South Africa.

The impact that the mining industry has on the other sectors of the economy is, therefore important. The next section discusses the linkages between the mining industry and the rest of the economy in South Africa.

### 2.5.1 The mining sector's linkages with manufacturing and the rest of the economy

According to Hirschman (Leeuw, 2012, p. 14) economic linkages arise when economic activities in one industry lead to economic growth in other industries and / or the emergence of new industries. He states that economic linkages are forward and backward biased.

Mining created 524 632 jobs directly and another 841 260 jobs were created in 2012 in the industries that either supply goods and services to the mining sector, or use mining products for downstream value addition, or which are related to the spending multipliers from mining and mining employees in the economy (Chamber of Mines, 2013). The Chamber of Mines further states that the social multiplier of mining is very significant for the country, given the dependency ratio of 10 to 1, meaning about 13 600 000 people were directly dependent for the daily food on their table on the 1 365 892 jobs created by the mining sector.

Figure 11 below indicates the contribution of mining to the national economy and development in South Africa which shows that it is considerable.

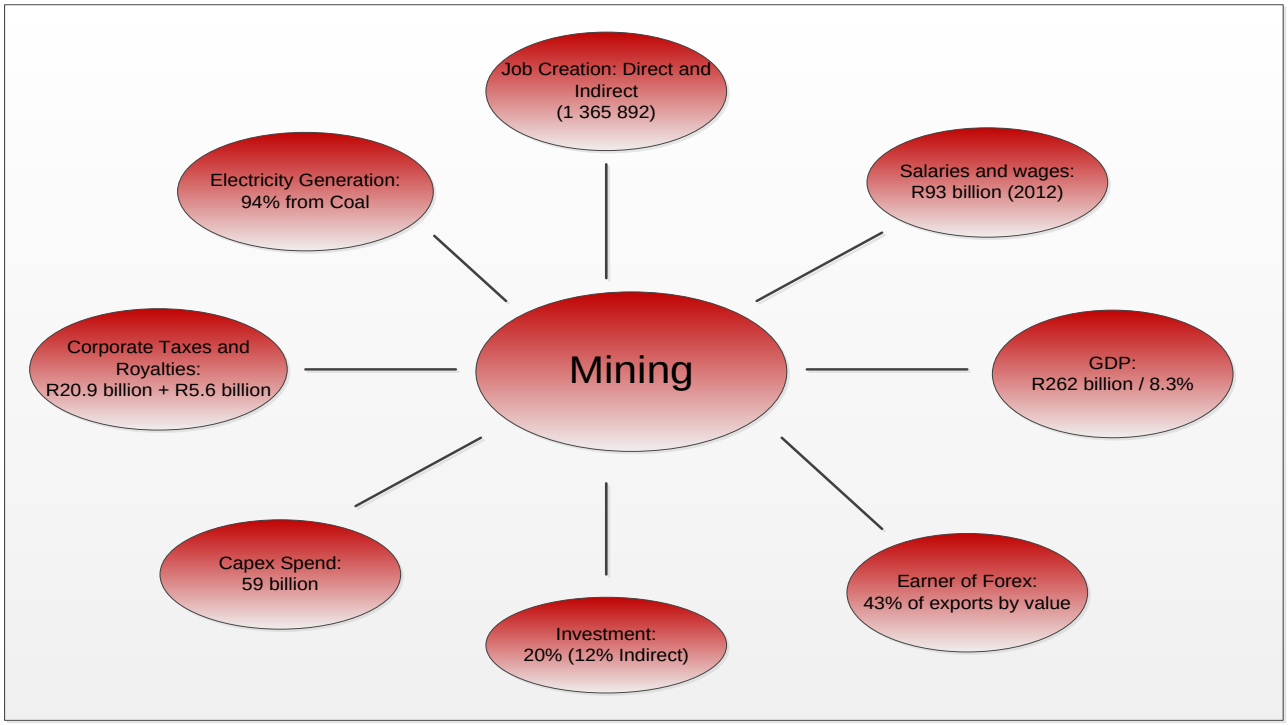



**Figure 11:** Contribution of mining to the economy (Chamber of Mines, 2013)

South Africa has a long history as a resource nation and the mineral resources have undoubtedly helped the country achieve its current status in the African continent.

More than 81% of the mining sector's overall spending on its intermediate input requirements, valued at R169 billion in 2012, was sourced from domestic suppliers of goods and services (Industrial Development Corporation, 2013). The IDC further states that these backward linkages (meaning the spending in local economy) benefitted many sectors which supply goods and services. The sectors are: machinery and equipment; transport equipment; wood products; fabricated metal products; non-metallic minerals; chemicals and petroleum products; water; electricity; transport services; construction and civil engineering; finance and business services.

The mining sector's forward or downward linkages pertain largely to the following sectors (Industrial Development Corporation, 2013): basic metals (mainly the basic iron and steel sector, which consume iron ore); motor vehicles, parts and accessories (e.g. PGMs for catalytic converters); chemicals (e.g. phosphate for fertiliser industry); petroleum refineries (e.g. coal for Sasol's operations); electricity (coal for Eskom's power generation);

construction and civil engineering (e.g. building materials); and other industries such as jewellery manufacturing (e.g. gold, platinum, diamond).

According to Technology Innovation Agency (2012, p. 12) research into the multiplier and induced effects of the mining sector indicate the key areas of its GDP contribution as illustrated in Table 7 below:

Table 7: Contribution of mining sector and its linkages to GDP

| ITEM | CONTRIBUTION % |
|---|---|
| Direct GDP contribution | 8.3 |
| Backward linkages | 2.3 |
| Downward linkages | 2.2 |
| Induced effects | 6.1 |
| TOTAL | 19.1 |

Source (Technology Innovation Agency, 2012)

From table 7 it can be seen that out of the 19.1% contribution to the GDP by the mining sector, only 2.2% was contributed through downward linkages. This indicates that downstream beneficiation provides an opportunity to increase the total GDP contribution through the linkages between the mining industry and other sectors, in particular the manufacturing industry. It is the author's view that for the above to happen, the mining industry will have to resolve many of the constraints and challenges it is faced with. The next section, therefore presents the challenges facing the mining industry from the literature point of view.

### 2.5.2 Challenges Facing the Mining Industry

The World Bank argues that sustainable development in the mining sector requires projects that are financially viable, environmentally sound, and socially responsible, implemented with sound governance (not only companies but also communities and governments) and have lasting developmental value, especially at the community level (Van der Veen & Strongman, 2003, p. 18).

Mining companies globally are faced with a series of economic, financial and operational challenges and South Africa is no exception (Lane, et al., 2013). The authors further state that South African mining companies have unique local issues with profound implications. According to them mining companies require a degree of political stability, investment friendliness, appropriate transportation infrastructure and balanced fiscal regimes to operate successfully (Lane, et al., 2013).

It is argued that there are several issues prevalent across the African continent in direct contrast to these requirements, which contribute to the perception of Africa as a risky destination for business (Lane, et al., 2013, p. 4). Amongst the issues, the following are the challenges that face the South African mining industry: poor governance, the prevalence or perception of corruption, and civil unrest. For example, the world's three largest platinum producers, Anglo American Platinum, Impala Platinum and Lonmin, lost R12.6 billion in revenue due to a five month long labour unrest by the Association of Mineworkers and Construction Union (AMCU) (Business Day, 2014). The annual demands for higher wages are often characterised by demands from trade unions and workers who may not have a full appreciation of the challenges faced by the mining companies.

Among the challenges facing the mining industry are the strength of the rand, rising mining costs and crime (Coetzee & Horn, 2006).

There are also increasing expectations by the South African government with regard to the role the mining companies should play in society. The government expects the mining companies to fulfil social needs such as education, healthcare and the provision of basic services; these needs are typically fulfilled by governments in developed countries (Lane, et al., 2013).

In a study conducted by Price Waterhouse Coopers (2013, p. 18) the top challenges disclosed by mining companies are as follows:

<u>Labour unrest:</u>

The industry has seen an increase in labour unrest and violent strike action over increased wages and employment conditions. Inter-union rivalries have exacerbated already difficult wage negotiations. The impact of ongoing business disruptions and work stoppages is significant production loss and other losses.

Socio-economic impact:

Mining developments have led to an influx of workers to surrounding communities, attracted by the prospect of direct and indirect employment.

Volatile commodity prices and foreign exchange fluctuations:

The market prices for commodities are volatile due to global economic conditions that are beyond the control of South African companies. This creates uncertainty and could have a negative impact on revenue, cash flows, profitability and asset values.

Energy cost increases and power fluctuations**:**

Power shortages are a key challenge hindering growth in the mining sector, negatively affecting production and employee safety. Energy costs are likely to continue to rise significantly as the electricity provider is authorised to raise prices by an average of 8% in each of the next five years, starting from 2013. The mining operations are dependent on electricity supplied by Eskom, the state-owned power generating company.

Loss of social licence to operate**:**

Non-compliance with Social and Labour Plan (SLP) approved targets may lead to mining licences being suspended or cancelled.

Safety and employee health:

Failure to achieve high safety levels may result in safety stoppages in terms of Section 54 of the mine health and Safety Act. This has an impact on employee welfare, production and a company's licence to operate.

Resource nationalism and regulatory uncertainty**:**

The South African National Assembly has endorsed the Minerals and Petroleum Resources Development Act (MPRDA) Amendment Bill, which will facilitate strategic nationalisation of mining sector assets, enforce local processing requirements, and impose export bans (Ernst & Young, 2014). This law poses risks to investors. The report further state that iron ore, coal, platinum and gold producers face the risk of export controls being imposed and of being forced to sell at a discount in the local market.

Infrastructure**:**

Lack of or insufficient infrastructure capacity, access, development and funding may lead to lost opportunities and financial losses as well as decreased competitiveness and market share (Price Waterhouse Coopers, 2013, p. 19). Future sustainability and growth depends on infrastructure development keeping pace with demand.

Other events that stop or delay production:

Factors which potentially hinder the achievement of production and growth targets include unexpected geological conditions, logistical constraints, labour relations, and compliance with environmental legislation (Price Waterhouse Coopers, 2013, p. 19).

From the above, it can be summarised that the major challenges facing the mining industry include labour unrest, price volatility, employee skills, and political and legal environment. Given these challenges, the question that can be asked is whether the country will be able to successfully implement forward linkages pertaining to high level downstream mineral beneficiation.

## 2.6 Summary

In an attempt to comprehensively answer the question posed by this research regarding the constraints to establishing high levels of beneficiation as an economic activity in South Africa, an understanding of mineral beneficiation and the role played by the mining sector in the country's economy was required. To achieve this, this chapter provided a review of mineral beneficiation in South Africa, including the economic value added by the precious minerals in the three mining sectors (PGM's, gold and diamond sectors), the beneficiation strategies and challenges faced by these sectors, and potential for further value addition.

Further, the chapter touched on South Africa's manufacturing industry and its competitiveness borrowing from a report by the World Economic Forum (2013) which indicated that among the challenges affecting national competitiveness were inadequately educated work force, restrictive labour regulation, government bureaucracy, corruption, poor work ethic, inadequate supply of infrastructure, and policy instability. These are considered in this study as relevant to manufacturing as well and by implication to its competitiveness.

This chapter also provided an overview of the South African mining industry and the challenges and opportunities faced by the industry. It was shown that the industry's direct contribution to the GDP was more than 8% and through its linkages the contribution to GDP and jobs creation was even more substantial. Among the key challenges to the industry were labour unrest, socio-economic impact, volatile commodity prices, foreign

exchange fluctuations, energy costs, the health and safety of employees, and infrastructure.

A search for previous research on mineral beneficiation in South Africa similar to this study, found a dearth of information with only two academic articles. One focused broadly on the questions of mineral policy (Mtegha, 2005) and its contribution in the broader objectives of national economic and social development, and the other developed a linkage model for South Africa's mineral sector (Leeuw, 2012) in which resource based research could drive the creation of employment in South Africa by developing the output of research on minerals into business opportunities including via beneficiation. His research found that the linkage model is one of the instruments to be used for employment creation in industries that support or are linked to the mining industry.

Although touching on mineral beneficiation, none of the previous research found focused on forward linkages to identify key factors and challenges constraining high levels of beneficiation in South Africa. This study focused specifically on the forward linkages with the aim of filling the gap by identifying the key factors for downstream beneficiation and determining the constraints to establishing high levels of beneficiation as an economic activity in South Africa.

In the following chapters ahead, information obtained in this chapter is used and contrasted with primary data collected from the field. The next chapter defines the methodology used to conduct this research.

# CHAPTER 3: RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter outlines the methodology that was used to conduct this research. Because information on beneficiation from practitioners' perspectives is not readily available and by extension related constructs derived from these perspectives are also not available, it was decided to collect both quantitative and qualitative data to broaden the view point collected and obtain explanations for these as to deepen understanding of the key issues. In addition, it was decided to analyse the data collected, among other methods selected, using factor analysis by way of construct identification technique provided by ANOVA, so as to obtain the key factors considered by practitioners regarding beneficiation. Hair et al. (2006) explains that ANOVA used in this way, automatically separates the data or components into three to five key axes which are distinguishable as most of the data, if not all will align to these axes of the ANOVA matrix hence becoming factors from which constructs are determined.

Further, to maximise the opportunity of gathering information from a limited sample, Creswell's (2014) recommendation of mixed method approach was preferred which allows the use of a single questionnaire to capture both closed and open-ended questions, to enable quantitative and qualitative data capture. Therefore, the research was conducted through the mixed methods approach.

A mixed methods research design is a procedure for collecting, analysing, and interpreting data comprising of both quantitative and qualitative research method. Researchers may capture both in a single questionnaire to understand a research problem (Creswell, 2012). When used in combination, of both quantitative and qualitative methods in the same questionnaire, they complement each other and allow for more complete analysis (Ivankova, et al., 2006). This also provides within – method type of triangulation (Denzin, 1978) although not data triangulation.

The type of mixed method design employed in this study is the convergent parallel design. According to Creswell (2014, 219), in a convergent parallel mixed method design a researcher collects both quantitative and qualitative data in a single questionnaire and

analyses them separately, and then compares the results to see if the findings confirm or disconfirm each other. Figure 12 illustrates the convergent parallel mixed method design.

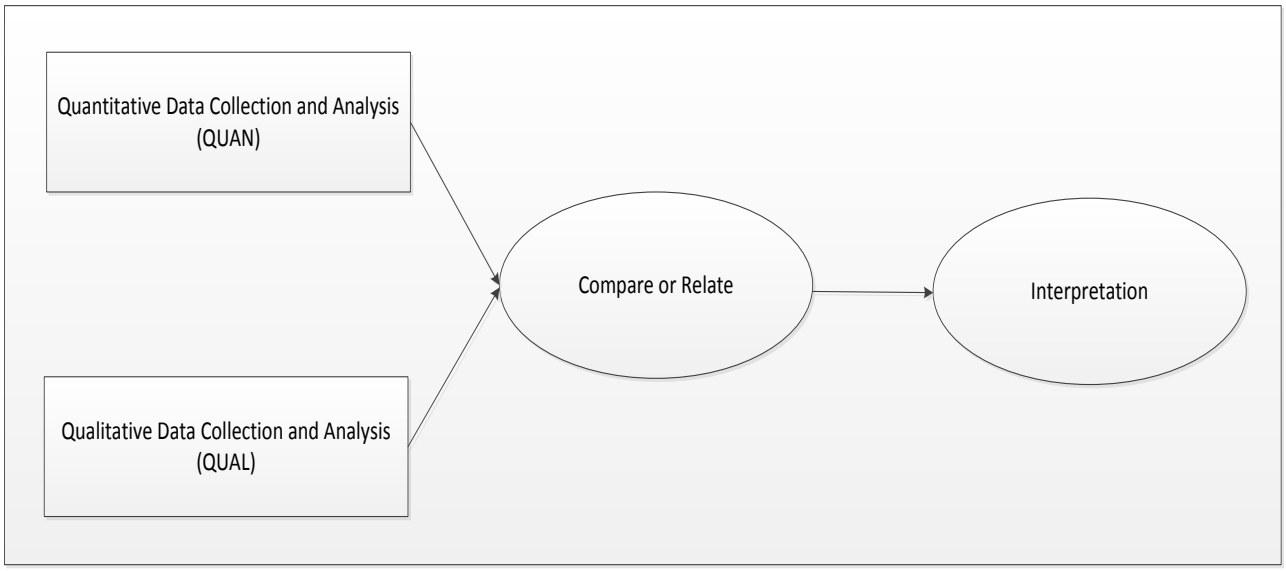



**Figure 12:** Convergent Parallel Mixed Method Design (Cresswell, 2014, p. 220)

## 3.2 Data Collection and Research Instruments

Primary data were collected concurrently, whereby the quantitative and qualitative data are collected at the same time in one questionnaire. According to Creswell (2012) when data are collected concurrently, the two forms (quantitative and qualitative) of data are independent of each other.

A questionnaire was developed for the selected population (Appendix A); the letter requesting participation together with the objectives of the study were emailed or hand delivered together with the questionnaire to prospective respondents; and the research ethics procedure as defined in the Wits University's Senate Standing Orders on Higher degrees was followed.

Secondary data was reviewed by considering available documentation. According to Churchill (1999, p. 215) secondary data must not be bypassed, the researcher must begin with secondary data, and only when data is exhausted and shows diminishing returns that the researcher can proceed to primary data.

Policy documents, key legislation, reports, and other industry and sector information available in the public domain were reviewed to access the secondary information sought. The secondary information provided valuable insight on the South African mining industry and government's key priorities and strategies regarding downstream mineral beneficiation.

### 3.2.1 Questionnaire

Questionnaires were used to collect primary data. On each questionnaire both closed-ended (structured) and open-ended (unstructured) questions were included to collect information from industry experts and stakeholders in the mining industry. Closed-ended questions provide the researcher with quantitative or numerical data and open-ended questions provide qualitative or text information (Zohrabi, 2013, p. 254). Seliger and Shohamy (1998) are of the view that closed-ended questions are more efficient because of their ease of analysis. While on the other hand, Gillham (2000) argues that open-ended questions can lead to a greater level of discovery. Using both therefore complements each other.

Twenty eight closed - ended questions and eleven open - ended questions were asked. The aim of the close-ended questionnaire was to give the researcher responses that could be quantified easily as well as developing profiles of the factors impacting or influencing beneficiation in the South Africa. The aim of the open-ended questionnaire was to give respondents an opportunity to share their insight related to beneficiation with the view of substantiating their view based on the closed-ended questions.

The purpose of each question is given in table B1 which is in Appendix B.

## 3.3 Population and Sample Size

### 3.3.1 Population

According to Blumberg et al. (2008) a population is the total collection of elements about which we wish to make some inferences. For the purpose of this study the population was defined as individuals who are considered stakeholder experts in the mining and manufacturing sectors of South Africa. In the context of this study experts are defined as

individuals with extensive knowledge or ability based on experience or occupation in the area of beneficiation. These experts are believed, by virtue of credentials, training, education or experience, to have special knowledge of beneficiation beyond that of average person, to the extent sufficient for this research to rely upon their opinions. These experts were selected from different sectors which are: mining, manufacturing, consulting, academic, and non-governmental organisations. Mining refers to individuals who are involved in the upstream operation (primary and secondary stages) of mineral exploration; manufacturing industry covers individuals who are involved in the tertiary and final stages of the mineral beneficiation process as indicated in table 4 of chapter 2. Individuals from consulting were selected from consulting firms which consult mainly with the mining and manufacturing industries. The study also benefited from experts in the faculties of academic institutions that offer mining engineering qualifications, and non-governmental institutions aligned to mining and manufacturing.

### 3.3.2 Sampling and Size

To address the research question and objectives, the researcher decided on people that can best provide information and determined the number of individuals that were needed to provide information as advised by Creswell (2012).

The researcher purposefully selected individuals who can provide the necessary information. Purposeful sampling means that the researcher intentionally selected participants who have experience and knowledge of the mining and manufacturing industries and are knowledgeable on mineral beneficiation. This was done in line with the central idea of purposeful sampling that participants are chosen from different backgrounds so that their views reflect this difference and, therefore, provide a good qualitative study (Creswell, 2012).

The researcher used telephone, electronic mail and social media platforms to request participation from selected population.

## 3.4 Pre-Testing of the Questionnaire

The purpose of pre-testing a questionnaire is considered a good practice in ensuring the development of a good quality questionnaire (Boyce, 2002, p. 534). Through pre-testing

the researcher can determine whether: the instructions of the questionnaire are clear and easy to follow; every statement is fully understood by respondents; the statement sequence in logical; and the language and wording are understandable and non-contradictive.

The questionnaire was tested on six respondents, two from academia and one each from mining industry, manufacturing industry, consulting and a political organisation.

Based on face validity, careful consideration was given to the language, logic and sensitivity of the statements. After adjustments were made, no further changes were deemed necessary.

## 3.5 Method of Analysis

Quantitative data were subjected to statistical analyses. The data collected were first tested for reliability using Cronbach's Alpha Coefficient as is good practice (Dunn, et al., 2013) before being further processed.

Qualitative data were subjected to content analysis. Content analysis is the process of identifying, coding, and categorising the primary patterns of data (Creswell, 2012). This means analysing the content of the responses. Content analysis involves reading research transcripts through a number of times, identifying key points and identifying the themes emanating from participant's responses (Mathu, 2010, p. 198). The themes are then grouped into more manageable groups of sub-themes, and finally, a summary table of the main themes emanating from the participant's responses is drawn up (Thorpe & Holt, 2008, p. 116). Qualitative data was subjected to a procedure called data transformation, where the qualitative sub-themes were changed into quantitative variables. The researcher then took the qualitative sub-themes, grouped and counted them to form quantitative measures and themes (Cresswell, 2014).

## 3.6 Validity and Reliability

According to Patton (2002) validity and reliability are the two factors which any researcher should be concerned with while designing a study, analysing results and judging the quality of the study. There is a relationship between reliability and validity. A test can be

reliable but not valid, but a test cannot be valid without first being reliable (Salkind, 2000). Therefore, the criteria of reliability and validity was considered carefully in this research since reliability is a necessary condition for validity and only reliable and valid instruments will yield accurate results.

### 3.6.1 Validity

Zikmund (2003) refers to validity as an ability of the measuring instrument to measure what is intended to be measured. Ticehurst and Veal (Cited by Sakunasingha, 2006) refer to validity as the extent to which information collected in a research study truly reflects the phenomenon being measured.

According to Zohrabi (2013, p.258) in order to strengthen the validity of evaluation data and findings, the researcher should try to collect data through several sources. This research used both qualitative and quantitative techniques to collect data. Gathering data through one may not be as credible as with several sources (Zohrabi, 2013, p. 258).

For quantitative data, factor analyses were done as a data reduction method to define the underlying constructs of the mineral beneficiation program. The validity of a test concerns what the test measures and how well it does so (Anastasi & Urbina, 1997, p. 113).

Factor analysis was used to examine the correlation among a number of variables and identify clusters of highly interrelated variables and identify clusters of highly interrelated variables that reflect underlying themes, or factors within a theme (Leedy & Ormrod, 2011, p. 278). According to Garret-Mayer (2006) factor analysis is a data reduction tool used to remove redundancy and duplication from a set of correlated variables. Appendix D provides the detailed results of factor analyses including the wording and rotation done.

Factor analysis was also used to separate the results from stakeholders with the aim of comparing responses different industries.

Kaiser measure of sample adequacy (MSA) was used to determine whether a factor analysis may be appropriate because it gives an indication of the inter correlations among variables (Tabachnick & Fidell, 2001).

To determine whether a factor analyses may be appropriate, MSA should be computed (Tabachnick & Fidell, 2001). This index ranges from 0 to 1, reaching 1 when a variable is perfectly predicted by the other variables. The measure can be interpreted with the following guidelines (Hair, et al., 1998):

- ✓ ≥ 0.80 : meritorious
- ✓ 0.70 : middling
- ✓ 0.60 : mediocre
- ✓ 0.50 : miserable
- ✓ < 0.50 : unacceptable.

### 3.6.2 Reliability

Reliability is a measure where similar results are obtained over time and across situations (Zikmund, 2003). Punch (2003) states that reliability tests the consistency and stability of a measurement instrument and its dependability.

Merriam (1998, p.206) believes that the purpose is not to attain the same results but rather to agree that based on the data collection processes the findings and results are consistent and dependable. In order to calculate the internal consistency between the items of the measuring instruments and therefore, the reliability of the construct (factors) retained in the exploratory factor analyses, it is necessary to calculate the Cronbach's Alpha Coefficient (Reynaldo & Santos, 1999, p. 3). According to SAS Institute (2011) the Cronbach's Alpha coefficient is based on the average correlation of variables within the test. The greater the Cronbach's Alpha coefficient, the more reliable the scale is.

According to Nunnally and Bernstein (1994, p.295) the overall score for each participant can be obtained by summing interrelated items. The reliability of this type of scale can be estimated through Cronbach's Alpha coefficient by determining the internal consistency of the test or through the average correlation of items within the test.

Field (2005, p. 675) explains that for cognitive tests such as intelligence tests, a Cronbach Alpha coefficient of 0.80 is generally appropriate and for ability tests, the cut-off point of 0.70 is more suitable. This is corroborated by Nunnally and Bernstein (1994, p. 265) who suggest the Cronbach's Alpha value above the customary cut-off of 0.70 for internal

consistency. Field (2005, p. 675) however, indicates that a Cronbach Alpha value as low as 0.60 can be acceptable when attitudes are measured.

For the purpose of this study, and given that the nature of the study is perception oriented, it was decided that a Cronbach Alpha value of 0.60 would be acceptable.

The open – ended questions were analysed using thematic content analysis which meant listing all the individual responses and then obtaining relevant themes. Thematic content analysis emphasizes pinpointing, examining, and recording patterns (or themes) within data (Greg & McQueen, 2012).

Thematic analysis is performed through a process of coding in six phases to create established and meaningful patterns. These patterns are: familiarisation with data; generating initial codes; searching for themes among codes; reviewing themes; defining and naming themes; and producing the final report (Braun & Clarke, 2006).

## 3.7 Ethical Considerations

Ethical considerations are important in academic and business research, as in any field of human activity (Sakunasingha, 2006).

Ethical considerations were addressed by adhering to University of the Witwatersrand research ethics guidelines for approval according to the Senate Orders of Higher degrees.

## 4.1 Introduction

This chapter presents the results and analysis of the primary data collected.

## 4.2 Section A: Demographic Information of Respondents

Section A of the questionnaire focused on the demographic information of the respondents and it was divided into 3 parts:

- Part A – the industry represented by respondents.
- Part B – the number of years of working experience within the represented industry.
- Part C – the highest education level of respondents.

### 4.2.1 The industry represented by respondents

The questionnaire determines the industry represented by the respondents. The aim of this part was to compare the representation of the views of respondents from different industries linked to mineral beneficiation. Table 8 presents the distribution of the industries represented by respondents.

Table 8: Industries represented by respondents

| Sequence | Industry | Frequency | Percentage |
|---|---|---|---|
| 1 | Mining | 13 | 27.1% |
| 2 | Manufacturing | 11 | 22.9% |
| 3 | Consulting | 10 | 20.8% |
| 4 | Academic | 6 | 12.5% |
| 5 | Non-governmental organisation | 8 | 16.7% |
| **Total** | | **48** | **100%** |

Of the 48 participants who completed the questionnaire, 27% were from the mining industry, 23% from the manufacturing industry; 21% represented the consulting industry; while 12.5% were academics; and 17% were representatives of the non-governmental organisations. The representation of views is reasonably distributed with a greater emphasis on views from practitioners in the field.

### 4.2.2 Number of years working experience

The intention of this question was to determine whether the numbers of years' of experience of the respondent are sufficient for them to give a credible opinion on the key factors affecting mineral beneficiation in South Africa. Graphical presentation of the distribution of the respondents' number of years' experience is presented in Figure 13.

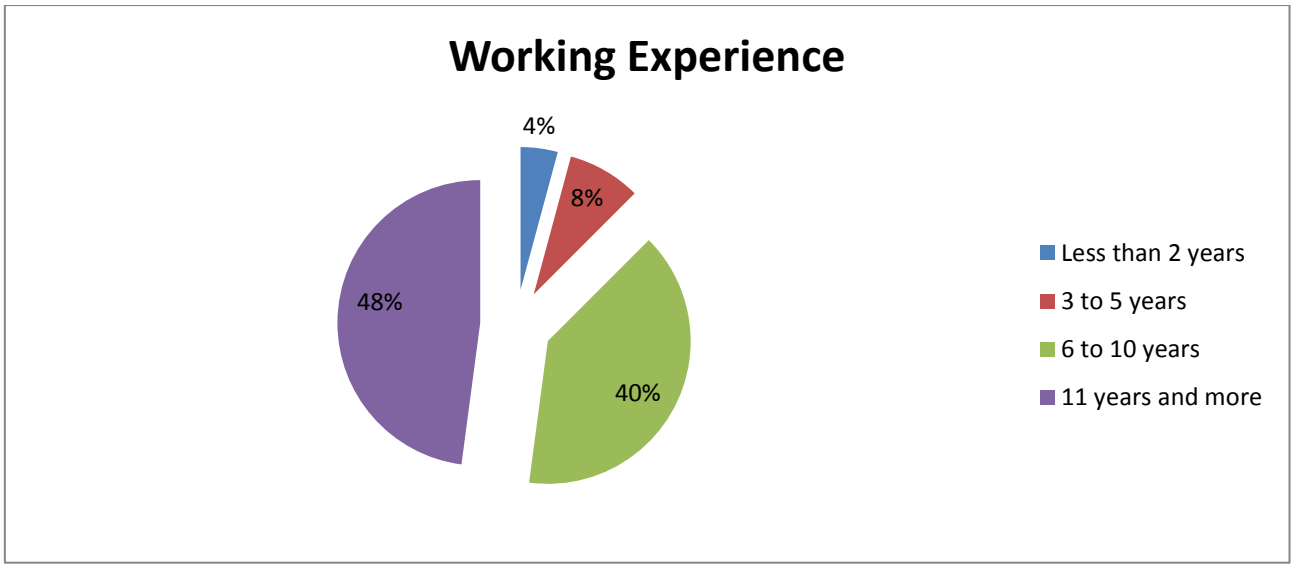



**Figure 13:** Respondent's number of years working experience

Figure 13 indicates that 48% of the respondents had more than 11 years working experience in the industry they represented, 40% had between 6 and 10 years, while 8% had between 3 and 5 years work experience, and only 4% had less than 2 years working experience. From the data, it is apparent that the respondents are generally adequately experienced to provide credible opinion on the key factors affecting beneficiation.

### 4.2.3 Education level of respondents

The aim of this question was to determine the level of education of respondents as a higher level of education than matric level is expected to provide a deeper insight of the issues and knowledge of the key factors affecting mineral beneficiation in South Africa. Table 9 presents the educational level of the respondents and indicates that about 69% of the respondents have a postgraduate qualification and 31% an undergraduate qualification. From the data, all the respondents are considered to be sufficiently educated to have an in-depth insight and appreciation of the issues.

Table 9: Highest education level of respondents

| Sequence | Highest Education Level | Frequency | Percentage |
|---|---|---|---|
| 1 | Matric | 0 | 0 |
| 2 | FET Certificate or Trade Test | 0 | 0 |
| 3 | Undergraduate | 15 | 31% |
| 4 | Postgraduate | 33 | 69% |
| **Total** | | **48** | **100%** |

## 4.3 Section B: Statistical Analyses for Close-Ended Questions

### 4.3.1 Frequency Analysis for Close-Ended Questions

Lind et al. (2008, p.06) say that descriptive analysis is the method of organising, summarising, and presenting data in an informative way. In this section all the close-ended questions were subjected to statistical descriptions of frequency tables, mean, skewness and range.

Frequency distribution is a grouping of data into mutually exclusive classes showing the number of observations in each class (Lind, et al., 2008, p. 22). A frequency distribution has been conducted for each question as discussed below.

Skewness is asymmetry in a statistical distribution, in which the curve appears distorted or skewed either to the left or to the right. Skewness can be quantified to define the extent to which a distribution differs from a normal distribution. In a normal distribution, the graph appears as a classical, symmetrical "bell-shaped curve." In a perfect normal distribution the tails on either side of the curve are exact mirror images of each other; when a distribution is skewed to the left, the tail on the curve's left-hand side is longer than the tail on the right-hand side, and the mean is less than the mode. This situation is also called negative skewness; and when a distribution is skewed to the right, the tail on the curve's right-hand side is longer than the tail on the left-hand side, and the mean is greater than the mode. This situation is also called positive skewness.

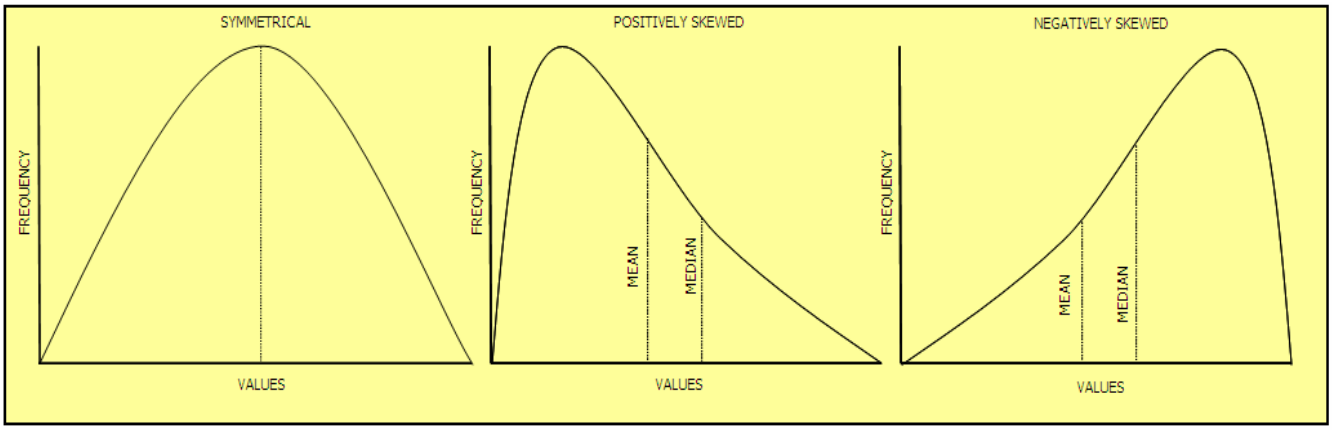



**Figure 14:** Diagrams of various skewness types (Lind, et al., 2008)

The mean indicates the average of all the numbers. For the purpose of this study, mean values of less than 2 indicate that respondents agree and mean values more than 3 indicate than respondents disagree.

The range is the difference between the highest and the lowest values within a set of data numbers. A range of 3 indicates that respondents were either positive or negative, and a range of 4 indicates that some respondents were neutral and did not have an opinion on the question asked.

Detailed statistical analyses which include descriptive statistics and frequency tables for the close-ended questions are given in Appendix C and Appendix D respectively. A summary of the results of the responses is presented in table 10 below.

Table 10: Summary of Results of responses from close-ended questions

| Item | Question | Mean | Skewness | Range | % Agreed and Strongly Agreed | % disagreed and strongly disagreed |
|---|---|---|---|---|---|---|
| B1 | Mining will continue for a long time to play a vital role in the economy of South Africa | 1.625 | 1.587 | 3 | 89.6% | 10.4% |
| B2 | The future of SAs economy will continue to be closely linked to the mining industry for a long time | 1.958 | 1.233 | 4 | 83.3% | 16.6 |
| B3 | Export of raw minerals versus beneficiated products results in SA losing significant potential revenue from such minerals | 1.75 | 1.709 | 4 | 85.4% | 8.2% |
| B4 | Beneficiation is the vehicle through which SA's resource-based comparative advantage can be transformed to a national competitive advantage | 1.813 | 1.238 | 3 | 84.4% | 16.6% |

| Item | Question | Mean | Skewness | Range | % Agreed and Strongly Agreed | % disagreed and strongly disagreed |
|---|---|---|---|---|---|---|
| B5 | Mineral beneficiation program should be the country's major priority in mineral policy | 1.833 | 1.107 | 3 | 79.2% | 20.8% |
| B6 | Beneficiation will increase employment by a significant amount | 2 | 0.728 | 3 | 72.9% | 27.1% |
| B7 | Beneficiation will strengthen the local manufacturing industry | 1.854 | 0.891 | 3 | 81.3% | 18.7% |
| B8 | Mineral beneficiation will lead to much higher economic growth than currently experienced | 1.958 | 0.945 | 3 | 85.4% | 8.2% |
| B9 | Beneficiation will add significant value to the export market | 1.938 | 0.959 | 3 | 83.3% | 16.6% |
| B10 | Beneficiation programmes are driven by the country's competitiveness | 2.104 | 0.797 | 4 | 70.8% | 8.4% |
| B11 | Beneficiation programmes are driven by the country's availability of raw minerals | 2.958 | 0.128 | 4 | 50% | 43.8% |
| B12 | Linkages between the mining and manufacturing sector are important for local beneficiation | 1.917 | 1.129 | 3 | 85.4% | 14.6% |
| B13 | Beneficiation activities should be undertaken by mining companies | 3.313 | -0.193 | 4 | 35.4% | 50% |
| B14 | Beneficiation activities should be undertaken by the manufacturing industry | 2.021 | 0.769 | 3 | 72.9% | 27.1% |
| B15 | Beneficiation requires manufacturing competitiveness | 1.833 | 1.058 | 3 | 83.3% | 16.7% |
| B16 | Mining companies have the skills and capacity to acquire and operate beneficiation plants | 3.5 | -0.458 | 4 | 22.9% | 60.4% |
| B17 | It is economically viable for mining companies to develop competencies for beneficiation | 2.854 | 0.048 | 4 | 52.1% | 45.8% |
| B18 | SA's manufacturing industry is competitive | 3.083 | -0.172 | 4 | 37.5% | 45.9% |
| B19 | Beneficiation will lead to the regulation of commodity prices | 3.104 | 0.136 | 4 | 33.3% | 35.5% |
| B20 | Mining companies support local beneficiation | 3.292 | -0.03 | 4 | 31% | 48% |
| B21 | South Africa has the necessary technical skills for beneficiation | 3.167 | 0.102 | 4 | 42% | 46% |
| B22 | Beneficiation programme will attract foreign investment | 2.229 | 1.004 | 4 | 77.1% | 16.7% |
| B23 | South Africa has access to international markets for beneficiated products | 2.25 | 0.884 | 4 | 75% | 18% |
| B24 | There are research and development incentives to encourage downstream value addition and investment | 3.229 | -0.386 | 4 | 31.5% | 52.1% |
| B25 | It is cheaper to do business in South Africa compared to other developed and developing countries | 3.766 | -0.765 | 4 | 14.9% | 70.2% |
| B26 | South Africa's labour laws are friendly towards business | 3.872 | -0.979 | 4 | 12.8% | 72.3% |
| B27 | South Africa's labour laws will support the beneficiation programme | 3.255 | -0.336 | 4 | 27.7% | 48.9% |

| Item | Question | Mean | Skewness | Range | % Agreed and Strongly Agreed | % disagreed and strongly disagreed |
|---|---|---|---|---|---|---|
| B28 | South Africa has adequate research and development institutions to support beneficiation | 2.83 | 0.186 | 4 | 53.2% | 40.4% |

An explanation of the results in table 10 for close-ended questions is presented below:

- ✓ *Question B1: Mining will continue for a long time to play a vital role in the economy of South Africa.*

The purpose of this question was to determine if mining industry, through its linkages, will continue contributing to the economy of South Africa for a long time. The descriptive analyses show a mean value of 1.625, the skewness of 1.587 and the range of 3. The skewness is positively skewed as the respondents chose the lower values as indicated by the mean, this means the majority of the respondents are positive about the mining industry continuing for a long time to play a vital role in the economy of South Africa.

This fact is important because the success of local beneficiation will depend on the sustainability of the local mining industry. It is the view of the author that the contribution of the mining sector will be determined by its ability to create sustainable job opportunities in other sectors of the economy through its connectedness, particularly the industrial or manufacturing sector.

- ✓ *Question B2: The future of SAs economy will continue to be closely linked to the mining industry for a long time.*

Literature survey in chapter 2 found that the mining industry's direct contribution to the South Africa's GDP was 8.3% and through its linkages it was 19.1%. The purpose of this question was to determine if this trend will continue. The descriptive statistics indicate that data is positively skewed with a skewness of 1.233 and that respondents chose lower values as indicated by the mean of 1.958. The results show that the majority of respondents optimistic that the future of South Africa's economy will continue for a long time to be closely linked to the mining industry.

From this it can be assumed that local beneficiation will benefit from the contribution of the mining industry. This is premised on the mining industry being a strong primary industry capable of generating growth in other industries along the mineral beneficiation value chain.

- ✓ *Question B3: Export of raw minerals versus beneficiated products results in SA losing significant potential revenue from such minerals.*

This question yielded a mean of 1.75, the skewness of 1.709 and the range of 4. This means that the data is positively skewed and respondents chose lower values. The results showed that the majority of respondents agreed that South Africa loses significant potential revenue by exporting raw minerals instead of beneficiated products. This indicates that most respondents agree that downstream beneficiation of minerals will result in South Africa earning more revenue from exports of beneficiated products.

- ✓ *Question B4: Beneficiation is the vehicle through which SA's resource-based comparative advantage can be transformed into a national competitive advantage.*

This question yielded a mean of 1.813, skewness of 1.283 and the range of 3. Data was positively skewed meaning respondents chose lower values, and that the majority of respondents (84.4%) as can be seen in table 10, agreed that beneficiation is the vehicle through which South Africa's comparative advantage can be transformed into a national competitive advantage.

Comparative advantage refers to the mineral wealth the country possesses and competitive advantage refers to the country's ability to generate wealth from its mineral endowment. The fact that most respondents agreed with this question, means that there is a need to locally refine minerals before they are exported.

- ✓ *Question B5: Mineral beneficiation program should be the country's major priority in mineral policy.*

Descriptive statistics indicate a mean of 1.833, skewness of 1.107 and a range of 3. The positive skewness indicates that respondents chose lower values. The majority of respondents agreed that mineral beneficiation should be the country's major priority in

mineral policy. This indicates that there is an urgent need for the country to develop policies that will support beneficiation.

- ✓ *Question B6: Beneficiation will increase employment by a significant amount.*

This question tested whether beneficiation will have a positive impact on employment both at the upstream and downstream levels. Table 10 indicates that this question yielded a mean of 2.00, skewness of 0.728 and a range of 3. The skewness is moderately positively skewed and indicates that respondents chose moderately lower values as indicated by the mean of 2.00. Looking at the frequency table on appendix C, 72.9% of the respondents agreed that beneficiation will increase employment by a significant amount and 27.1% were pessimistic.

One of the reasons that majority of respondents indicated that beneficiation will increase employment in the downstream industries can be attributed to the fact that the final stage of beneficiation has a high labour intensity. The view by 27.1% of the respondents that beneficiation will not increase employment by a significant amount is a concern.

- ✓ *Question B7: Beneficiation will strengthen the local manufacturing industry.*

This question yielded a mean of 1.854, skewness of 0.891 and a range of 3. Data was positively skewed as the respondents chose lower values as indicated by the mean.

Table 10 shows that majority of respondents agreed that beneficiation will strengthen the local manufacturing industry. As suggested in chapter 2 that downstream beneficiation is likely to happen at the manufacturing industry as it requires the competence of manufacturing, and that more value to minerals will be added at this stage, it is safe to assume that manufacturing industry will be strengthened and more employment will be created.

- ✓ *Question B8: Mineral beneficiation will lead to much higher economic growth than currently experienced.*

The purpose of this question was to determine the impact of beneficiation on the country's economic performance. The majority of respondents agree that mineral beneficiation will

lead to much higher economic growth than the current economic growth. From this it can be assumed that economic growth will result from the increased revenue realised from the value added minerals.

- ✓ *Question B9: Beneficiation will add significant value to the export market.*

Literature indicated that exports of raw minerals versus beneficiated products resulted in South Africa losing up to 89% of potential revenue. The purpose of this question was to confirm if beneficiation will add significant value and increase the export revenue.

Table 10 indicates that majority of respondents agree that beneficiation will add significant value to the export market. This affirms that increased local beneficiation will add significant value to the export market. In chapter 2 it was indicated that only 11% of the country's minerals were beneficiated in 2008 and created added value worth R86 billion.

- ✓ *Question B10: Beneficiation programs are driven by the country's competitiveness.*

Descriptive statistics indicate a mean of 2.104, a skewness of 0.797 and a range of 4. The skewness is moderately positively skewed and indicates that respondents chose moderately lower values. The frequency analysis in appendix c indicates that 70.8% of respondents agree that beneficiation programs are driven by the country's competitiveness, 20.8% of the respondents were neutral and 8.4% disagreed.

- ✓ *Question B11: Beneficiation programs are driven by the country's availability of raw minerals.*

This question yielded a mean of 2.958, skewness of 0.128 and a range of 4. The skewness is symmetrical (very close to zero) meaning respondents chose values that are evenly spread. Table 10 indicates that only 50% of the respondents agreed, and 43.8% disagreed that beneficiation programs are driven by the country's comparative advantage.

Literature indicated little evidence in support of the view that possession and production of raw minerals automatically gives a country a competitive advantage in beneficiation activities. Through questions B10 and B11 it was confirmed that the country needs competitive advantage which refers to capacity and ability to carry out a beneficiation

programme as opposed to just availability of raw minerals.

- ✓ *Question B12: Linkages between the mining and manufacturing sector are important for local beneficiation.*

Chapter 2 indicated that the four stages on mineral beneficiation require the competence on the two industries. With the mining industry involved in the first two upstream stages and the manufacturing industry more concerned with the last two downstream stages.

This question yielded a mean of 1.917, skewness of 1.129 and a range of 3. The positive skewness indicates that respondents chose lower values. Table 10 shows that majority of respondents agreed that linkages between the mining and the manufacturing sector are important for local beneficiation. This confirms that there should be synergies between the two industries in order for the local beneficiation programme to be successful.

- ✓ *Question B13: Beneficiation activities should be undertaken by mining companies.*

The purpose of questions 13 and 14 was to determine from respondents if beneficiation should be undertaken by mining companies or manufacturing companies.

This question yielded a mean of 3.313, skewness of -0.193 and a range of 4. A moderately negative skewness indicates that respondents chose moderately upper values. The results indicate that 50% of the respondents did not agree that beneficiation activities should be undertaken by mining companies, 14.6% of the respondents were neutral and 35.4% agreed.

- ✓ *Question B14: Beneficiation should be undertaken by the manufacturing industry.*

This question yielded a mean of 2.021, a positive skewness of 0.769 and a range of 3. Most respondents (73%) indicated that beneficiation should be undertaken by the manufacturing industry.

It was indicated in chapter 2 that beneficiation is a competence of the manufacturing industry. Most respondents indicated that mining companies must focus on what they do best – upstream operations. It should, however be noted that there are some respondents who were of the view that mining companies must develop competencies for beneficiation

and this would result in mining companies being involved in the entire value chain on mining and refining. This means mining companies would have to develop facilities or plants where minerals would be further processed and refined.

- ✓ *Question B15: Beneficiation requires manufacturing competitiveness.*

This question yielded a mean of 1.833, a positive skewness of 1.058 indicating that respondents chose lower values, and a range of 3. Table 10 indicates that the majority of respondents (83.3%) agreed that manufacturing competitiveness is required for successful beneficiation.

- ✓ *Question B16: Mining companies have the skills and capacity to acquire and operate beneficiation plants.*

This question yielded a mean of 3.50, skewness of -0.458 and a range of 4. The skewness is negatively skewed and indicates that respondents chose upper values. Table 10 indicates that 60.4% of the respondents disagreed that mining companies have the skills and capacity to acquire and operate beneficiation plants. Only 22.9% said mining companies have the necessary skills and capacity to operate beneficiation plants, and 16.7% did not know.

- ✓ *Question B17: It is economically viable for mining companies to develop competencies for beneficiation.*

This question yielded a mean of 2.854, skewness of 0.058 and a range of 4. The skewness is symmetrical and indicates respondents chose evenly spread values. Table 10 indicates an almost equal split between the respondents who agree (52.1%) and those who disagree (45.8%) that it is economically viable for mining companies to develop competencies for beneficiation.

Questions 16 and 17 tested whether mining companies will be able to carry out the beneficiation programme. It is important to note that even though some respondents said mining companies possess the skills and has the capacity to beneficiate, some respondents were of the view that it is not economical for mining companies to do so.

- ✓ *Question B18: South Africa's manufacturing industry is competitive.*

This statement yielded a mean of 3.083, skewness of -0.172 and a range of 4. The skewness is negatively skewed and shows that respondents chose upper values as indicated by the mean. Only 37.5% of respondents agreed that South Africa's manufacturing industry is competitive and 45.9% of the respondents disagreed.

Literature indicated that beneficiation requires the competence of the manufacturing industry and the fact that most of the respondents said South Africa's manufacturing industry is not competitive presents a major challenge to beneficiation.

- ✓ *Question B19: Beneficiation will lead to the regulation of commodity prices.*

Regulation of commodity prices mean that mining companies will have to supply local manufacturing companies at regulated prices, and that individual companies will not be able to determine or negotiate their own prices. Regulated prices may benefit the downstream manufacturing companies at the expense of upstream mining companies and this may result in mining companies not supporting the beneficiation program.

Table 10 indicates a mean of 3.104, skewness of 0.136 and a range of 4. There is almost an even split between respondents who agree (33.3%), those who disagree (35.5%) and those who did not know (31.3%) whether beneficiation will lead to the regulation of commodity prices. Therefore, it could not be determined from respondents whether beneficiation will lead to the regulation of commodity prices or not.

- ✓ *Question B20: Mining companies support local beneficiation.*

Table 10 indicates a mean of 3.292, skewness of -0.03 and a range of 4. The skewness is symmetrical indicating that respondents chose evenly spread values. The results indicate that 48% of the respondents disagreed that mining companies support beneficiation. Only 31% of the respondents said mining companies support local beneficiation and 21% did not know.

The fact that most of the stakeholders were of the view that mining companies will not support local beneficiation presents a challenge for the sustainability of local beneficiation.

It is the researcher's view that local beneficiation of minerals will depend on the sustainable supply of raw minerals by the local mining industry and therefore, support from mining companies is important.

- ✓ *Question B21: South Africa has the necessary technical skills for beneficiation (engineers, scientists, technologists etc.)*

Descriptive statistics indicate a mean of 3.167, skewness of 0.102 and a range of 4. Table 10 indicates an almost equal split between respondents who agree (42%) and those who disagree (46%) that South Africa has the necessary technical skills for beneficiation. The fact that most stakeholders did not agree with this question presents a possible challenge for local beneficiation.

It is the author's view that local beneficiation needs technical expertise in the fields of engineering, science and technology, because these fields are important for innovation, product development, the establishment of new industries, and the sustainability of existing industries.

- ✓ *Question B22: Beneficiation programme will attract foreign investment.*

This question yielded a mean of 2.229, skewness of 1.004 and a range of 4. Skewness is positively skewed and respondents chose moderately lower values as indicated by the mean. Table 10 indicates that majority of respondents agree (77%) that beneficiation programme will attract foreign investment and this is important in the establishment of new industries and support of existing manufacturing companies.

- ✓ *Question B23: South Africa has access to international markets for beneficiated products.*

Descriptive statistics indicate a mean of 2.25, a positive skewness of 0.884 and a range of 4. This indicates that lower values were selected. The majority of the respondents agree that South Africa has access to international markets for beneficiated products.

- ✓ *Question B24: There are research and development incentives to encourage downstream value addition and investment.*

This question yielded a mean of 3.229, skewness of -0.386 and a range of 4. The skewness is negatively skewed indicating that respondents chose upper values. The results in table 10 indicate that the majority of respondents disagree that there are research and development incentives to encourage downstream value addition and investment, the fact that presents a possible constraint to local beneficiation programme. It is the author's view that research and development plays a major role in the establishment of new industries and the development of innovative products.

- ✓ *Question B25: It is cheaper to do business in South Africa compared to other developed and developing countries.*

This question yielded a mean of 3.766, a negative skewness (-0.765) indicating that respondents chose upper values and a range of 4. The majority of respondents (70.2%) disagree with the statement that says it is cheaper to do business in South Africa compared to other developed and developing countries.

It is the author's view that the ease of doing business in South Africa will encourage establishment of new manufacturing companies which will carry out beneficiation and the fact that most stakeholders were of the view that it is not cheaper to do business in South Africa presents a challenge to the beneficiation programme.

- ✓ *Question B26: South Africa's labour laws are friendly towards business.*

This question yielded a mean of 3.872, skewness of -0.979 and a range of 4. The skewness is negatively skewed indicating that the respondents chose upper values. The majority of respondents disagree with a statement that claims South Africa's labour laws are friendly towards business. It is the author's view that investors are most likely to invest in a country with labour laws that will support their businesses.

- ✓ *Question B27: South Africa's labour laws will support the beneficiation programme.*

Descriptive statistics indicates a mean of 3.255, a negative skewness (-0.336) which indicates that respondents chose upper values, and a range of 4. The majority of respondents disagreed that South Africa's labour laws will support the beneficiation programme.

The author is of the view that unfavourable labour laws will discourage investment and the establishment of new businesses. The fact that the majority of respondents say the country's labour laws are not conducive to business and will not support the beneficiation programme indicates a serious concern and a constraint to local mineral beneficiation.

- ✓ *Question B28: South Africa has adequate research and development institutions to support beneficiation.*

Descriptive statistics indicates a mean of 2.83, a positive skewness of 0.186 and a range of 4. The purpose of the question was to determine if the country has adequate research and development institutions which will help develop innovative products to support beneficiation.

Table 10 indicates that most of the respondents agreed that South Africa has adequate research and development institutions to support beneficiation.

### 4.3.2 Construct Identification

Factor analyses were done as a data reduction method to define the underlying constructs of the key factors affecting mineral beneficiation (see details in appendix D). Factor analysis reduces and analyses large sets of data to identify factors, and assess their influence on a set of measured variables (Field, 2005). A specialised statistical software program called SPSS was used to identify factors from the close-ended questionnaire (Green, et al., 2000; SAS Institute Inc. , 2011). The factors were based on the close-ended questions.

The researcher also used factor analyses to separate the results from respondents with the aim of formulating comparisons between different industries.

In addition, Cronbach's Alpha coefficients determined through statistical analysis of the constructs measuring the key drivers affecting downstream mineral beneficiation in South Africa. The results are presented in table 11 below:

Table 11: Results of Factor Analyses and Cronbach's Alpha Coefficient

| Factor | Construct | Item (s) | Cronbach's Alpha Values | MSA |
|---|---|---|---|---|
| K1 | Mining industry will continue to play an important role in the economy of South Africa | B-1; B-2 | 0.812 | 0.76 |
| K2 | Mining industry supports the beneficiation programme | B-12; B-13; B-16; B-17; B-20 | 0.609 | |
| K3 | Mineral beneficiation will create employment and significantly contribute to the economy of South Africa | B-3; B-4; B-5; B-6; B-7; B-8; B-9; B-22; B-18 | 0.817 | |
| K4 | South Africa has the necessary capacity to carry out a sustainable beneficiation programme | B-16; B-17; B-18; B-20; B-21; B-23; B-24; B-25. | 0.732 | |
| K5 | South Africa's Manufacturing industry is competitive and ready for beneficiation | B-18; B-14; B-28 | 0.760 | |
| K6 | South Africa's legislation supports beneficiation | B-26; B-27; B-19 | 0.654 | |
| K7 | Requirements for successful sustainable beneficiation programme | B-10; B-11; B-12; B-13; B-14; B-15 | 0.169 | |

It is interesting to note that most constructs yielded Cronbach Alpha coefficients above 0.6. Because the study was measuring both perception and attitude towards mineral beneficiation Cronbach values above 0.6 were considered acceptable. Factor B7 yielded a Cronbach value of 0.169 and was discarded.

Table 12 is presented to summarise and outline the mean, standard deviation values from the factors. The table presents statistical differences for the independent variable – the industry represented by respondents.

Table 12: The effect of industry represented by respondents on the measured factors

| Factor | Construct | Industry | Mean | Std. Dev. | N | Minimum | Maximum | Skewness |
|---|---|---|---|---|---|---|---|---|
| K1 | Mining industry will continue to play an important role in the economy of South Africa | 1-Mining | 1.58 | 0.73 | 13 | 1.00 | 3.50 | 1.763 |
| | | 2-Manufacturing | 1.77 | 0.87 | 11 | 1.00 | 4.00 | 1.678 |
| | | 3-Consulting | 2.05 | 1.25 | 10 | 1.00 | 4.50 | 0.803 |
| | | 4-Academic | 1.67 | 0.25 | 6 | 1.50 | 2.00 | 0.968 |
| | | 5-NGO | 1.94 | 1.01 | 8 | 1.00 | 4.00 | 1.179 |
| K2 | Mining industry supports the beneficiation programme | 1-Mining | 2.71 | 0.57 | 13 | 2.00 | 3.80 | 0.848 |
| | | 2-Manufacturing | 2.71 | 0.77 | 11 | 1.20 | 3.40 | -1.087 |
| | | 3-Consulting | 3.16 | 0.84 | 10 | 2.20 | 4.20 | -0.120 |
| | | 4-Academic | 3.47 | 0.64 | 6 | 2.20 | 4.00 | -2.093 |
| | | 5-NGO | 3.17 | 0.68 | 8 | 2.20 | 4.00 | -0.411 |
| K3 | Mineral beneficiation will create employment and contribute to the economy of SA | 1-Mining | 2.25 | 0.84 | 13 | 1.33 | 3.56 | 0.528 |
| | | 2-Manufacturing | 1.87 | 0.35 | 11 | 1.33 | 2.44 | 0.273 |
| | | 3-Consulting | 2.21 | 0.76 | 10 | 1.33 | 3.67 | 0.593 |
| | | 4-Academic | 1.93 | 0.19 | 6 | 1.67 | 2.22 | 0.248 |
| | | 5-NGO | 1.85 | 0.47 | 8 | 1.22 | 2.44 | 0.122 |
| K4 | SA has the necessary capacity to carry out a sustainable beneficiation programme | 1-Mining | 3.10 | 0.53 | 13 | 2.45 | 4.00 | 0.253 |
| | | 2-Manufacturing | 3.17 | 0.67 | 11 | 2.00 | 4.18 | -0.19 |
| | | 3-Consulting | 2.21 | 0.76 | 10 | 1.82 | 3.91 | -1.137 |
| | | 4-Academic | 3.22 | 0.50 | 6 | 2.82 | 4.18 | 1.78 |
| | | 5-NGO | 3.33 | 0.53 | 8 | 2.34 | 4.18 | 0.233 |
| K5 | South Africa's Manufacturing industry is competitive and ready for beneficiation | 1-Mining | 2.97 | 0.46 | 13 | 2.33 | 4.00 | 0.608 |
| | | 2-Manufacturing | 2.67 | 0.45 | 11 | 2.00 | 3.33 | -0.304 |
| | | 3-Consulting | 2.37 | 0.85 | 10 | 1.33 | 4.33 | 1.355 |
| | | 4-Academic | 2.17 | 0.59 | 6 | 1.33 | 2.67 | -0.495 |
| | | 5-NGO | 2.79 | 0.53 | 8 | 1.67 | 3.33 | -1.659 |
| K6 | South Africa's legislation supports beneficiation | 1-Mining | 3.07 | 0.87 | 13 | 1.67 | 4.33 | -0.067 |
| | | 2-Manufacturing | 3.42 | 0.80 | 11 | 2.00 | 4.33 | -0.913 |
| | | 3-Consulting | 3.63 | 0.73 | 10 | 2.00 | 4.67 | -1.043 |
| | | 4-Academic | 3.89 | 0.34 | 6 | 3.33 | 4.33 | -0.666 |
| | | 5-NGO | 3.17 | 0.59 | 8 | 2.00 | 3.67 | -1.231 |
| K7 | Requirements for successful sustainable beneficiation programme | 1-Mining | 2.52 | 0.61 | 13 | 1.50 | 3.50 | -0.170 |
| | | 2-Manufacturing | 2.12 | 0.57 | 11 | 1.00 | 2.83 | -0.826 |
| | | 3-Consulting | 2.30 | 0.39 | 10 | 1.83 | 3.17 | 1.007 |
| | | 4-Academic | 2.56 | 0.42 | 6 | 2.00 | 3.00 | -0.221 |
| | | 5-NGO | 2.33 | 0.31 | 8 | 2.00 | 2.83 | 0.540 |

Further analysis of the constructs is presented below.

#### 4.3.2.1 Construct 1

***Mining industry will continue to play an important role in the economy of South Africa.***

Table 12 indicates that there was an agreement between respondents that the mining industry will continue to play an important role in the economy of the country, with respondents from the mining industry agreeing more and respondents from the consulting industry agreeing less.

It is important to observe that respondents from mining agreed more and this can be attributed to the fact that they are directly involved in the mining industry and are more familiar with the business of the industry. The issue of loyalty to the industry may also not be discarded. It is also important to note that the majority of respondents from all industries agreed that the trend on mining industry contributing to the economy will continue. This is important because without mining, local beneficiation may not be sustainable.

#### 4.3.2.2 Construct 2

***Mining industry supports the beneficiation programme.***

In this construct there was a difference in opinion with some agreeing and some disagreeing with the statement that says mining industry supports beneficiation. Respondents from academic institutions disagreed more, followed by respondents in the non-governmental organisations, and consulting firms. It was interesting to note that on the other hand respondents from the mining and manufacturing industries agreed although slightly with this construct, both with the same mean value.

It is important that mining industry should support local beneficiation. The results of this construct should be a concern to policy makers as they indicate a serious constraint to local beneficiation. Without the support of the mining industry, local manufacturing companies may not be adequately supplied with the important raw minerals to carry out beneficiation.

#### 4.3.2.3 Construct 3

***Mineral beneficiation will create employment and significantly contribute to the economy of South Africa.***

In this construct, questions were asked to test if mineral beneficiation will help address South Africa's problems of unemployment and poverty, and contribute to the economy of the country. There was a general agreement with this construct and respondents from the non-governmental organisations and manufacturing industry seemed to agree more while respondents from the mining industry agreed least.

The fact that respondents from the mining industry agreed least is a concern because it may indicate that they don't think beneficiation will have a great impact on reducing unemployment and poverty. This may be attributed to the fact that most, if not all beneficiation will not happen in the mining industry and may have a negative impact on employment in the mining industry even though it will increase employment in the manufacturing industry.

#### 4.3.2.4 Construct 4

***South Africa has the necessary capacity to carry out a sustainable beneficiation programme.***

This construct tested whether South Africa has the necessary skills, technology and resources to carry out beneficiation programme sustainably and there was a general disagreement by all respondents except with respondents from the consulting industry who agreed. Respondents from the non-governmental organisations disagreed more followed by respondents from academic institutions, while respondents from manufacturing and mining disagreed least.

For local beneficiation to be successful and sustainable, it is vital that the country should possess the necessary skills, technology and resources. The fact that the majority of respondents were of the view that South Africa does not have the necessary capacity to carry out local beneficiation is a concern that needs attention from policy makers.

#### 4.3.2.5 Construct 5

***South Africa's manufacturing industry is competitive and ready for beneficiation.***

There was a general agreement that South Africa's manufacturing industry is competitive and ready to carry out beneficiation. Respondents from academic institutions agreed more with this construct and respondents from mining industry agreed least.

The fact that most respondents agreed that South Africa's manufacturing industry is competitive is important given that the competitiveness of the manufacturing industry is vital to the establishment of new sectors that will carry out local beneficiation and compete internationally.

#### 4.3.2.6 Construct 6

***South Africa's legislation supports beneficiation.***

This construct tested whether the country's labour laws and legislation at large will support beneficiation programme and it was interesting to note that all categories of respondents disagreed. Respondents from academia disagreed more followed by consulting, manufacturing, non-governmental institutions and respondents from mining disagreed least.

The fact that the majority of respondents are of the view that the country's legislation will not support beneficiation is a concern. Legislation encompasses all the laws that dictate how to form or run a business. It refers to issues such as labour laws, government laws and regulations.

#### 4.3.2.7 Construct 7

***South Africa meets the requirements for successful sustainable beneficiation programme.***

It was indicated in Table 11 that this construct yielded a Cronbach value of 0.169 and therefore was not reliable. No further consideration is given to this construct.

## 4.4 Section C: Content Analyses for Open-Ended Questions

This section comprises data presentation and analysis of the open-ended questions for the study. The data were transcribed and content analysis used to obtain themes emanating from the study. Qualitative data were collected from responses of the questions provided in section C of the questionnaire and was subjected to a procedure called data transformation, where the qualitative sub-themes were changed into quantitative variables.

### 4.4.1 Presentation and Analysis of Qualitative Data

Table 13 below indicates the sub-themes from which themes were developed for the responses from the respondents. It should be noted that some of the respondents did not answer all open-ended questions.

The respondent's views for questions C1; C2; C3; C4; C5; C6; C9 and C10 are collated and analysed based on the following key sub-themes as tabulated in Table 13:

Table 13: Sub-themes and frequencies recorded in the responses to open-ended questions

| | Manufacturing | Mining | Consulting | Academics | NGO | Overall Response | Themes |
|---|---|---|---|---|---|---|---|
| **C1** | LB = 8 | LB= 10 | LB= 8 | LB= 6 | LB= 8 | LB = 40 | Low beneficiation, Import & Export |
| | IM = 9 | IM= 13 | IM= 8 | IM= 6 | IM= 8 | IM = 45 | |
| **C2** | CE= 9 | CE= 9 | CE= 6 | CE= 4 | CE= 6 | CE= 34 | Poverty, unemployment and equality |
| | AP= 8 | AP= 9 | AP= 5 | AP= 4 | AP= 6 | AP= 32 | |
| | AI = 6 | AI = 6 | AI = 3 | AI = 3 | AI = 4 | AI = 22 | |
| **C3** | AD = 8 | AD = 7 | AD = 7 | AD = 5 | AD = 6 | AD = 33 | Economic development |
| **C4** | IP = 9 | IP = 8 | IP = 7 | IP = 4 | IP = 5 | IP = 31 | Impact on mining companies |
| | PR = 8 | PR = 6 | PR = 6 | PR = 3 | PR = 3 | PR = 26 | |
| **C5** | MB = 7 | MB = 8 | MB = 4 | MB = 2 | MB = 3 | MB = 24 | Support from mining companies |
| **C6** | SB = 7 | SB = 8 | SB = 6 | SB = 4 | SB = 5 | SB = 30 | Sustainability and viability of beneficiation |
| **C9** | BV = 5 | BV = 6 | BV = 5 | BV = 4 | BV = 2 | BV = 22 | Viability of forward linkages |
| **C10** | AM = 9 | AM = 10 | AM = 7 | AM = 4 | AM = 6 | AM = 36 | Access to international markets |

Key to table 13:

1. The numbers refer to the number of respondents who indicated the respective sub-themes
2. The sub-themes are abbreviated as follows:

- ✓ C1 → (LB = There is Low beneficiation; IM = Imports are more than exports for finished goods)
- ✓ C2 → (CE= Will create employment; AP = Will alleviate poverty and AI = Will address inequality)
- ✓ C3 → (AD = SA should adopt mineral beneficiation)
- ✓ C4 → (IP = Will improve productivity; PR = Will increase profitability)
- ✓ C5 → (MB = Mining companies support beneficiation)
- ✓ C6 → (SB = SA can sustain a beneficiation program)
- ✓ C9 → (BV = Forward linkages are viable)
- ✓ C10 → (AM = SA will have access to international markets for finished goods)

On question C1, the view of 40 respondents from all industries sampled was that there is low level of mineral beneficiation in South Africa. In addition, 45 out of 48 respondents indicated that South Africa exports more raw minerals than finished goods while importing high finished goods. To illustrate, a select few of the 45 respondents comments on Question C1 are cited below:

> "*Downstream mineral beneficiation is still low in the country despite value addition investment. We still export more than 50% raw minerals and import more finished products."*

> *"Most of South Africa's beneficiated products are consumed locally, and if other strategic minerals such as platinum and gold are locally beneficiated, this will lead to increased export revenue."*

> *"South Africa does not do enough beneficiation locally to available minerals. Most value is lost to other countries who export finished products to South Africa."*

> *"There is a revenue opportunity lost because the country exports its raw minerals cheaper and imports finished products at high prices."*

It was notable from the 45 respondents that South Africa exported raw minerals and imported finished products which led to the country missing out on the opportunity to

increase export revenue. Thus the impact of beneficiation on imports and exports emerged as themes on this question.

On question C2, 34 respondents from all industries were of the opinion that beneficiation will create employment, 32 were of the view that beneficiation will alleviate poverty and only 22 said it will address the issues of inequality. Some of the examples of the respondents comments are cited below:

*"If mineral beneficiation cannot contribute in resolving South Africa's socio-economic ills of poverty, unemployment and inequality, the same might also apply to developed countries which refine South Africa's minerals."*

*"I agree to some extent because beneficiation is a complex environment which requires the high level of skills and professionals; South Africa's poorly educated and unemployed population may not benefit from such a program."*

*"Mineral beneficiation will create jobs and assist in reducing unemployment. It will assist in reducing poverty as every investment comes along with benefits of infrastructure development that will assist downstream industries as well. However, inequality is a different ballgame altogether. There is no correlation between these two. Inequality is driven by perception and historical issues."*

The above comments of the 34 respondents concurred that the mineral beneficiation programme would create jobs and deal with issues of poverty. On the other hand many were not sure whether these jobs would deal with issues of inequality. From the 32 respondents poverty, unemployment and inequality emerge as themes for this question

Question C3 asked whether South Africa should adopt mineral beneficiation as a priority for economic development. Table 15 indicates that 33 respondents agreed. Some of the examples of the respondents comments on Question C3 are cited below:

*"Not all minerals can be economically beneficiated in the country, thus it is imperative to conduct a detailed study on the type of minerals that South Africa can add the biggest value and still be competitive with other mining countries".*

*"Mineral beneficiation should be adopted as a priority because it will lead to additional industrial and manufacturing opportunities as well as creating funds to use in local skills development if applied correctly"*

*"SA should adopt mineral beneficiation as a priority for economic development because the programme will attract foreign direct investment into the country which will result into economic growth for the country"*

*"South Africa should adopt mineral beneficiation as part of micro-economic policy taking into consideration the potential economic and contribution toward GDP. The current figures directly related to export of raw minerals stand to double with mineral beneficiation being prioritised as part of the broader macro-economic policy"*

Responses from the 33 individuals indicated that beneficiation has a potential to play an important role to the economic development of South Africa and create much needed jobs. It was also observed from the responses that not all minerals should be beneficiated and more care should be taken not to beneficiate at the expense of the mining industry. The theme emanating from this question is, therefore impact of beneficiation on economic development

On question C4, which asked about the impact of beneficiation on the mining industry, 31 respondents said beneficiation will increase productivity in the mining industry and 26 respondents said it will increase profitability of the mining companies. Some of the examples of the respondents comments on Question C4 are cited below:

*"It is not correct to split the mineral beneficiation equation between mining and manufacturing sectors. The mining sector, having acquired additional skills much needed for fabrication operations stands to remain productive and increase profits"*

*"With the current high labour costs in South Africa, mineral beneficiation will impact the production of raw materials with increased unit cost per ton, and therefore affect profitability"*

*"I believe beneficiation will improve the situation in the mining industry, mine operators and managers will understand the end user's requirements better". This will therefore improve efficiency and effectiveness in the mining industry.*

The responses to this question from the various individuals indicate conflicting views with respect to productivity and profitability. It was felt that local beneficiation of minerals will have an impact, either positive or negative, on the performance of the mining companies. For this question the mineral beneficiation impact on mining companies with regards to productivity and profitability emerged as a theme.

On Question C5, only 24 respondents said mining companies will fully support the value added beneficiation program. It is interesting to note that most respondents who said mining companies will support beneficiation are from the mining industry (8 out of 13) and the least number of respondents who said mining companies will support beneficiation were academics (2 out of 6). Some of the examples of the respondents comments on Question C5 are cited below:

*"Mining companies will only support beneficiation if it is done by them. There is no gain for them if the program is driven by other companies in the manufacturing sector".*

*"Mining bosses will take their business elsewhere as beneficiation will force them to supply the local market at cheaper prices and this will simply affect their profitability. They will simply not support it"*

*"They will support the program as long as it does not interfere with their business and it guarantees the same levels of profitability and efficiencies.*

*"Most mining companies have signed long term contracts with their international clients and I don't see them supporting local beneficiation".*

*"I don't think mining companies will support this program because it will require changes in business model (operations and the market)".*

*"Most mining companies in South Africa are owned and controlled by foreign investors, with a mandate to supply and benefit international markets".*

The comments from the 24 respondents indicate that they do not think mining companies will support the local beneficiation programme. Factors such as the ownership and profitability of the mining companies are cited as reasons for mining company's resistance to beneficiation. Therefore support from mining companies emanate as theme.

On Question C6, 30 respondents were of the view that South Africa can sustain the mineral beneficiation programme. Some examples of the respondents comments on Question C6 are cited below:

*"Yes, only if the government stays away from the industry and allows the free market system where companies can compete with one another to create the best possible products"*

*"No. the current South Africa's labour laws, labour cost and government legislation will constrain the beneficiation programme. In addition availability of resources such as energy & electricity at the affordable price is a constraint"*

*"There is plenty of labour in the market. The unionised, militant workforce however may make beneficiated product an expensive export commodity and therefore South Africa not a first choice supplier. However there is nothing stopping mining companies from owning beneficiation and manufacturing to cut out the middle man, keeping costs low and selling off finished products.*

*"South Africa can sustain the beneficiation programme through the combination of skills, raw minerals, research and development institutions (CSIR, Mintek, and Universities etc.), government support etc."*

*"The sustainability of the beneficiation program will depend on the sustained availability of mineral endowments. Through companies such as Arcellor Mittal, Sasol, Eskom etc. the country has demonstrated that it can successfully and sustainably run downstream operations"*

The responses from the 30 respondents highlighted challenges facing business in South Africa and that if the challenges can be addressed, the beneficiation programme will be sustainable. Sustainability of beneficiation emerged as a theme.

On Question C9, only 22 respondents were of the opinion that forward linkages are a viable option. Some of the examples of the respondents comments on Question C9 are cited below:

*"No, labour issues first need to be resolved and unions need to be relieved of some of their power."*

*"In truth, there are a number of factors affecting the current state of mining in the country and worker strikes are not necessarily the biggest issue at play. As the world has begun to resort to recycling platinum supplies for re-use, the demand for South Africa's platinum resources is decreasing, making SA's status as the world's largest source of primary platinum a characteristic that no longer reaps the benefits it used to"*

*"No rather be better at what you are already good at. Think of Ricardo's economic theory of competitive advantage"*

It must be noted that whilst most respondents did not answer this question, other respondents provided short answers such as "Yes and No" without elaborating. From the 22 comments received, there was the view that more still needs to be done before forward linkages become viable. Viability of forward linkages emerged as a theme.

On Question C10, 36 respondents said South Africa will have access to international markets for finished products. Some of the examples of the respondents comments on Question C10 are cited below:

*"Yes, if we give our entrepreneurs adequate support and focus on quality and effectiveness, the country will have a market share in the world"*

*"Yes we will, however we need to be competitive on costs and prices. This is a challenge for us now as we produce at a high cost, thus we are inefficient".*

*"Yes, currently SA has access to international markets for its raw minerals and I think the relationship has already been established".*

*"Yes, countries that buy finished products from developed nations will come to South Africa. Quality and competitive pricing will however be vital".*

In commenting about access to international markets for finished products the 39 respondents felt that South Africa would enjoy access to international markets for finished products. This, according to the majority of respondents will depend on economic factors such as quality products, competitive pricing, efficiency and effectiveness. The political relationship between South Africa and other countries will also play an important role. From this question the access to international markets for beneficiated products emerged as a theme.

Questions C7 and C11 asked the respondents to list the key drivers and challenges to beneficiation and the reasons for exporting more raw minerals. Table 14 summarises the responses of the respondents to these questions and lists the key drivers and challenges in descending order from the highest frequency of citation to the lowest.

Table 14: Key drivers and top challenges affecting beneficiation

| **Key drivers for sustainable beneficiation** | | **Top challenges constraining the beneficiation programme** | |
|---|---|---|---|
| **Item** | **Frequency** | **Item** | **Frequency** |
| i. Skills | 28 | a) Labour laws | 29 |
| ii. Quality of education | 23 | b) Local skills shortage | 28 |
| iii. Availability of infrastructure (transportation, access to water, refineries etc.) | 23 | c) Corruption | 27 |
| iv. Availability of minerals at competitive prices | 22 | d) Expensive labour / unstable labour workforce | 25 |
| v. Government laws and regulations amenable to beneficiation | 22 | e) Availability of energy | 23 |
| vi. Disciplined labour | 21 | f) Political uncertainty | 21 |
| vii. Reliable energy supply | 21 | g) Inadequate infrastructure | 20 |

| Key drivers for sustainable beneficiation | | Top challenges constraining the beneficiation programme | |
|---|---|---|---|
| viii. Collaboration between research institutions and the industry | 18 | h) Unavailability of capital | 19 |
| ix. Entrepreneurial activity | 16 | i) Lack of investment in research and development | 17 |
| x. Political commitment and leadership | 13 | j) Foreign mining interest | 10 |
| xi. Competitive pricing for finished goods | 9 | k) Heavy taxes by government | 9 |
| xii. Local and export market for the product | 7 | l) Limited access to raw minerals | 5 |
| xiii. Economies of scale | 4 | m) Long term contracts by mining companies to supply international markets with raw minerals | 3 |

Source: Collated from respondents

The top key drivers for sustainable beneficiation as identified by respondents and indicated in table 14 are:

- ✓ Skills.
- ✓ Quality of education.
- ✓ Availability of infrastructure (transportation, access to water, refineries etc.).
- ✓ Availability of minerals at competitive prices.
- ✓ Government laws and regulations amenable to beneficiation.
- ✓ Disciplined labour.
- ✓ Reliable energy supply.
- ✓ Collaboration between research institutions and the industry.

The top challenges constraining the beneficiation programme as identified by respondents are (see table 14):

- ✓ Labour laws.
- ✓ Local skills shortage.
- ✓ Corruption.
- ✓ Expensive labour / unstable labour workforce.
- ✓ Availability of energy.
- ✓ Inadequate infrastructure.
- ✓ Availability of capital.
- ✓ Lack of investment in research and development.
- ✓ Foreign mining interest.
- ✓ Heavy taxes by government.

It is notable that the top key drivers and challenges for beneficiation identified by the respondents are in line with the cross-cutting constraints identified in literature by Eunomix (2012) and Department of Minerals and Energy (2011).

## 4.5 Summary

Chapter 4 provided data presentation and analysis for the study. The profile of participants and the industry they represent were described, quantitative and qualitative data were analysed and results provided, and themes were obtained. The next chapter discusses the results.

# CHAPTER 5: DISCUSSION OF RESEARCH FINDINGS

## 5.1 Introduction

This chapter discusses and compares the results from primary data in the field and secondary data in the literature review chapter. In light of the findings, it then considers the propositions of the study.

## 5.2 Discussion of themes and constructs from primary data

### 5.2.1 Theme 1: Impact of beneficiation on Imports and exports

Theme 1 finds that practitioners and knowledgeable people in the field concur that there is currently low level of mineral beneficiation taking place in South Africa, resulting in the country exporting more raw minerals and missing out on the opportunity to earn more revenue from exporting high value beneficiated products. The results suggest that beneficiation will increase export revenue and decrease imports of finished products.

Theme 1 was compared with construct 1 where respondents agreed that the mining industry will continue to play an important role in the economy of South Africa. From literature in chapter 2 the mining sector contributed over 8.3% to the GDP of South Africa in 2012 but with low beneficiation taking place as in 2008 only 11% of the country's minerals were beneficiated creating value worth R86 billion.

Therefore the results suggest that an increase in local beneficiation will create more value from exporting finished products. It is important to note that this will only be possible if manufacturing companies are supplied with raw minerals by local mining companies at competitive prices and do not have to import raw minerals from other countries because they cannot source it locally at the same or competitive prices.

### 5.2.2 Theme 2: Poverty, unemployment and equality

This theme captures the prevailing perception from practitioners surveyed that beneficiation will increase entrepreneurial activity in the downstream manufacturing industry which will create more jobs. From this it can be assumed that beneficiation will address the issue of unemployment and poverty. The results however did not address the

issue of inequality, whether it can be addressed by beneficiation as respondents registered conflicting views with some saying the company bosses will continue to benefit more than employees, and others saying that beneficiation presents an opportunity for many small businesses which can be owned by entrepreneurs from previously disadvantaged backgrounds.

As indicated by construct 3 there is a general agreement that mineral beneficiation will create employment and significantly contribute to the economy of South Africa. This is supported by 73% of the respondents who agreed that beneficiation will increase employment by a significant amount (see Appendix C). These views dispute a view by Hausmann et al. (2008) that mineral beneficiation in South Africa will not address the problems of poverty, unemployment and inequality.

Therefore, the results imply that in order to achieve the goals of increasing employment, alleviating poverty and inequality, care must be taken to ensure that beneficiation companies are owned and operated by local people.

### 5.2.3 Theme 3: Economic development

There was an agreement amongst respondents as captured in theme 3 that beneficiation will contribute immensely to the GDP of the country and will result in the establishment of additional industrial and manufacturing companies. These additional companies should then contribute to the economy through direct taxes and employment creation among other benefits.

This view is supported by the quantitative results that beneficiation will significantly contribute to the economy of South Africa. Frequency analysis presented in Appendix C indicates that 85.4% of all respondents agreed that mineral beneficiation will lead to much higher economic growth than currently experienced. Construct 3 agrees with this view.

It is therefore, expected that beneficiation will strengthen the manufacturing industry, which currently employs about 250 000 employees in South Africa (Creamer Media, 2013) by creating more jobs. This is pertinent as authors have noted that the manufacturing industry’s contribution has been in the decline since the peak of 21.3% in 1981 and notably in the early 2000s due to infrastructural bottlenecks, unfavourable economic policies, and

exacerbated by the global financial crisis in 2008 / 2009 (Pan-African Investment & Research Services, 2011).

### 5.2.4 Theme 4 and Theme 5: The impact of beneficiation on mining companies

Even though there was an assurance from the minister of Mineral Resources that mining companies will not be forced to beneficiate or subsidise the manufacturing industry (National Union of Metal Workers of Southern Africa, 2014), the results indicate concern that the beneficiation programme may lead to prices of minerals and commodities being regulated by government to support the local manufacturing industry. On the positive side it was felt that mining companies will benefit from the programme if prices are not regulated as production will increase and more consumption will lead to profitability.

Frequency analysis as appended in Appendix C indicates that 33% of respondents to the close-ended questions were of the view that beneficiation will lead to the regulation of commodity prices. Construct 2 indicates that the majority of respondents, notably from academia, non-governmental institutions and consulting firms were of the view that South Africa's mining industry will not support the beneficiation programme.

Mining companies sell their minerals to international markets at international prices and benefit from export parity pricing. The results indicate that it may be difficult for most mining companies to support local beneficiation because they have entered into long term contracts with their international clients and because some are owned by international investors. This in turn may have a negative impact on foreign direct investment (FDI) as companies wishing to invest in beneficiation may hold back their investments until there is assurance that local beneficiation will be supported by mining companies, and investors in the mining industry may withdraw their investments and not support local beneficiation at the expense of the already established international markets.

Therefore though the results generally indicate that mineral beneficiation will increase employment, and contribute to the economy of the country, care must be taken not to force mining companies to beneficiate or support the manufacturing industry as this move might weaken the mining industry.

### 5.2.5 Theme 6: Sustainability and viability of the beneficiation programme

The results in theme 6 indicate that sustainability of the beneficiation programme will depend on the availability of raw minerals at affordable prices. The country will also need to invest in research and development and government should support initiatives that are aimed at increasing innovation and creativity.

Parallel to this, construct 4 indicates that South Africa lacks the necessary capacity to carry out a sustainable beneficiation program. 46% of the respondents said the country does not have the necessary technical skills such as engineers, scientists and technologists for beneficiation. This view is supported by a study conducted by the World Economic Forum (2013) which listed inadequate educated workforce as the number one challenge affecting South Africa's general competitiveness.

Therefore the results suggest that sustainability and viability of the beneficiation programme will not only depend on mining and manufacturing sectors but also on the other sectors of the economy, such as the education system which should produce quality technical and entrepreneurial skills.

### 5.2.6 Theme 7: Access to international markets

The results in theme 7 indicate that South Africa enjoys access to international markets due to its relationship with other countries. It was however warned that South Africa's finished products will have to be of high quality and sold at competitive prices. Appendix C indicates that 75% of the respondents to close-ended questions said that South Africa will have access to international markets for beneficiated products.

Though it is expected that South Africa will have access to international markets, it is important that a plan be put in place to overcome challenges such as global competition, local costs of manufacturing, cheap imports of finished goods, influx of incentivised and illegal goods, productivity and efficiency, exchange rates, and volatile currency.

## 5.3 Key drivers for sustainable beneficiation programme

The majority of respondents listed the following as the key drivers for a sustainable beneficiation programme in South Africa arranged from the highest frequency of citation to

the least: Skills; quality of education; availability of infrastructure; availability of minerals at competitive prices; government laws and regulations amenable to beneficiation; disciplined labour; reliable energy supply; and collaboration between research institutions and the industry; the level of entrepreneurial activity in South Africa; political commitments and leadership; competitive pricing; local and export market for finished products; economies of scale; and the business friendly government . It can be seen that the availability of competent skills and good quality of education to support this are the most widely recognised factors by practitioners and experts surveyed as key drivers for sustainable beneficiation in South Africa.

To investigate this further, a graphical technique such as Pareto analysis could be used to determine the causes and effects, however for the purpose of this study and because most of the factors are not directly related, only the top 5 key drivers for sustainable beneficiation identified by stakeholders are discussed further below:

*Skills:* Although this is the most cited factor for driving beneficiation in South Africa, it is acknowledged by authors to be scarce in South Africa. The preparation of skills starts from primary education and goes all the way to tertiary education (Leeuw, 2012, p. 112). Leeuw found that South Africa does not have adequate quantity and quality of skills to undertake research, product and service development, and entrepreneurship. This can be attributed to the fact that South African education system is not producing enough learners with mathematics and physical science at high school level (World Economic Forum, 2013; Leeuw, 2012) and these subjects are a pre-requisite to study science and engineering at tertiary level which are the core disciplines in creating skills for the downstream mineral beneficiation programme.

*Quality of education:* This factor was also highly recognised as a key driver for sustainable beneficiation by respondents and goes hand-in-hand with and is a prerequisite for skills, as good quality of education provides good skills. However, this factor is also found to be inadequate in South Africa. A study conducted by World Economic Forum (2013) presented in chapter 2 indicates that South Africa displayed a dismal performance on the quality of primary education, ranking number 133 out of 148 countries, number 146 on the quality of education in general and ranks last in the quality of mathematics and science.

The report ranked South Africa 89th out of 148 countries on the quality of higher education and training. Quality of education is important because it has the ability to create the necessary skills required across the mineral beneficiation value chain.

*Availability of infrastructure:* This factor was another cited highly by a majority of respondents. According to the World Economic Forum (2013, p.4) well-developed infrastructure reduces the effect of distance between regions, integrating the national market and connecting it at low cost to markets in other countries and regions. Among the infrastructure requirements for the downstream beneficiation are: refineries and processing plants; rail and road transportation network to transport raw minerals from mining companies to refineries, and transportation of finished products from refineries to the harbour or airports for exporting; and the sustainable availability of water and electricity to keep the refineries running. In the case of South Africa authors (Eunomix, 2012; Creamer, 2014; Edwards & Lawrence, 2012) cited the perennial constraints regarding the security of electricity supply, the increased costs of water, and the poor rail and harbour capacity as the major infrastructure issues.

*Availability of minerals at competitive prices:* This factor was among those rated highly by respondents as driver of sustainable beneficiation in South Africa. According to the Department of Mineral Resources (2011) report South Africa will experience a constraint of limited access to raw materials for beneficiation. This is due to the current structural arrangement in the mining industry, which remains geared towards export of raw minerals with the current producers tied to long term contracts with their international clients. Therefore, it is important for South African mining companies to fully support the beneficiation programme and ensure a sustainable supply of raw minerals to local manufacturing companies at competitive prices.

*Government laws and regulation amenable to beneficiation:* Clearly it is important for government to develop and enforce laws and regulations that are clear and support the downstream beneficiation programme. Section 26 of the Mineral and Petroleum Resources Amendment (MPRDA) Bill deals with mineral beneficiation however there were some problems identified with the Bill in the definition of beneficiation (Creamer, 2014) which make it unclear. Among the problems identified in the definition of "beneficiation" and

section 26 of the MPRDA were the following (Creamer, 2014): it is not clear whether the section relates only to specific holders or covers mineral commodities in general; there is an element of price control at the discretion of the Minister which is contrary to free-market principles; it is not clear what constitutes a transformation or value addition; and it is not clear what baselines will be determined by the Minister and this leaves too much discretion in the Minister as to the implementation of section 26.

Considering the status in South Africa of the top drivers of sustainable beneficiation cited by the respondents, it becomes apparent that the country will have to put measures in place to ensure that it meets the requirements of the top drivers in order to successfully implement and sustain the beneficiation programme.

## 5.4 Challenges constraining the beneficiation programme

The majority of respondents listed the following as the challenges constraining the beneficiation programme in South Africa arranged from the highest frequency of citation to the least: South Africa's Labour laws; local skills shortage; corruption; expensive labour and or unstable labour workforce; availability of energy; political uncertainty; inadequate infrastructure; unavailability of capital for establishment of new industries; lack of investment in research and development; foreign mining interest; heavy taxes by government; limited access to raw minerals by beneficiating companies; and long term contracts by mining companies to supply the international markets with raw minerals. The respondents views are in line with the Global Competitive Report (World Economic Forum, 2013) which listed the five greatest obstacles to doing business in South Africa as: inadequately educated labour force; restrictive labour regulation; inefficient government bureaucracy; corruption; and poor work ethic in the national workforce.

Similarly in this section as mentioned in the previous one, a graphical technique such as Pareto analysis could be used to determine the causes and effects, however for the purpose of this study and because most of the challenges are not directly related, only the top 5 challenges for sustainable beneficiation from stakeholders are discussed below:

*Labour Laws*: labour laws refer to standards and social norms for the minimum socially acceptable conditions under which employees or contractors are allowed to work. The South Africa's labour laws are enforced by the department of labour.

This factor was the most highly cited by respondents as responsible for constraining beneficiation. The descriptive statistics presented in Appendix C supports this with the majority of respondents (72.3%) of the view that South Africa's labour laws are not friendly towards business and 48.9% of the view that labour laws will not support beneficiation. The literature also supports this where it was indicated in Chapter 2 that according to the World Economic Forum (2013) South Africa displayed a concerning ranking of 116 out of 148 countries on labour market efficiency. It follows that the country's labour laws will have to be reviewed with the view of making them friendly towards business to be able to support the beneficiation programme.

*Local Skills Shortage*: This was the second most highly cited factor by respondents for constraining beneficiation. From the descriptive statistics 46% of the respondents were of the view that South Africa does not have the necessary technical skills to carry out a sustainable beneficiation. The literature also supports this view that South Africa has a widely recognised skills shortage, largely attributed to mismatch of skills and demand versus those in supply (Deloitte, 2014). This means that South Africa's education system is not producing the required good quality and quantity of skills needed for beneficiation.

*Corruption*: This was highly rated by respondents as one of the factors constraining beneficiation. The prevalence or perception of corruption is one of the challenges faced by South Africa's mining industry. Lane et al. (2013) supports this view indicating that corruption is generally acknowledged as a negative force and can have a negative impact on investments linked to the mining industry, including investments in beneficiation.

*Expensive labour or unstable labour force*: Expensive labour refers to the high sums of all wages paid to employees as well as the cost of employee benefits to the company, and unstable labour force refers to issues pertaining to competency, dedication and effectiveness of employees to serve their companies.

This was another factor rated by respondents to be among the top five constraints to beneficiation. It is supported by the literature where inadequately educated workforce and restrictive labour regulation are cited as the most problematic factors for doing business in South Africa (World Economic Forum, 2013). According to McCarthy (2005) the South African labour cost inflation currently exceeds inflation and productivity gains and has been cited as the major constraint to investment in transformation of raw minerals. This implies that the employed unskilled workers in South Africa are being paid too much, and effectively means that it is too expensive to do business in South Africa.

*Availability of energy:* This factor was also cited among the top five constraints to beneficiation. Since most beneficiation programmes require large and uninterrupted supply of energy (e.g. refining of minerals), South Africa's current problems of load shedding compounded by demand of electricity and investment in power generation presents a huge challenge for investment in beneficiation projects. In the literature review given earlier, it was found that energy shortages are a key challenge hindering growth in the mining sector. According to Price Waterhouse Coopers (2013, p.18) energy costs are likely to continue to rise significantly as the electricity provider is authorised to increase prices by an average of 8% in each year for five years, starting from 2013. Therefore in view of this gap in supply unable to meet demand of energy, there is a major impediment to beneficiation.

Considering the key constraints cited by respondents as responsible for limiting beneficiation, it becomes apparent that the major challenges are related to human resources.

It is interesting to note that when the key drivers cited by respondents are compared with the constraints cited, the gap towards achieving beneficiation is emphasised. Notably, skills are identified as a top driver for beneficiation but at the same time a major constraint at present, this identifies a major gap. Similarly the need for good supportive infrastructure particularly the lack of adequate energy is emphasised. Another gap highlighted in this manner is the lack of supportive legal framework particularly supportive labour laws.

## 5.5 Discussion of Propositions

*Proposition 1: South Africa's labour laws are the main constraint to sustainable beneficiation.*

The results of the study indicate that 72.3% of respondents disagreed with the statement that says South Africa's labour laws are friendly towards business, rather most respondents (49%) were of the view that South Africa's labour laws will not support beneficiation programme. Considering respondent views by category, it is interesting to note that all categories concurred that South Africa's legislation does not support beneficiation (section 4.3.2.6), which is an overwhelming agreement. In addition, the respondents were asked to list the top 5 challenges that are a constraint to the beneficiation program and labour laws were the most cited by respondents as the top challenge; Further, respondents identified expensive labour or unstable labour workforce as among the top five constraints to beneficiation (section 5.4), which may be argued has a link with labour laws. From the results of the study, the importance of labour laws is highlighted and takes centre stage.

Interestingly, labour laws as a constraint is not explicitly stated in the literature. A survey on mining companies by PWC (see section 2.5.2) noted labour unrest rather than labour laws as being among the top challenges. In the same report labour relations are also mentioned but as one of the factors that stop or delay production. No study was found which identified labour laws specifically as a challenge to either the mining industry or manufacturing industry, and there was no study found identifying labour laws as a challenge to beneficiation.

Proposition 1 that South Africa's labour laws are the main constraint to sustainable beneficiation is therefore supported by the results of this study.

*Proposition 2:* B*eneficiation does not add significant economic value to South Africa and its export market.*

From the results, 83% of the respondents agreed that beneficiation will add significant value to the export market and 85% of the respondents were of the view that beneficiation will lead to much higher economic growth than currently experienced. It is also notable that

a majority of respondents (73%) were of the view that beneficiation will increase employment by a significant amount and that a beneficiation programme will attract foreign investment (77%). Theme 3 (section 5.2.3) indicates that there was an agreement amongst respondents that beneficiation will contribute immensely to the GDP of the country and will result in the establishment of additional industrial and manufacturing companies. Both increased employment and increased foreign investment are associated with an increase in economic activity in the country and therefore this sentiment indicates an expected positive impact from beneficiation on the economic performance of the country. In addition, when asked whether South Africa should adopt mineral beneficiation as a priority for economic development, an overwhelming majority (79%) of respondents agreed. Nevertheless, considering respondent views by category, it is interesting to note that although all categories generally concurred that mineral beneficiation will create employment and significantly contribute to the economy of South Africa, respondents from the mining sector and consulting sector agreed less than the others and are nearly neutral (section 4.3.2.3 and table 12). This is of concern as the mining sector may not be fully convinced of the economic benefit of beneficiation for the country as a whole and so may be unwilling to cooperate fully when needed. This sentiment may be attributed to the fact that beneficiation is perceived to belong mainly in the manufacturing sector rather than mining sector (B13 and B14 in table 10) and may therefore be perceived by the mining sector as a threat in that it may create a negative impact on employment in the mining industry even though it increases employment in the manufacturing industry. It was previously argued that to be operational, beneficiation requires close cooperation between the mining and manufacturing sectors to, for example, sustain the supply of raw minerals at competitive prices (section 2.2.2) and also to resolve challenges in the mining sector in order to facilitate the linkages with the manufacturing sector (section 2.5.1). This may be the task for government to create an enabling environment that facilitates cooperation between mining sector and the manufacturing sector.

Given that the results by category of industry concur but slightly with some categories notably mining sector and consultants nearly neutral on this aspect, the results may therefore not be reliable given the small numbers sampled.

Proposition 2 which say beneficiation does not add significant economic value to South Africa and its export market is rejected but weakly by the results of this study, and is therefore not conclusive. It requires further investigation.

*Proposition 3: Skills shortage and lack of research and development activities are the main causes for low beneficiation levels in South Africa.*

The study found that most respondents were fairly evenly split (42% for and 46% against) over the view whether South Africa has the necessary technical skills to carry out a sustainable beneficiation programme. Complementing the results, theme 6 (section 5.2.5) derived from responses to the open-ended questions also indicates that 46% of the respondents were of the view that the country does not have the necessary technical skills in the form of engineers, scientists and technologists to carry out beneficiation. This low confidence in availability of necessary skills is significant as skills was the most highly cited key driver for sustainable beneficiation in the country (Table 14). Further, when asked to list the top 5 challenges constraining beneficiation, local skills shortage was the second most highly cited challenge constraining beneficiation (Table 14). Clearly, skills shortage is the biggest gap identified by respondents in the study since it is both the most highly rated driver for beneficiation and yet a top constraint to beneficiation. Addressing of skills in the country should therefore be considered a top priority for government and other stakeholders for purposes of increasing beneficiation potential in the country.

The results in theme 6 (section 5.2.5) indicate that for sustainable beneficiation programme, the country will need to invest in research and development and that government should support initiatives that are aimed at increasing innovation and creativity. However, when asked whether research and development incentives existed, most respondents (52%) disagreed that there were research and development incentives to encourage downstream beneficiation and investment with only 32% respondents agreeing, which means very few stakeholders were aware of such incentives. In addition, 53% respondents were confident that South Africa has adequate research and development institutions to support beneficiation while 40% disagreed, which is a large percentage of stakeholders that have no confidence in the institutions. This indicates low confidence in the institutional capacity of the country to support research and

development. Further, when asked to list the top 5 challenges constraining beneficiation, some respondents included the lack of investment in research and development among the top challenges constraining beneficiation. Among the list however it was not among the top 5 most frequently cited constraint coming at number 9 down the list (Table 14). Although it is considered by some respondents as one of the top challenges, it is not a top priority to most of the other respondents. It is possible that there are actually proper incentives in place and proper research institutions in the country to support research and development, but this may not be well advertised or marketed to stakeholders.

Proposition 3 that skills shortage and lack of research and development activities are among the main causes for low beneficiation levels in South Africa is partly supported by the results of this study. The results of the study support the proposition where it states that skills shortage is among the main causes for low beneficiation levels in South Africa. However, the results of the study are inconclusive with regard to the proposition where it states that lack of research and development activities are among the main causes for low beneficiation levels in South Africa.

# CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

## 6.1 Introduction

This chapter concludes the study through exploring and interpreting research findings in light of the aim of the study, objectives, research question and research proposition.

## 6.2 Conclusion

Research Propositions:

Proposition 1: This proposition is supported by the results of the study. There is an overwhelming consensus from all respondents in the study that South Africa's labour laws are a major constraint to beneficiation. This is a key finding which requires an urgent intervention by government to resolve.

Proposition 2: This proposition is not supported. The results of the study indicate that majority of respondents were of the view that beneficiation will add significant economic value to South Africa and its export market, but when considering the respondent's views by category, it was noted that respondents from mining and consulting sectors agreed less that beneficiation will add significant economic value to South Africa. This is a concern as the mining sector may not be fully convinced of the economic benefits of beneficiation for the country and may not be willing to fully cooperate when needed. Because there is no overwhelming consensus by all respondents, this proposition is therefore not conclusive and needs further investigation.

Proposition 3: The component in proposition3 of skills shortage as the main cause for low beneficiation is strongly supported by the results of the study with an overwhelming consensus from all participants. The clear gap highlighted by the study (between the key drivers and top challenges) suggest the need for urgent intervention by government to resolve the skills shortage challenge. Regarding the component in proposition 3 of research and development as the main cause of low beneficiation, the results of the study do not support the proposition as it is not widely acknowledged by all participants of the study.

Research Objectives:

Objective (i):

In establishing the reasons for low levels of mineral beneficiation in South Africa, the study found that the key factors that affect the sustainability of the beneficiation programme are: skills; quality of education; availability of infrastructure; availability of minerals at competitive prices; government laws and regulation amenable to beneficiation; disciplined labour; reliable energy supply; collaboration between research institutions and the industry; entrepreneurial activity; political commitment and leadership; competitive pricing; local and export market for the product; economies of scale; and business friendly government.

The study found the following to be the main constraints to beneficiation, which are viewed as the reasons for low levels of mineral beneficiation:

- Considered together, expensive labour / unstable labour workforce and labour laws are a major impediment to beneficiation. As a case in point the South African labour cost inflation currently exceeds inflation and productivity gains which greatly constrain investment in transformation of raw minerals.
- The shortage of local skills is another major impediment to beneficiation as South Africa does not have the necessary technical skills in the form of engineers, scientists and technologists to carry out beneficiation programme. Backed by the literature, this is explained as being largely attributed to a mismatch between skills and demand on the other hand and supply on the other.
- Inadequate energy in the country presents a huge challenge for investments in beneficiation projects as most beneficiation programmes require large and uninterrupted supply of energy. South Africa is currently grappling into problems of load shedding compounded by growing demand for electricity and insufficient investment in power generation capacity, presenting a key challenge to beneficiation.
- Corruption in the country is perceived to be a key impediment to beneficiation as it has the effect of discouraging investment in new business development.

- Lack of sufficient investment in research and development in South Africa has contributed to weak support for potential breakthrough R&D programmes that could increase the prospects of innovation and creativity in creating products for beneficiation.

It is noteworthy that a significant portion of the major constraints identified in the study related to human resources (labour, skills and corrupt behaviour). This took an in proportionately large share of the concerns which raises great attention to the issue of human resources in South Africa. In addition the study found other constraints to mineral beneficiation to be: political uncertainty; inadequate infrastructure; availability of capital to finance beneficiation plants; heavy taxes by government; limited access to raw minerals emanating from foreign mining interests and long term contracts between mining companies and their international clients to supply the international markets with raw minerals.

The study also found a general agreement among respondents that mining companies do not support beneficiation and that South Africa lacks the necessary capacity to carry out a sustainable beneficiation programme.

Objective (ii):

To ascertain if respondents from mining, manufacturing, academic institutions, consulting firms and non-governmental organisation feel that there is a need for mineral beneficiation in South Africa as opposed to direct exports of raw ores to generate revenue, the researcher aimed to formulate a comparison between responses from stakeholders from different industries. However, a comparative study could not be done due to the small size of the sample and because not the same number of responses were obtained from different industries.

From the overall sample the study found that export revenue will be increased significantly if beneficiation is encouraged and South Africa will import less finished products, which in the final analysis will benefit the country better than mere export of raw ores.

From the above it can be seen that the research aim was achieved in that the study managed to determine, evaluate and analyse the constraints to sustainable mineral beneficiation programme in South Africa from the perspectives of the stakeholders in the mining value chain in South Africa. This helped answer the research question which was formulated to determine the constraints to establishing high levels of beneficiation as an economic activity in South Africa, and address the problem statement.

This research has made a contribution by addressing the lack of high levels of mineral beneficiation is South Africa. It is envisaged that this will provide the basis to help unlock the constraints to sustainable mineral beneficiation and help policy makers make informed decisions.

## 6.3 Limitations and Recommendations for Further Study

Several limitations are identified that could be addressed in future research. These limitations are the following:

Due to the size and complexity of South African mining industry, the theory was limited to focus mainly on the precious metals and minerals with specific focus on platinum group metals, gold and diamond sectors. Further study can replicate this research to include other mineral sectors.

The study relied on the availability of a small sample of individuals, which may result in the findings being applicable only to that sample. Future studies can benefit from a large sample to cover all stakeholder experts in the beneficiation process.

Both quantitative and qualitative data were collected from the same sources which sought within-method triangulation rather than data triangulation and therefore most data was analysed separately. Future studies can benefit from collecting quantitative data and qualitative data from different sources and performing triangulation to support or contradict claims.

Analysis of qualitative data could have included precise definitions and descriptions of the characteristics the researcher was looking for. Future study can benefit from defining each characteristic precisely by considering using specific examples from data collected to illustrate each characteristic.

Other recommendations for future studies include:

Replication of this study to provide a comparative study to other countries that have carried out beneficiation programmes;

Evaluation of whether the beneficiation programme will benefit communities in South Africa and address the issues of poverty, inequality and unemployment;

Development of a theoretical framework from the initial findings obtained in this study and carrying out validation tests for theory building purposes: and

Conducting further investigation on proposition 2 of this study, by assessing whether beneficiation will add significant economic value to South Africa and its export market.

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# APPENDIX A: Letter and Questionnaires




**Ethics Clearance Number (MIAEC 036/14)**

Direct Telephone: +27 16 960 6883
Direct Facsimile: +27 11 522 5340
E-mail:zweli.tom@sasol.com or
zweli.tom@gmail.com

Dear Sir / Madam,

**RE: Request to participate in an academic research study**

I am completing a Master of Science in Engineering degree at the University of the Witwatersrand, Johannesburg, and I am conducting research on the state of downstream mineral beneficiation in South Africa and the constraints thereof. *Beneficiation refers to the transformation of a mineral to a higher value product for the export market.*

For the purpose of gathering data, and as a stakeholder in the industry, you have been selected to participate in the study by completing the attached questionnaire. Completing the questionnaire should take approximately 15 minutes.

I understand that you are very busy and your participation in this research will be greatly appreciated. Your participation in the study is entirely voluntary.

The results of this questionnaire will be used for academic purposes only. A concerted and conscious effort will be made to keep the results confidential and the anonymity of the respondents is also guaranteed.

Please note that by submitting the completed questionnaire you agreement to participate in the research is assumed.

Thank you for giving your valuable time to assist me in this research.

Yours sincerely,

Zweli Tom

MSc Eng Student – University of the Witwatersrand, Johannesburg

Tel: 016 960 6883

Cel: 082 404 5211

Email: zweli.tom@sasol.com or zweli.tom@gmail.com

## SECTION A: Demographic Information

*(Please place a cross (X) in the appropriate box)*

| **A1: Industry** | | |
|---|---|---|
| Mining | | 1 |
| Manufacturing | | 2 |
| Consulting | | 3 |
| Academic | | 4 |
| Non-Profit Organisation | | 5 |
| Other (Specify) | | 6 |

| **A2: Number of years' experience in Industry** | |
|---|---|
| Less than 2 years | 1 |
| 3 to 5 years | 2 |
| 6 to 10 years | 3 |
| 11 years and more | 4 |

| **A3: Highest Education Level** | | |
|---|---|---|
| Matric | | 1 |
| FET Certificate or Trade Test | | 2 |
| Undergraduate | | 3 |
| Postgraduate | | 4 |
| Other (Specify) | | 5 |

| **Position** | |
|---|---|

***If you would like to receive feedback from the research, please fill in your details:***

| Name | |
|---|---|
| E-mail | |

## SECTION B: Close - Ended Questionnaire

| *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|
| ***Strongly Agree*** | ***Agree*** | ***Neither Agree nor Disagree*** | ***Disagree*** | ***Strongly Disagree*** |

| | STATEMENT | SCALE | | | | |
|---|---|---|---|---|---|---|
| B1 | Mining will continue for a long time to play a vital role in the economy of South Africa | 1 | 2 | 3 | 4 | 5 |
| B2 | The future of SAs economy will continue to be closely linked to the mining industry for a long time | 1 | 2 | 3 | 4 | 5 |
| B3 | Export of raw minerals versus beneficiated products results in SA losing significant potential revenue from such minerals | 1 | 2 | 3 | 4 | 5 |
| B4 | Beneficiation is the vehicle through which SA's resource-based comparative advantage can be transformed into a national competitive advantage | 1 | 2 | 3 | 4 | 5 |
| B5 | Mineral beneficiation program should be the country's major priority in mineral policy | 1 | 2 | 3 | 4 | 5 |
| B6 | Beneficiation will increase employment by a significant amount | 1 | 2 | 3 | 4 | 5 |
| B7 | Beneficiation will strengthen the local manufacturing industry | 1 | 2 | 3 | 4 | 5 |
| B8 | Mineral beneficiation will lead to much higher economic growth than currently experienced | 1 | 2 | 3 | 4 | 5 |
| B9 | Beneficiation will add significant value to the export market | 1 | 2 | 3 | 4 | 5 |
| B10 | Beneficiation programmes are driven by the country's competitiveness | 1 | 2 | 3 | 4 | 5 |
| B11 | Beneficiation programmes are driven by the country's availability of raw minerals | 1 | 2 | 3 | 4 | 5 |
| B12 | Linkages between the mining and manufacturing sector are important for local beneficiation | 1 | 2 | 3 | 4 | 5 |
| B13 | Beneficiation activities should be undertaken by mining companies | 1 | 2 | 3 | 4 | 5 |
| B14 | Beneficiation activities should be undertaken by the manufacturing industry | 1 | 2 | 3 | 4 | 5 |
| B15 | Beneficiation requires manufacturing competitiveness | 1 | 2 | 3 | 4 | 5 |
| B16 | Mining companies have the skills and capacity to acquire and operate beneficiation plants | 1 | 2 | 3 | 4 | 5 |
| B17 | It is economically viable for mining companies to develop competencies for beneficiation | 1 | 2 | 3 | 4 | 5 |
| B18 | SA's manufacturing industry is competitive | 1 | 2 | 3 | 4 | 5 |
| B19 | Beneficiation will lead to the regulation of commodity prices | 1 | 2 | 3 | 4 | 5 |
| B20 | Mining companies support local beneficiation | 1 | 2 | 3 | 4 | 5 |
| B21 | South Africa has the necessary technical skills for beneficiation (engineers, scientists, technologists etc.) | 1 | 2 | 3 | 4 | 5 |
| B22 | Beneficiation programme will attract foreign investment | 1 | 2 | 3 | 4 | 5 |
| B23 | South Africa has access to international markets for beneficiated products | 1 | 2 | 3 | 4 | 5 |
| B24 | There are research and development incentives to encourage downstream value addition and investment | 1 | 2 | 3 | 4 | 5 |
| B25 | It is cheaper to do business in South Africa compared to other developed and developing countries | 1 | 2 | 3 | 4 | 5 |
| B26 | South Africa's labour laws are friendly towards business | 1 | 2 | 3 | 4 | 5 |
| B27 | South Africa's labour laws will support the beneficiation programme | 1 | 2 | 3 | 4 | 5 |
| B28 | South Africa has adequate research and development institutions to support beneficiation | 1 | 2 | 3 | 4 | 5 |

## SECTION C: Open - Ended Questionnaire

1. Given the abundance of mineral resources in South Africa, what do you think of the state of downstream mineral beneficiation with regards to exports and imports?

_____
_____
_____
_____

2. According to Hausmann, Klinger and Lawrence (2007) mineral beneficiation in South Africa will not address the problems of poverty, unemployment and inequality, what do you think about this statement and why?

_____
_____
_____
_____

3. Do you think South Africa should adopt mineral beneficiation as a priority for economic development and why?

_____
_____
_____
_____

4. What do you think will be the impact of downstream mineral beneficiation on the mining companies (in terms of productivity and profitability)?

_____
_____
_____
_____

5. Do you think mining companies will fully support the value added beneficiation program?

_____
_____
_____
_____

6. If adopted, can South Africa sustain the mineral beneficiation program? Please elaborate.

_____
_____
_____
_____

7. In your view, what are the key drivers for sustainable beneficiation program?

_____
_____

8. What do you think are the main reasons for exporting more raw minerals than high value finished products in South Africa?

_____
_____
_____
_____
_____

9. Given the current state of mining in South Africa (i.e. challenges in the Platinum belt), do you think forward linkages are a viable option?

_____
_____
_____
_____
_____

10. Do you think South Africa will have access to international markets for beneficiated products?

_____
_____
_____
_____
_____

11. What are the top 5 challenges that are a constraint to the beneficiation programme?

_____
_____
_____
_____
_____
_____

## APPENDIX B: Purpose of Each Question

Table B1: Purposes of each close-ended question

| Question | Purpose of Question |
|---|---|
| B1 | The purpose of this question was to determine if stakeholders believe the mining industry will continue to play a leading role in contributing to the economy of South Africa. This question would help provide an understanding as to whether mining industry will exist to supply the beneficiation programme. |
| B2 | South Africa's economy was previously and is currently closely linked to the mining industry. This question was aimed at establishing if this trend will continue for a long time in the future. |
| B3 | South Africa currently exports most of its endowments as raw or partially processed minerals. This question was aimed at establishing from the stakeholders if this led to the country losing significant potential revenue by not further processing or beneficiating minerals. |
| B4 | South Africa has a comparative advantage due to its wealth of mineral endowment. This question was aimed at establishing from stakeholders if beneficiation will transform the country's comparative advantage into competitive advantage. |
| B5 | South Africa has a number of policies around minerals and mining and the purpose of this question was to establish from stakeholders if the policy to adopt mineral beneficiation should be prioritised above other policies. |
| B6 | This question was asked to establish from stakeholders if mineral beneficiation will significantly increase employment opportunities. |
| B7 | Downstream beneficiation is likely to happen at the manufacturing industry and it is important to determine the impact of it on local manufacturing industry. The purpose of this question was to establish from stakeholders if beneficiation will strengthen the local manufacturing industry. |
| B8 | Though most of South Africa's minerals are exported as raw or partially processed minerals, research indicated that mining industry, through its linkages contributes about 19.1% to the GDP of South Africa. This question was aimed at establishing if stakeholders believed beneficiation will significantly lead to much higher contribution through mining and its linkages. |
| B9 | It is important to note that most of the consumers of raw minerals are international customers. Research indicates that mining industry accounts for more than 40% of the country's exports, the purpose of this question was to establish from stakeholders if this trend will continue in the upward trajectory if mineral are processed locally. |
| B10 | This question was aimed at establishing from the stakeholders if the success of beneficiation programmes depends on the country's competitiveness or the availability of raw minerals. |
| B11 | This question was aimed at establishing from the stakeholders if the success of beneficiation programmes requires the country to have raw minerals or to be competitive. |
| B12 | The purpose of this question was to establish from stakeholders if there should be linkages in the form of agreements between the upstream mining companies and downstream manufacturing companies for the beneficiation programme to be successful. |
| B13 | There are macro-economic factors such as the Rand / Dollar exchange rates and export parity pricing which benefit mining companies when they export their products to international companies, it is believed that mining companies may not benefit from these factors if they have to supply the local market, therefore the purpose of this question was to establish if stakeholders believed mineral beneficiation must be undertaken by mining companies themselves. |

| | |
|---|---|
| B14 | Local manufacturing companies may benefit from cheaper supplies of raw minerals due to many factors such as the currency, transportation costs and proximity to mining companies. It is acknowledged that this benefit may come at the expense of mining industry and therefore, this question was asked to find out from stakeholders if they believed beneficiation should be undertaken by the manufacturing companies. |
| B15 | The purpose of this question was to determine if the beneficiation programme will require manufacturing industry to be competitive. |
| B16 | A successful beneficiation programme requires skills and capacity. The purpose of this question was to determine from stakeholders if mining companies possess the skills and capacity to operate beneficiation plants. |
| B17 | Successful beneficiation programmes require large amounts of investment and are costly to operate. The purpose of this question was to determine from stakeholders if it was economically viable for mining companies to have capacity for beneficiation. |
| B18 | The question was aimed at determining the readiness of the South Africa's manufacturing industry, its purpose was to find out from stakeholders if manufacturing industry has the capacity to carry out beneficiation. |
| B19 | Beneficiation programme requires constant, reliable, and affordable supply of raw minerals from the upstream operations to the downstream operations. The purpose of this question was to establish is stakeholders believed beneficiation will lead to the regulation of prices for raw minerals. |
| B20 | The success of the local beneficiation programme will depend, among other things, on the support of the mining companies. The purpose of this question was to determine from stakeholders if mining companies support the idea of local beneficiation. |
| B21 | Local beneficiation will require the country to possess the necessary technical skills in the form of engineers, scientists and technologist, and the purpose of this question was to establish if stakeholders believed the country possesses such skills. |
| B22 | Foreign direct investment is important to ensure that projects are adequately funded. This question was aimed at establishing if stakeholders believed foreign investors will support South Africa's beneficiation programme. |
| B23 | Research indicated that South Africa has access to international markets for raw or partially processed minerals, and that the country imports finished products made from these minerals. These questions was asked to determine if stakeholders believed SA will have access to international markets for finished goods and if the international market will be willing to buy finished products made in South Africa. |
| B24 | New product development requires research and development which leads to innovation and creativity. The question was aimed at finding out if stakeholders believed the South Africa encourages research and development. |
| B25 | One of the requirements for investment in business is the ease of doing business. This question was aimed at determining if it affordable to do business in South Africa compared to other countries which are already involved in downstream beneficiation. |
| B26 | The purpose of this question was to find out from stakeholders if South Africa's labour laws will encourage investment in downstream operations. |
| B27 | The purpose of this question was to find out from stakeholders if South Africa's labour laws will encourage investment in downstream operations and support the beneficiation programme. |
| B28 | New product development requires research and development which leads to innovation and creativity. The question was aimed at finding out if stakeholders believed the South Africa has adequate research and development institutions which will support the beneficiation programme. |

Table B2: Purposes of each open-ended question

| Question | Purpose of Question |
|---|---|
| 1 | This question acknowledges that South Africa has abundance of mineral resources and it was important to get the opinion of the stakeholders on the impact of this abundance on exports and imports. The purpose was to determine whether the stakeholders believe the status quo should be maintained or beneficiation should be undertaken locally and products |
| 2 | South Africa is faced with challenges of poverty, unemployment and inequality. The purpose of this question was to determine from stakeholders if local beneficiation will have an impact on these challenges. |
| 3 | This question complements a closed ended question and it was aimed at obtaining an insight from stakeholders as to whether mineral beneficiation should be made the country's priority. |
| 4 | Any policy shift or change in the mining industry has a potential to have an impact on the mining companies. The question was aimed at establishing from stakeholders if productivity and profitability of the mining companies will be positively or negatively affected. |
| 5 | This question was aimed at obtaining insight and reasons from stakeholders on whether mining companies will support local beneficiation or not. |
| 6 | There are many factors (both at micro and macro levels) which can affect the sustainability of beneficiation. This question was aimed at determining these factors from stakeholders |
| 7 | The purpose of this question was to determine from stakeholders, the key drivers for sustainable beneficiation programme. |
| 8 | Research indicates that there are low levels of beneficiation undertaken in South Africa. The purpose of this question was to find out the reasons for low levels or no beneficiation from stakeholders. |
| 9 | Recently the South Africa's mining industry has been facing labour challenges, in particular the platinum belt. It was important for this research to determine the impact of these challenges on downstream operations. |
| 10 | The purpose of this question was to establish if stakeholders believed South Africa will enjoy access to international markets for locally beneficiated products. |
| 11 | This question was aimed obtaining from stakeholders the major constraints to beneficiation in South Africa. |

## APPENDIX C: Descriptive Statistics of Close-Ended Questions

| Question | N Valid | Mean | Median | Std. Deviation | Skewness | Kurtosis | Range |
|---|---|---|---|---|---|---|---|
| B1 | 48 | 1.625 | 1 | 0.8903 | 1.587 | 2.005 | 3 |
| B2 | 48 | 1.958 | 2 | 1.051 | 1.233 | 0.884 | 4 |
| B3 | 48 | 1.75 | 1 | 1.0417 | 1.709 | 2.746 | 4 |
| B4 | 48 | 1.813 | 2 | 0.9819 | 1.238 | 0.674 | 3 |
| B5 | 48 | 1.833 | 1 | 1.1172 | 1.107 | -0.214 | 3 |
| B6 | 48 | 2 | 2 | 1.0314 | 0.728 | -0.595 | 3 |
| B7 | 48 | 1.854 | 2 | 0.8749 | 0.891 | 0.267 | 3 |
| B8 | 48 | 1.958 | 2 | 0.7707 | 0.945 | 1.387 | 3 |
| B9 | 48 | 1.938 | 2 | 0.8606 | 0.959 | 0.723 | 3 |
| B10 | 48 | 2.104 | 2 | 0.9728 | 0.797 | 0.478 | 4 |
| B11 | 48 | 2.958 | 2.5 | 1.3832 | 0.128 | -1.407 | 4 |
| B12 | 48 | 1.917 | 2 | 0.9416 | 1.129 | 0.687 | 3 |
| B13 | 48 | 3.313 | 3.5 | 1.3862 | -0.193 | -1.325 | 4 |
| B14 | 48 | 2.021 | 2 | 1.139 | 0.769 | -0.838 | 3 |
| B15 | 48 | 1.833 | 2 | 0.907 | 1.058 | 0.557 | 3 |
| B16 | 48 | 3.5 | 4 | 1.0518 | -0.458 | -0.693 | 4 |
| B17 | 48 | 2.854 | 2 | 1.3207 | 0.048 | -1.458 | 4 |
| B18 | 48 | 3.083 | 3 | 1.0485 | -0.172 | -1.184 | 4 |
| B19 | 48 | 3.104 | 3 | 1.153 | 0.136 | -0.807 | 4 |
| B20 | 48 | 3.292 | 3 | 1.1101 | -0.03 | -1.127 | 4 |
| B21 | 48 | 3.167 | 3 | 1.2262 | 0.102 | -1.335 | 4 |
| B22 | 48 | 2.229 | 2 | 0.9944 | 1.004 | 0.493 | 4 |
| B23 | 48 | 2.25 | 2 | 1.0417 | 0.884 | 0.036 | 4 |
| B24 | 48 | 3.229 | 4 | 1.1713 | -0.386 | -0.888 | 4 |
| B25 | 47 | 3.766 | 4 | 1.026 | -0.765 | 0.032 | 4 |
| B26 | 47 | 3.872 | 4 | 1.0958 | -0.979 | 0.464 | 4 |
| B27 | 47 | 3.255 | 3 | 1.1125 | -0.336 | -0.71 | 4 |
| B28 | 47 | 2.83 | 2 | 1.2036 | 0.186 | -1.293 | 4 |

## APPENDIX D: Frequency Analysis of Close-Ended Questions

| B1 | | | | | |
|---|---|---|---|---|---|
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 27 | 56.3 | 56.3 | 56.3 |
| | 2 | 16 | 33.3 | 33.3 | 89.6 |
| | 3 | 1 | 2.1 | 2.1 | 91.7 |
| | 4 | 4 | 8.3 | 8.3 | 100 |
| | Total | 48 | 100 | 100 | |
| **B2** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 18 | 37.5 | 37.5 | 37.5 |
| | 2 | 22 | 45.8 | 45.8 | 83.3 |
| | 3 | 1 | 2.1 | 2.1 | 85.4 |
| | 4 | 6 | 12.5 | 12.5 | 97.9 |
| | 5 | 1 | 2.1 | 2.1 | 100 |
| | Total | 48 | 100 | 100 | |
| **B3** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 25 | 52.1 | 52.1 | 52.1 |
| | 2 | 16 | 33.3 | 33.3 | 85.4 |
| | 3 | 3 | 6.3 | 6.3 | 91.7 |
| | 4 | 2 | 4.2 | 4.2 | 95.8 |
| | 5 | 2 | 4.2 | 4.2 | 100 |
| | Total | 48 | 100 | 100 | |
| **B4** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 22 | 45.8 | 45.8 | 45.8 |
| | 2 | 19 | 39.6 | 39.6 | 85.4 |
| | 3 | 1 | 2.1 | 2.1 | 87.5 |
| | 4 | 6 | 12.5 | 12.5 | 100 |
| | Total | 48 | 100 | 100 | |
| **B5** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 26 | 54.2 | 54.2 | 54.2 |
| | 2 | 12 | 25 | 25 | 79.2 |
| | 3 | 2 | 4.2 | 4.2 | 83.3 |
| | 4 | 8 | 16.7 | 16.7 | 100 |
| | Total | 48 | 100 | 100 | |

| B6 | | | | | |
|---|---|---|---|---|---|
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 19 | 39.6 | 39.6 | 39.6 |
| | 2 | 16 | 33.3 | 33.3 | 72.9 |
| | 3 | 7 | 14.6 | 14.6 | 87.5 |
| | 4 | 6 | 12.5 | 12.5 | 100 |
| | Total | 48 | 100 | 100 | |
| **B7** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 19 | 39.6 | 39.6 | 39.6 |
| | 2 | 20 | 41.7 | 41.7 | 81.3 |
| | 3 | 6 | 12.5 | 12.5 | 93.8 |
| | 4 | 3 | 6.3 | 6.3 | 100 |
| | Total | 48 | 100 | 100 | |
| **B8** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 12 | 25 | 25 | 25 |
| | 2 | 29 | 60.4 | 60.4 | 85.4 |
| | 3 | 4 | 8.3 | 8.3 | 93.8 |
| | 4 | 3 | 6.3 | 6.3 | 100 |
| | Total | 48 | 100 | 100 | |
| **B9** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 15 | 31.3 | 31.3 | 31.3 |
| | 2 | 25 | 52.1 | 52.1 | 83.3 |
| | 3 | 4 | 8.3 | 8.3 | 91.7 |
| | 4 | 4 | 8.3 | 8.3 | 100 |
| | Total | 48 | 100 | 100 | |
| **B10** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 14 | 29.2 | 29.2 | 29.2 |
| | 2 | 20 | 41.7 | 41.7 | 70.8 |
| | 3 | 10 | 20.8 | 20.8 | 91.7 |
| | 4 | 3 | 6.3 | 6.3 | 97.9 |
| | 5 | 1 | 2.1 | 2.1 | 100 |
| | Total | 48 | 100 | 100 | |

| B11 | | | | | |
|---|---|---|---|---|---|
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 7 | 14.6 | 14.6 | 14.6 |
| | 2 | 17 | 35.4 | 35.4 | 50 |
| | 3 | 3 | 6.3 | 6.3 | 56.3 |
| | 4 | 13 | 27.1 | 27.1 | 83.3 |
| | 5 | 8 | 16.7 | 16.7 | 100 |
| | Total | 48 | 100 | 100 | |
| **B12** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 17 | 35.4 | 35.4 | 35.4 |
| | 2 | 24 | 50 | 50 | 85.4 |
| | 3 | 1 | 2.1 | 2.1 | 87.5 |
| | 4 | 6 | 12.5 | 12.5 | 100 |
| | Total | 48 | 100 | 100 | |
| **B13** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 5 | 10.4 | 10.4 | 10.4 |
| | 2 | 12 | 25 | 25 | 35.4 |
| | 3 | 7 | 14.6 | 14.6 | 50 |
| | 4 | 11 | 22.9 | 22.9 | 72.9 |
| | 5 | 13 | 27.1 | 27.1 | 100 |
| | Total | 48 | 100 | 100 | |
| **B14** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 21 | 43.8 | 43.8 | 43.8 |
| | 2 | 14 | 29.2 | 29.2 | 72.9 |
| | 3 | 4 | 8.3 | 8.3 | 81.3 |
| | 4 | 9 | 18.8 | 18.8 | 100 |
| | Total | 48 | 100 | 100 | |
| **B15** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 20 | 41.7 | 41.7 | 41.7 |
| | 2 | 20 | 41.7 | 41.7 | 83.3 |
| | 3 | 4 | 8.3 | 8.3 | 91.7 |
| | 4 | 4 | 8.3 | 8.3 | 100 |
| | Total | 48 | 100 | 100 | |

| B16 | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 1 | 2.1 | 2.1 | 2.1 |
| | 2 | 10 | 20.8 | 20.8 | 22.9 |
| | 3 | 8 | 16.7 | 16.7 | 39.6 |
| | 4 | 22 | 45.8 | 45.8 | 85.4 |
| | 5 | 7 | 14.6 | 14.6 | 100 |
| | Total | 48 | 100 | 100 | |
| **B17** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 8 | 16.7 | 16.7 | 16.7 |
| | 2 | 17 | 35.4 | 35.4 | 52.1 |
| | 3 | 1 | 2.1 | 2.1 | 54.2 |
| | 4 | 18 | 37.5 | 37.5 | 91.7 |
| | 5 | 4 | 8.3 | 8.3 | 100 |
| | Total | 48 | 100 | 100 | |
| **B18** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 2 | 4.2 | 4.2 | 4.2 |
| | 2 | 16 | 33.3 | 33.3 | 37.5 |
| | 3 | 8 | 16.7 | 16.7 | 54.2 |
| | 4 | 20 | 41.7 | 41.7 | 95.8 |
| | 5 | 2 | 4.2 | 4.2 | 100 |
| | Total | 48 | 100 | 100 | |
| **B19** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 3 | 6.3 | 6.3 | 6.3 |
| | 2 | 13 | 27.1 | 27.1 | 33.3 |
| | 3 | 15 | 31.3 | 31.3 | 64.6 |
| | 4 | 10 | 20.8 | 20.8 | 85.4 |
| | 5 | 7 | 14.6 | 14.6 | 100 |
| | Total | 48 | 100 | 100 | |
| **B20** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 1 | 2.1 | 2.1 | 2.1 |
| | 2 | 14 | 29.2 | 29.2 | 31.3 |
| | 3 | 10 | 20.8 | 20.8 | 52.1 |
| | 4 | 16 | 33.3 | 33.3 | 85.4 |
| | 5 | 7 | 14.6 | 14.6 | 100 |
| | Total | 48 | 100 | 100 | |

| B21 | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 2 | 4.2 | 4.2 | 4.2 |
| | 2 | 18 | 37.5 | 37.5 | 41.7 |
| | 3 | 6 | 12.5 | 12.5 | 54.2 |
| | 4 | 14 | 29.2 | 29.2 | 83.3 |
| | 5 | 8 | 16.7 | 16.7 | 100 |
| | Total | 48 | 100 | 100 | |
| **B22** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 9 | 18.8 | 18.8 | 18.8 |
| | 2 | 28 | 58.3 | 58.3 | 77.1 |
| | 3 | 3 | 6.3 | 6.3 | 83.3 |
| | 4 | 7 | 14.6 | 14.6 | 97.9 |
| | 5 | 1 | 2.1 | 2.1 | 100 |
| | Total | 48 | 100 | 100 | |
| **B23** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 10 | 20.8 | 20.8 | 20.8 |
| | 2 | 26 | 54.2 | 54.2 | 75 |
| | 3 | 3 | 6.3 | 6.3 | 81.3 |
| | 4 | 8 | 16.7 | 16.7 | 97.9 |
| | 5 | 1 | 2.1 | 2.1 | 100 |
| | Total | 48 | 100 | 100 | |
| **B24** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 4 | 8.3 | 8.3 | 8.3 |
| | 2 | 11 | 22.9 | 22.9 | 31.3 |
| | 3 | 8 | 16.7 | 16.7 | 47.9 |
| | 4 | 20 | 41.7 | 41.7 | 89.6 |
| | 5 | 5 | 10.4 | 10.4 | 100 |
| | Total | 48 | 100 | 100 | |
| **B25** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 1 | 1 | 2.1 | 2.1 | 2.1 |
| | 2 | 6 | 12.5 | 12.8 | 14.9 |
| | 3 | 7 | 14.6 | 14.9 | 29.8 |
| | 4 | 22 | 45.8 | 46.8 | 76.6 |
| | 5 | 11 | 22.9 | 23.4 | 100 |
| | Total | 47 | 97.9 | 100 | |

| B26 | | | | | |
|---|---|---|---|---|---|
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 2 | 4.2 | 4.3 | 4.3 |
| | 2 | 4 | 8.3 | 8.5 | 12.8 |
| | 3 | 7 | 14.6 | 14.9 | 27.7 |
| | 4 | 19 | 39.6 | 40.4 | 68.1 |
| | 5 | 15 | 31.3 | 31.9 | 100 |
| | Total | 47 | 97.9 | 100 | |
| **B27** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 3 | 6.3 | 6.4 | 6.4 |
| | 2 | 10 | 20.8 | 21.3 | 27.7 |
| | 3 | 11 | 22.9 | 23.4 | 51.1 |
| | 4 | 18 | 37.5 | 38.3 | 89.4 |
| | 5 | 5 | 10.4 | 10.6 | 100 |
| | Total | 47 | 97.9 | 100 | |
| **B28** | | | | | |
| | | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
| Valid | 1 | 5 | 10.4 | 10.6 | 10.6 |
| | 2 | 20 | 41.7 | 42.6 | 53.2 |
| | 3 | 3 | 6.3 | 6.4 | 59.6 |
| | 4 | 16 | 33.3 | 34 | 93.6 |
| | 5 | 3 | 6.3 | 6.4 | 100 |
| | **Total** | **47** | **97.9** | **100** | |

# APPENDIX E: Factor Analyses

**Reliability B1** **14:17 Monday, January 19, 2015 35**

The CORR Procedure

2 Variables: B1 B2

Inter-Item Correlation

| N | Mean | Minimum | Maximum | Range | Maximum/Minimum | Variance |
|---|---|---|---|---|---|---|
| 2 | 0.145 | -0.601 | 0.740 | 1.347 | -1.243 | 0.460 |

Cronbach Coefficient Alpha

| Variables | Alpha |
|---|---|
| Raw | 0.812 |
| Standardized | 0.826 |

Cronbach Coefficient Alpha with Deleted Variable

| Deleted Variable | Correlation with Total | Alpha | Scale Mean if item Deleted | Scale Variance if item Deleted | Squared Multiple Correlation |
|---|---|---|---|---|---|
| B1 | 0.491 | 0.801 | 2.484 | 4.920 | 0.805 |
| B2 | 0.423 | 0.802 | 2.471 | 4.902 | 0.798 |

Naming: Mining industry will continue to play an important role in the economy of South Africa

**Reliability B2** **14:17 Monday, January 19, 2015 36**

The CORR Procedure

5 Variables: B12 B13 B16 B17 B20

Inter-Item Correlation

| N | Mean | Minimum | Maximum | Range | Maximum/Minimum | Variance |
|---|---|---|---|---|---|---|
| 5 | .216 | -.241 | .590 | .831 | 4.00000 | .077 |

Cronbach Coefficient Alpha

| Variables | Alpha |
|---|---|
| Raw | 0.609 |
| Standardized | 0.579 |

Cronbach Coefficient Alpha with Deleted Variable

| Deleted Variable | Correlation with Total | Alpha | Scale Mean if item Deleted | Scale Variance if item Deleted | Squared Multiple Correlation |
|---|---|---|---|---|---|
| B12 | 0.025 | 0.687 | 12.958 | 12.381 | 0.146 |
| B13 | 0.495 | 0.473 | 11.563 | 7.698 | 0.435 |
| B16 | 0.659 | 0.407 | 11.375 | 8.324 | 0.485 |
| B17 | 0.655 | 0.365 | 12.021 | 7.085 | 0.480 |
| B20 | 0.066 | 0.688 | 11.583 | 11.695 | 0.183 |

Naming: Mining industry supports the beneficiation programme

**Reliability B3** **14:17 Monday, January 19, 2015 37**

The CORR Procedure

9 Variables: B3 B4 B5 B6 B7 B8 B9 B22 B18

Inter-Item Correlation

| N | Mean | Minimum | Maximum | Range | Maximum/Minimum | Variance |
|---|---|---|---|---|---|---|
| 9 | .346 | -.202 | .732 | .936 | -3.626 | .074 |

Cronbach Coefficient Alpha

| Variables | Alpha |
|---|---|
| Raw | 0.817 |
| Standardized | 0.827 |

Cronbach Coefficient Alpha with Deleted Variable

| Deleted Variable | Correlation with Total | Alpha | Scale Mean if item Deleted | Scale Variance if item Deleted | Squared Multiple Correlation |
|---|---|---|---|---|---|
| B3 | 0.575 | 0.791 | 16.708 | 24.211 | 0.525 |
| B4 | 0.736 | 0.770 | 16.646 | 23.255 | 0.716 |
| B5 | 0.629 | 0.783 | 16.625 | 23.176 | 0.599 |
| B6 | 0.698 | 0.774 | 16.458 | 23.190 | 0.643 |
| B7 | 0.549 | 0.795 | 16.604 | 23.563 | 0.407 |
| B8 | 0.692 | 0.783 | 16.500 | 25.234 | 0.733 |
| B9 | 0.636 | 0.786 | 16.521 | 24.978 | 0.698 |
| B18 | -0.149 | 0.876 | 15.375 | 31.856 | 0.163 |
| B22 | 0.477 | 0.803 | 16.229 | 24.414 | 0.409 |

Naming: Mineral beneficiation will create employment and significantly contribute to the economy of South Africa

The CORR Procedure

8 Variables: B16 B17 B18 B20 B21 B23 B24 B25

Inter-Item Correlation

| N | Mean | Minimum | Maximum | Range | Maximum/Minimum | Variance |
|---|---|---|---|---|---|---|
| 8 | .197 | -.182 | .587 | .769 | -3.231 | .036 |

Cronbach Coefficient Alpha

| Variables | Alpha |
|---|---|
| Raw | 0.732 |
| Standardized | 0.730 |

Cronbach Coefficient Alpha with Deleted Variable

| Deleted Variable | Correlation with Total | Alpha | Scale Mean if item Deleted | Scale Variance if item Deleted | Squared Multiple Correlation |
|---|---|---|---|---|---|
| B16 | 0.397 | 0.710 | 31.690 | 35.690 | 0.504 |
| B17 | 0.355 | 0.717 | 34.564 | 34.564 | 0.500 |
| B18 | 0.335 | 0.718 | 36.505 | 36.505 | 0.382 |
| B20 | 0.209 | 0.735 | 37.735 | 37.735 | 0.359 |
| B21 | 0.469 | 0.698 | 33.623 | 33.623 | 0.472 |
| B23 | 0.236 | 0.730 | 38.084 | 38.084 | 0.442 |
| B24 | 0.660 | 0.669 | 31.705 | 31.705 | 0.675 |
| B25 | 0.517 | 0.694 | 34.562 | 34.562 | 0.469 |

Naming: South Africa has the necessary capacity to carry out a sustainable beneficiation programme.



The CORR Procedure

3 Variables: B18 B14 B28

Inter-Item Correlation

| N | Mean | Minimum | Maximum | Range | Maximum/Minimum | Variance |
|---|---|---|---|---|---|---|
| 3 | -0.28 | -2.222 | 0.239 | 0.461 | -1.077 | 0.046 |

Cronbach Coefficient Alpha

| Variables | Alpha |
|---|---|
| Raw | 0.760 |
| Standardized | 0.880 |

Cronbach Coefficient Alpha with Deleted Variable

| Deleted Variable | Correlation with Total | Alpha | Scale Mean if item Deleted | Scale Variance if item Deleted | Squared Multiple Correlation |
|---|---|---|---|---|---|
| B14 | -0.199 | 0.382 | 5.936 | 3.148 | 0.052 |
| B18 | 0.026 | -0.222[a] | 4.809 | 2.419 | 0.097 |
| B28 | 0.103 | -0.569[a] | 5.085 | 1.819 | 0.059 |

a. The value is negative due to a negative average covariance among items

Naming: South Africa's manufacturing industry is competitive and ready for beneficiation.

**Reliability B6 14:17 Monday, January 19, 2015 40**

The CORR Procedure

3 Variables: B26 B27 B19

Inter-Item Correlation

| N | Mean | Minimum | Maximum | Range | Maximum/Minimum | Variance |
|---|---|---|---|---|---|---|
| 3 | 0.161 | -0.144 | 0.544 | 0.689 | -3.768 | 0.990 |

Cronbach Coefficient Alpha

| Variables | Alpha |
|---|---|
| Raw | 0.654 |
| Standardized | 0.665 |

Cronbach Coefficient Alpha with Deleted Variable

| Deleted Variable | Correlation with Total | Alpha | Scale Mean if item Deleted | Scale Variance if item Deleted | Squared Multiple Correlation |
|---|---|---|---|---|---|
| B19 | -0.037 | 0.705 | 7.128 | 3.766 | 0.058 |
| B26 | 0.472 | -0.338[a] | 6.383 | 2.198 | 0.323 |
| B27 | 0.260 | 0.151 | 7.000 | 2.739 | 0.332 |

a. The value is negative due to a negative average covariance among items

Naming: South African legislation supports beneficiation

The CORR Procedure

6 Variables: B10 B11 B12 B13 B14 B15

Inter-Item Correlation

| N | Mean | Minimum | Maximum | Range | Maximum/Minimum | Variance |
|---|---|---|---|---|---|---|
| 6 | .346 | -.202 | .732 | .936 | -3.626 | .074 |

Cronbach Coefficient Alpha

| Variables | Alpha |
|---|---|
| Raw | 0.169 |
| Standardized | 0.256 |

Cronbach Coefficient Alpha with Deleted Variable

| Deleted Variable | Correlation with Total | Alpha | Scale Mean if item Deleted | Scale Variance if item Deleted | Squared Multiple Correlation |
|---|---|---|---|---|---|
| B10 | 0.110 | 0.114 | 12.042 | 7.530 | 0.165 |
| B11 | 0.172 | 0.023 | 11.188 | 5.985 | 0.344 |
| B12 | 0.334 | -0.064[a] | 12.229 | 6.563 | 0.130 |
| B13 | -0.180 | 0.398 | 10.833 | 8.610 | 0.544 |
| B14 | -0.014 | 0.217 | 12.125 | 7.856 | 0.673 |
| B15 | 0.150 | 0.089 | 12.313 | 7.469 | 0.620 |

a. The value is negative due to a negative average covariance among items

Naming: Requirements for successful sustainable beneficiation programme