Identifying Barriers to Growth in Mineral Value Chains: An Analytical Framework Approach

by

Hermanus Jacobus van Zyl

Thesis presented in fulfilment of the requirements for the degree of Master of Engineering (Engineering Management) in the Faculty of Engineering at Stellenbosch University

Department of Industrial Engineering,
University of Stellenbosch,
Private bag X1, Matieland 7602, South Africa

Supervisors:
Supervisor: Mr W.G. Bam
Co-supervisor: Dr J.D. Steenkamp
Co-supervisor: Prof. C.S.L. Schutte

March 2017

Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Signature: ………………………………………

Date: March 2017

Abstract

Identifying Barriers to Growth in Mineral Value Chains: An Analytical Framework Approach

H.J. van Zyl
Department of Industrial Engineering,
University of Stellenbosch,
Private Bag X1, Matieland 7602, South Africa.
Thesis: MEng (Engineering Management)
March 2017

South Africa's comparative advantage in mineral processing brought by its immense wealth in mineral resources, has in recent years failed to fully translate to a national competitive advantage due to particular constraints. This hinders the local industry from capturing a more prominent share of the further-processed mineral market and transitioning the country to a stronger economic position through enabling South Africa to derive greater value from its mineral resources.

The mineral processing industry often finds itself going through various changes, with new barriers to growth constantly presenting themselves. Adapting to the ever-changing mineral production environment is a common struggle for many stakeholders involved in this complex field. Furthermore, each production phase has a very specific set of barriers and opportunities which are inherent to their environment and context within the chain. The key barriers to economic growth and business development which restrain participants within the value chain, has not yet been sufficiently identified nor has their extent and impact on the industry properly been established. It is discovered through literature, that no consistent system or guidelines exist which enables researchers or policymakers to systematically identify the barriers that are hindering the various stages of the value chain's expansion and growth. It is thus unclear how prominent certain problems are in specific mineral industries.

A comprehensive framework is thus required that can be applied to any mineral value chain (MVC) to identify the custom set of barriers faced in the different sectors comprising the chain and provide a better understanding of these barriers. The aim of this thesis was thus to develop such a framework which would allow its user to identify and analyse current barriers to growth in each of the stages of MVCs. The identified barriers are sector specific and thus cater directly to the role players actively involved in the chain. This allows for specialized barrier analysis for each firm in an MVC that is distinct and relates specifically to them.

Three primary framework design requirements were identified to achieve this aim, namely: identify and describe the MVC environment, identify barriers in the MVC, and prioritize the barriers. Six different approaches for describing and investigating value chains were reviewed in order to identify the current research gap and limitations of similar frameworks. These issues were addressed through the inclusion of 20 tools to fulfil each of the framework requirements. The tools were partitioned into six framework phases, with each phase focusing on a specific element of analysis.

In order to convey the utility of the framework, it was applied to a case study, namely the South African manganese industry. Four different production sectors were identified in the chain within the scope of the study, namely the mining, alloy manufacturing, EMD and EMM production sectors. Through an iterative process of interviews and surveys, 31 barriers to growth were identified across these four sectors, with *Oversaturated market* being the most significant impediment, followed closely by the rising costs of electricity, labour and transport.

Through expert analysis based on the results generated from the case study, it was concluded that the framework successfully facilitates the identification of barriers within a MVC. The validators concurred that the proposed framework addresses a specific need within the industry and is a useful tool for its stakeholders. The holistic and systematic approach to a multi-faceted and complex subject was identified as the framework's primary strength. All the shortcomings that were identified, were reviewed and addressed by reworking the framework where applicable.

Opsomming

Identifisering van Struikelblokke tot Groei in Mineraal Waardekettings: 'n Analitiese Raamwerk Benadering

("Identifying Barriers to Growth in Mineral Value Chains: An Analytical Framework Approach")

H.J. van Zyl

Department Bedryfsingenieurswese,

Universiteit Stellenbosch,

Privatesak X1, Matieland 7602, Suid-Afrika.

Tesis: MIng (Ingenieursbestuur)

Maart 2017

Suid-Afrika se vergelykende voordeel in mineraalverwerking wat aangebring is deur sy rykdom aan mineraalhulpbronne, het in die afgelope jare versuim om in 'n nasionale mededingende voordeel omskep te word as gevolg van bepaalde beperkings. Dit verhinder plaaslike bedrywighede om 'n meer prominente skyf van die verwerkte minerale mark op te neem en die land in 'n sterker ekonomiese posisie te plaas deur Suid-Afrika in staat te stel om meer waarde van sy minerale te verkry.

Die mineraalverwerkingsbedryf ondervind dikwels verskeie veranderinge en nuwe hindernisse tot groei wat voortdurend voorspring. Die aanpassing by die voortdurende veranderende mineraalproduksie-omgewing is 'n algemene stryd vir baie belanghebbendes betrokke by hierdie komplekse veld. Verder, het elke produksie fase van die ketting 'n baie spesifieke stel struikelblokke en geleenthede wat inherent is tot hul omgewing en konteks binne-in die ketting. Die kern hindernisse wat ekonomiese groei en sake-ontwikkeling binne die waardeketting beperk, is nog nie voldoende geïdentifiseer nóg is hul omvang en impak op die bedryf behoorlik bepaal nie. Geen ooreenstemmende stelsel of riglyne is in literatuur ontdek wat navorsers of beleidmakers bemagtig om stelselmatig die struikelblokke wat groei en ontwikkeling binne die verskeie sektore van die waardeketting teenwerk, te identifiseer nie. Dit is dus onduidelik hoe prominent sekere probleme in spesifieke mineraal nywerhede voorkom.

'n Omvattende raamwerk word dus vereis wat op enige mineraalwaardeketting (MWK) toegepas kan word om sodoende die struikelblokke in die verskeie sektore wat die ketting opmaak, te identifiseer en 'n beter begrip van hierdie hindernisse te verskaf. Die doel van hierdie tesis was dus om so raamwerk te ontwerp, wat sou toelaat dat gebruikers huidige struikelblokke tot ontwikkeling in elkeen van die MWK fases kan identifiseer en ontleed. Die geïdentifiseerde struikelblokke is sektor-spesifiek en maak dus direk voorsiening vir die rolspelers wat aktief betrokke is in die ketting. Dit laat dus 'n

gespesialiseerde versperrings-analises vir elke firma in die MWK toe, wat spesifiek aan hulle verwant is.

Drie primêre raamwerk-ontwerp vereistes is geïdentifiseer om hierdie doel te bereik, naamlik: identifiseer en beskryf die MWK-omgewing, identifiseer die struikelblokke in die MWK en prioritiseer die struikelblokke. Ses verskillende benaderings vir die beskrywing en bestudering van waardekettings is ondersoek, ten einde die huidige navorsingsgaping en beperkings van soortgelyke raamwerke te identifiseer. Hierdie kwessies is aangespreek deur die insluiting van 20 hulpmiddels wat aan elkeen van die raamwerk se vereistes voldoen. Hierdie hulpmiddels is in ses raamwerkfases verdeel, met elke fase wat op 'n spesifieke ontledingselement fokus.

Met die oog om die nut van die raamwerk oor te dra, is dit op 'n gevallestudie, die Suid-Afrikaanse mangaanbedryf, toegepas. Vier verskillende produksie sektore is in die ketting geïdentifiseer wat binne die bestek van die studie val, naamlik die mynbou, allooivervaardiging, EMD- en EMM-produksie sektore. Na 'n iteratiewe proses van onderhoude voer en opnames maak, is 31 struikelblokke tot groei oor die vier sektore geïdentifiseer, met die *Oorversadigde mark* wat as die beduidendste struikelblok bestempel is. Dit is gevolg deur die stygende koste van elektrisiteit, arbeid en vervoer.

Die ontleding van resultate wat uit die gevallestudie verkry is deur kundiges, het tot die gevolgtrekking gelei dat die raamwerk suksesvol die indentifisering van struikelblokke in 'n MWK kan fasiliteer. Diegene wat by die validasieproses betrokke was, het saamgestem dat die voorgestelde raamwerk 'n spesifieke behoefte in die bedryf aanspreek en as 'n nuttige hulpmiddel beskou kan word. Die holistiese en sistematiese benadering tot 'n veel-vlakkige en ingewikkelde onderwerp, is as een van die raamwerk se hoof kenmerke aangewys. Al die tekortkominge wat tydens hierdie proses uitgewys is, is aangespreek en die raamwerk is toepaslik hersien.

Acknowledgements

Many individuals have made valuable contributions to this study and share in its success. I would like to express my sincere gratitude to the following people for their boundless assistance, advice and support during the course of this study:

- My supervisor, Wouter Bam, for sharing your valuable insight and continuously pointing me in the right direction. You have been an exceptional study leader and without your guidance, this study would not have been successful.
- Co-supervisor, Dr Joalet Steenkamp, for being and endless source of knowledge in the pyrometallurgy field and providing so many referrals for my research, which served to be invaluable.
- Co-supervisor, Professor Corne Schutte, for your assistance in the latter stages of the study.
- Anglo American for providing financial assistance during the course of this study.
- All the company representatives that partook in the research interviews and surveys. The information that you provided served as the backbone of the study.
- SAIMM and the 2nd School on Manganese Ferroalloy Production for the opportunity to have my work validated by the delegates that attended the event, as well as Raymond van der Berg that facilitated the validation process.
- The individuals that put valuable time and effort into validating my framework and providing very insightful feedback, namely Dr Nic Barcza, Professor Dee Bradshaw, Dr Dawie van Vuuren, Attie Rossouw and Oliver Witt.
- My colleagues in the Value Capture Systems research group, for all the motivation and support. The time spent working alongside each of you is filled with fond memories.
- Lastly, I would like to thank my friends and family. Your boundless words of motivation, support through easy and difficult times, and never-ending love has lead me to where I am today. Each of you are immensely appreciated.

Nomenclature

BEE	-	Black Economic Empowerment
BBBEE	-	Broad-Based Black Economic Empowerment
BBSEE	-	Broad-Based Socio-Economic Empowerment
BIF	-	Barrier Identification Framework
BRICS	-	Brazil, Russia, India, China, South Africa
C	-	Carbon
c/kWh	-	Cents per Kilowatt Hour
CIS	-	Commonwealth of Independent States
CMD	-	Chemical Manganese Dioxide
CPI	-	Consumer Price Index (also referred to as inflation rate)
CSIR	-	Council for Scientific and Industrial Research
DMR	-	Department of Mineral Resources
EMD	-	Electrochemical Manganese Dioxide
EMM	-	Electrolytic Manganese Metal
FAT	-	Framework Assessment Tool
GDP	-	Gross Domestic Product
GVC	-	Global Value Chain
Ha	-	hectare
HCFeMn	-	High-carbon ferromanganese
HMM	-	Hotazel Manganese Mines
IDZ	-	Industrial Development Zone
IMnI	-	International Manganese Institute
kWh	-	Kilowatt hour
KMF	-	Kalahari Manganese Fields
kt	-	Kiloton
ktpa	-	kilotons per annum
MCFeMn	-	Medium-carbon ferromanganese
Mn	-	Manganese
MnO	-	Manganese oxide
MPRDA	-	Mineral and Petroleum Resources Development Act
Mt	-	Mega ton (equivalent to one million tons)
MVA	-	Mega Volt Ampere
MVC	-	Mineral Value Chain
MWh	-	Megawatt Hour
Nersa	-	National Energy Regulator
NGP	-	New Growth Path
NGO	-	Non-Governmental Organisation
NHREC	-	National Health Research Ethics Committee
PGM	-	Platinum Group Metal

R&D	-	Research and Development
RCA	-	Root Cause Analysis
ROM	-	Run of Mine
SAF	-	Submerged Arc Furnace
SAIMM	-	Southern African Institute of Mining and Metallurgy
SARB	-	South African Reserve Bank
SiMn	-	Silicomanganese
SLTO	-	Social License to Operate
Tpa	-	Tonnes per annum
TFR	-	Transnet Freight Rail
TIA	-	Technology Innovation Agency
UNCTAD	-	United Nations Conference on Trade and Development
USD	-	United States Dollar
VC	-	Value chain
ZAR	-	South African Rand

Contents

List of Figures

List of Tables

Chapter 1

1 Introduction

This chapter introduces the reader to the background scope of this thesis. Background information and the rationale of the study are provided, followed by the research design, which consists of the problem statement, research aim and objectives, and the research scope. An overview of the research methodology is discussed afterwards, which is followed by a description of the choice for a suitable case study, the data collection approach and the ethical approval of the research. The chapter concludes with an overview of the thesis structure.

1.1 Background and rationale

From a South African perspective, the mineral industry plays a significant part in the domestic economy. Overall, the country is estimated to have the world's fifth-largest mining sector regarding GDP value, with its total reserves remaining one of the world's most valuable with an estimated worth of $2.5-trillion (Chamber of Mines of South Africa 2014). It has the world's largest reserves of manganese and platinum group metals (PGMs) and is a major producer of other valuable minerals, such as gold. Given the country's history in mineral wealth, many mineral and metal companies are key players in the global industry. Their key strengths include a high level of technical and production expertise, as well as extensive R&D activities.

The relative contribution of the mineral industry to South Africa's GDP has declined over the past 10 to 20 years (Brand South Africa 2016; Department of Mineral Resources RSA 2015b). Nonetheless, the industry is continually adapting to changing local and international world conditions, and remains a cornerstone of the economy, making a significant contribution to economic activity, job creation and foreign exchange earnings. Mining and its related mineral processing industries are critical to South Africa's socio-economic development, as exemplified in the following list (Chamber of Mines of South Africa 2014):

- The South African minerals industry creates approximately one million jobs (500 000 direct and 500 000 indirect);
- Accounts for about 18% of GDP (8.6% direct, 10% indirect and induced);
- Is a critical earner of foreign exchange at more than 50%;
- Accounts for 20% of investment (12% direct);
- Attracts significant foreign savings (R1.9-trillion or 43% of value of JSE);
- Accounts for 13.2% of corporate tax receipts (R17-billion in 2010) and R6-billion in royalties;
- Accounts for R441-billion in expenditures, R407-billion spent locally;
- Accounts for R78-billion spent in wages and salaries;
- Accounts for 50% of volume of Transnet's rail and ports;
- Accounts for 94% of electricity generation via coal power plants;
- Takes 15% of electricity demand.

These factors serve as an indication of the importance and integral part the mineral industry plays in South Africa. The list provides insight into the complexity of MVCs and the numerous aspects it influences on a large scale. There are, however, numerous factors that have progressively grown during the past couple of years which has had detrimental effects on mineral industries, which threatened the country's dominant market position. These factors include (Basson et al. 2007; Steenkamp & Basson 2013):

- New policies affecting the minerals industry;
- Scarcity of local reductants;
- Deficiency of electricity generation capacity and the growing threat of rising electricity costs, and;
- Economic strain due to the recent fall in the manganese commodity market.

If we look at some of these factors strictly from the manganese industry perspective, it can be investigated further. The manganese ore and alloy production capacity added during the commodity boom cycle (between 2001 and 2007 when the manganese commodity cycle was at a peak (Ratshomo 2013)) have declined, resulting in the current market remaining oversaturated and in ample overcapacity of manganese ore and alloys (International Manganese Institute 2015). As a repercussion, manganese is presently one of the worst performing commodities with prices at its lowest point, not seen since the 90's (International Manganese Institute 2015).

It is evident that the manganese industry like so many other metal and mineral industries has entered an onerous period. This has led to the industry shifting focus to address challenges not only regarding short-term gain, but to ensure long-term viability (Basson et al. 2007). These measures include appealing for a review of specific legislative policies in the mining and mineral market to improve support from government, improvement of operational efficiency, development of logistical infrastructure, as well as initiatives to increase the capacity of power generation and local reductant production (Basson et al. 2007).

Literature on the subject of both local and foreign mineral industries provides an ample amount of sources which suggest that many barriers exist that prohibit economic growth in the sector (Elliot 2015b; Edinger 2014; Baxter 2014; Ford et al. 2007). The consequences of these constraints limit research and development, job creation and local value capture. The severity of these barriers and the legitimate impact thereof on business in the long term is still uncertain, with many of the potential outcomes of the industry not yet investigated.

There is thus a clear need for research that will provide a better understanding of the barriers and opportunities towards economic growth currently faced in the mining and minerals industry, as well as an indication of the potential outlook thereof in the near future. It is thus necessary to identify the different role players shaping the industry and determine the effect of their relationships, as well as their respective impact on the industry as a whole. This will provide an in-depth understanding of the current mineral value chain environment in South Africa and identify the key factors shaping the chain. This could serve as an initial stage of determining where improvements can be made to promote the development of the local mineral industry.

Little research has been done to provide guidelines as to how to analyse a mineral value chain to identify the barriers faced by different role players within the industry. A framework is required which addresses each of these issues in order to provide an indication of the severity of major barriers faced in key areas of a mineral value chain. With this framework, barriers can be identified throughout a mineral value chain and provide a better understanding as to why and how they occur.

The framework would need to provide an overview of all role players involved in the mineral value chain, identify potential areas for improvement in production activities, and provide steps for stakeholders to gain a larger market share and receive an overall economic advantage. This will be achieved through providing sufficient information on the current state of the industry and where the major bottlenecks and other constraints occur. Companies in involved in MVCs could use such a framework to identify and understand the barriers they face in order to directly address them or appeal to government to address them. It could also be of use to government and researchers who want to understand the barriers to identify what the optimal interventions would be from a national perspective.

This framework would thus ensure that South African stakeholders would produce much higher value products and allow for economic growth within the country. It would enable more value to be retained within the country while also increasing skilled labour and job creation. The research is expected to promote the mineral industry and provide insight into the barriers that occur throughout its various sectors. This could then serve as a stepping stone to ultimately transform South Africa's mining sector from a predominantly primary commodity exporter to an exporter of higher value processed minerals.

1.2 Research design

The research design elaborates on the need for solutions in the field of barrier identification and analysis of mineral value chain environments, as well as the process designed to address these issues. This section discusses the problem statement which prompted the study, the research aim and objectives, the research questions, scope of the research and concludes with the layout of the thesis structure.

1.2.1 Problem statement

South Africa's comparative advantage brought about its immense wealth in mineral resource endowment, has in recent years failed to fully translate to a national competitive advantage due to particular constraints. These barriers hinder the local industry from capturing a more prominent share of the further-processed mineral market and transitioning the country to a stronger economic position through enabling South Africa to derive greater value from its mineral resources. The key barriers to economic growth and business development which restrain role players in the value chain has not yet been sufficiently identified nor has their extent and impact on the industry properly been established. Furthermore, no consistent system or guidelines exist which enables users to identify current barriers, which are unique to particular sectors of a value chain. It is thus unclear how prominent certain problems are in specific mineral industries.

Much of the literature providing an overview of the South African minerals industry is relatively outdated and was published before many major impediments occurred. Examples include the sharp rise in electricity tariffs, unreliable power supply, the commodity cycle facing a record low point, increased labour disputes in the mining sector, and the implementation of new government policies affecting the industry (Gajigo et al. 2011; Basson et al. 2007; Bonga 2008; Steenkamp & Basson 2013). Alternatively, in some cases current constraints are identified in literature, but is limited to a specific sector within the value chains (Elliot 2015b; Elliot 2014; Von Below 1992), such as mining, only information for a specific mineral is available (International Manganese Institute & RPA 2015; Pooe & Mhelembe 2014; Gajigo et al. 2011), or the investigation scope is too broad (D'Harambure 2015; Elliot 2015b).

The minerals industry often finds itself going through various changes, as mentioned above, with new barriers to growth constantly presenting themselves. Adapting to the ever-changing mineral product environment is a common struggle for many role players involved in this complex field. Furthermore, every role player has a very specific set of barriers and opportunities which are inherent to the environment and context of their position within the chain. For instance, mining companies that primarily make use of generators to supply power to their equipment might not be as severely affected by the rise in electricity tariffs as an alloy producer which uses over 7 000 MWh of electricity per year. These companies are more likely, however, face greater problems from an unsettled workforce and labour strikes on the other hand. A framework is consequently required that will enable the user to identify the latest/current barriers, which are unique to the respective sectors of the chain and cater directly to the role players involved in the industry.

1.2.2 Research aim and objectives

The primary aim of this research is to develop an analytical framework to identify and analyse the barriers to economic growth in mineral value chains (MVCs). In other words, a framework will be developed that can be applied to any specific mineral value chain to identify barriers in different sectors of the chain and also provide a better understanding of these barriers. In order to attain this research aim successfully, the following four research objectives were identified.

The first objective is to identify the primary design requirements and tools in order to develop the proposed framework. Through this objective, the fundamental attributes are established that details the necessary criteria for the framework that is required to address the problem statement. The second objective is to design a framework which will address these design requirements and ensure that a relevant and useful tool is developed, particularly for active stakeholders involved in MVCs.

The third objective is to illustrate the utility and use of the framework by applying it to a relevant case study. The final research objective is to validate the results of the case study and the framework through expert analysis and determine its potential need in the industry, its usefulness and whether it has any shortcomings. The four research objectives and corresponding research questions are indicated in Figure 1-1. The research questions provide insight to certain prospects that will need to be taken into consideration when addressing the corresponding objectives.

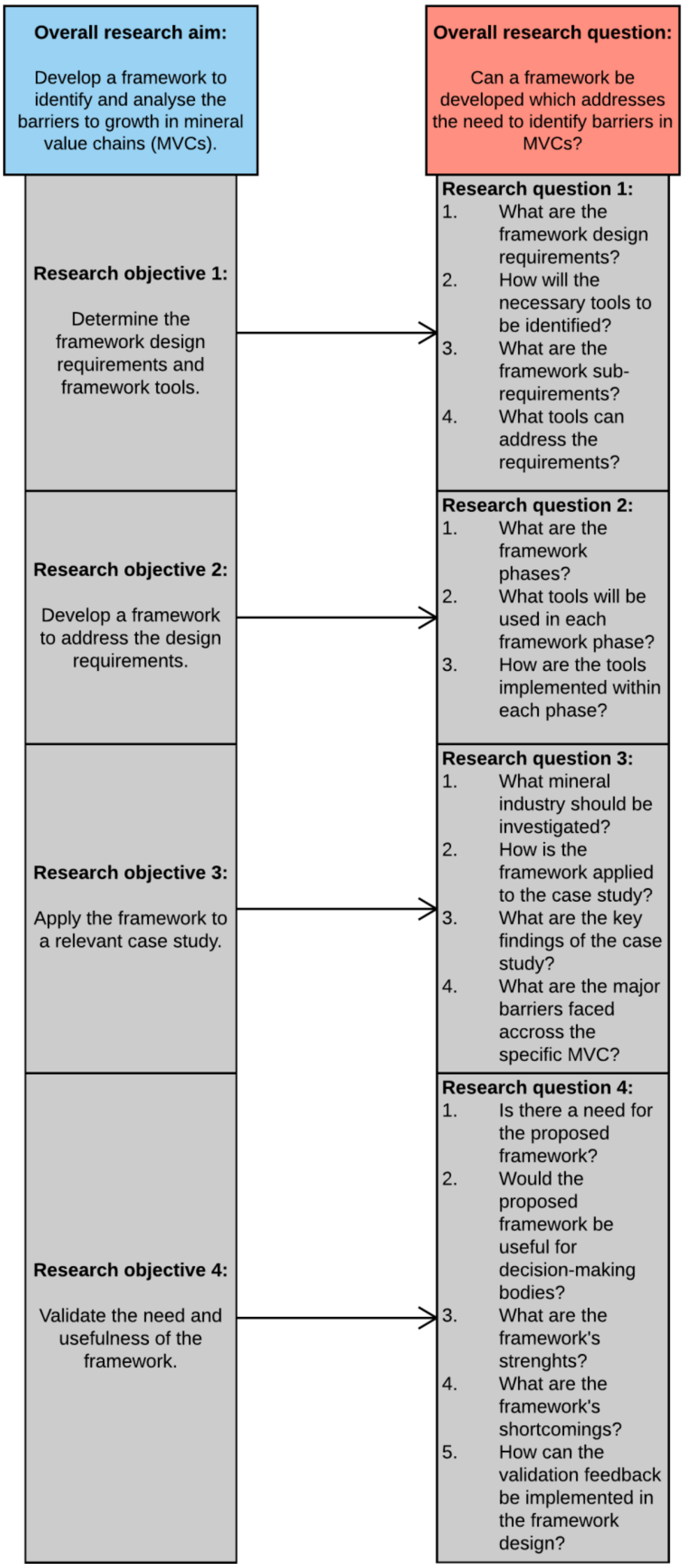


Figure 1-1: Research objectives and corresponding research questions

1.2.3 Research scope

As apparent from the research aim and objectives, this research is primarily focused on the development, implementation, and validation of the proposed framework. A high-level overview of the framework aims is described as follows:

- **Need:** Addressing a specific need arising from minerals industry for a system to identify and analyse barriers in an MVC;
- **Usefulness:** Developing a framework that is useful and provides a valuable contribution to role players in the MVC;
- **Redundancy:** Developing a new and unique framework, applicable to any MVC and sector within an MVC, that is capable of identifying current barriers;
- **Shortcomings and recommendations:** Identify and address limitations of the proposed framework, while expanding and introducing its strengths.

The utility of the framework is evaluated through its application to a suitable case study, which is further discussed in section 1.4. The results generated from this procedure was used as a means to validate the above-mentioned characteristics of the proposed framework, as seen in sections 9.2 and 9.3.

1.3 Research methodology

The research method used for this study contains the following of six processes:

1. Problem articulation;
2. Background and literature review;
3. Framework design;
4. Application of the framework to a case study;
5. Validation of the framework, and;
6. Research conclusions.

The background and literature review, framework design and the application of the framework to a case study, will be integrated and used concurrently to form two separate research stages, namely *Framework requirement and tool identification* and *Framework integration.* The full research methodology structure is represented in Figure 1-2. Each of the five stages is described as follows:

- *Problem articulation:* The problem statement and objectives of the research are identified;
- *Framework requirement and tool identification:* The framework design requirements and tools required to address the problem statement and research objectives are identified;
- *Framework integration:* The framework methodology is developed and applied to a relevant case study;

- *Validation:* The framework methodology and the results generated from the case study are validated to determine whether the proposed framework is useful and addresses a need within the minerals industry;
- *Research conclusion:* The key findings of the research are discussed, and recommendations are made for future work.

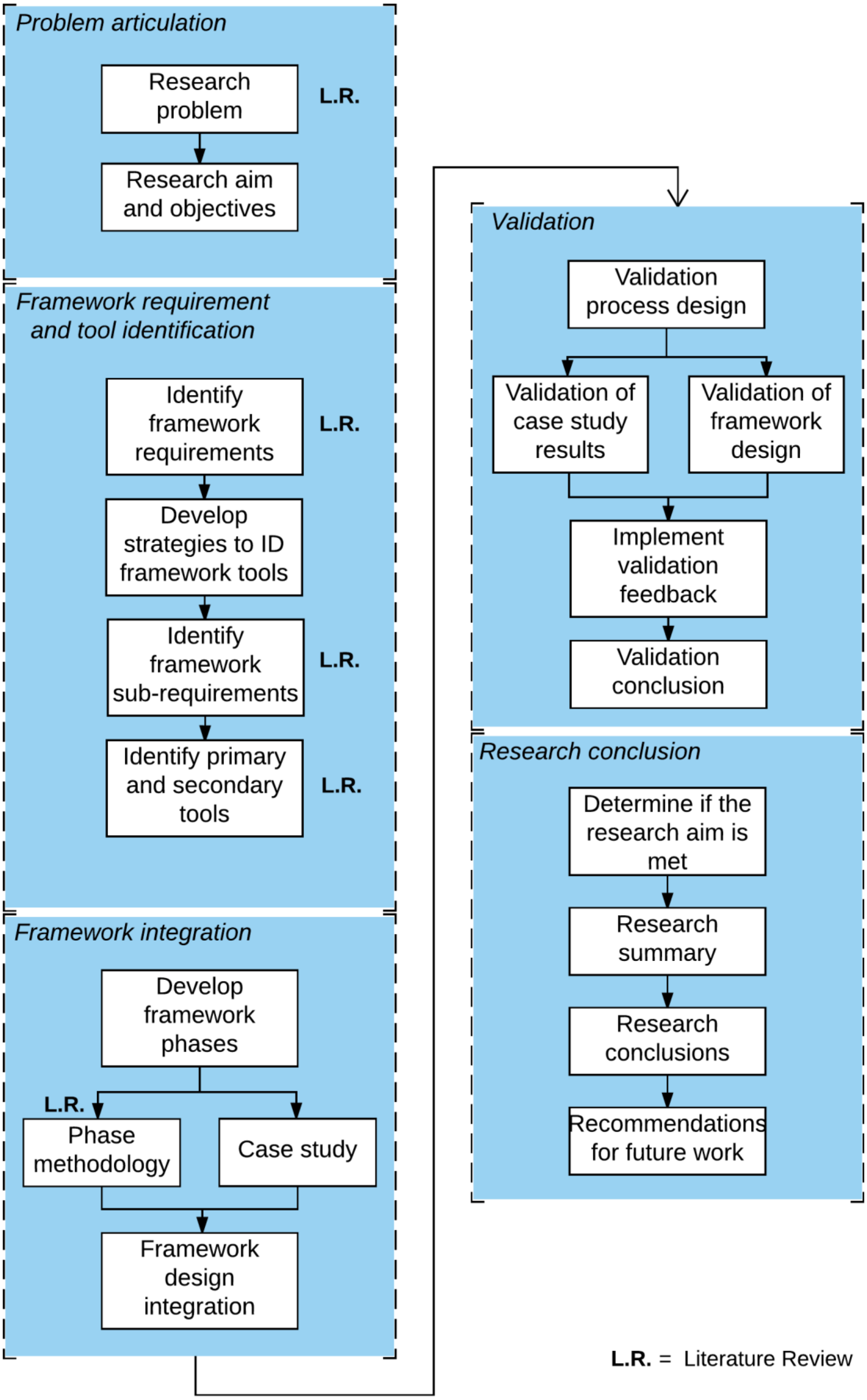


Figure 1-2: Overview of the implemented research methodology

Table 1-1 indicates how the research methodology is implemented for this study, as shown in Figure 1-2, will address each of the research objectives stated in Figure 1-1.

Table 1-1: How the research methodology will address the objectives

	Research objective 1: Determine the framework design requirements and framework tools.	**Research objective 2:** Develop a framework to address the design requirements.	**Research objective 3:** Apply the framework to a relevant case study.	**Research objective 4:** Validate the need and usefulness of the framework.
Problem articulation	✓			
Framework requirement and tool identification	✓	✓		
Framework integration		✓	✓	
Validation of the framework				✓
Research conclusions				✓

1.4 Case study selection

The scope of the proposed framework is restricted to address barriers within a specific mineral value chain. In order to evaluate the framework, it is applied to a relevant case study. The South African manganese industry has been selected as a suitable case study for the following reasons:

- Manganese has significant commercial value, especially for the production of steel. Thus the results gathered from the case study will be of significant value;
- This mineral is mainly used as an alloying element, meaning this industry is analogous to the many other mineral industries, such as chrome and iron, which also primarily manufacture alloys for steel;
- South Africa is major player in the manganese industry, making information for the study more accessible and readily available;
- Manganese is predominantly used in steel manufacturing, which limits the product scope and simplifies the analysis for the study.

An international perspective will also be incorporated into the study to determine South Africa's global market presence. Since the entire value chain is very extensive and becomes increasingly intricate further down the chain, the scope of the value chain analysis will be limited to activities involving the primary processing of the ore for product manufacturing (often intermediate products, such as alloys which are later used for steel production.

All the role players involved in the activities up to this point will form part of the analysis and description of the MVC environment. This scope is broad enough to illustrate all the framework's capabilities, without the study becoming tedious. The framework will be described conceptually through the use of literature, examples and the South African manganese industry as a case study.

It is important to note that the case study will only be used for illustrative purposes in providing an example of the framework application and provide an indication of possible quantitative and qualitative results. It is possible that some of the results might not be entirely complete, as it might require more time for analysis. Since some of the analyses in the framework's research phases are too time-consuming for the scope of the study, some of the sections might be limited (such as the case in the root cause analysis phase where only two barriers were investigated). All the results are, however, gathered through comprehensive research from credible sources, are as accurate as possible and validated through experts in relevant fields of knowledge.

1.5 Data collection approach

Multiple data collection techniques will be incorporated throughout the study to reinforce the triangulation of data and therefore establish the qualitative outcomes of the research. Data triangulation is employed in this study through the use of qualitative research and the collection of specific operational data from companies (such as electricity usage, when operational delays occur, the productivity of the workforce, etc.), literature review, and interviews with industry experts. The triangulation supports the credibility, reliability, and validity of the findings through the cross-verification of information (Write Content Solutions 2016). The general data collection method used throughout the study is shown in Figure 1-3. This study incorporates triangulation with the following two approaches:

1) **Data source triangulation:** Evidence from different data sources (primary and secondary research) are collected. This includes interviews with relevant companies' respondents, questionnaires, company documents, public records, literature review and observations.

2) **Methodology triangulation:** Multiple methods to gather data was combined and utilised, which included conducting surveys, conversational interviewing and semi-structured question interviewing to determine the barriers faced by companies. The results are compared with barriers gathered during company reports, news articles and relevant publications on the manganese industry.

The applied primary data collection tools include document reviews and semi-structured interviews with the help of an interview guide. The guide provided structure to the interviews, yet allowed for questions to be added in accordance with responses provided by the interviewees. Interviews were specifically used during the Delphi process to identify barriers within the industry on a first-hand basis. Open questions were used to ensure that the interviewee had leeway to reply and allow for the interviewee's knowledge and understanding of the industry to be tapped. This allowed for new areas of research to be explored which has previously been limited.

The interview questions were exploratory in nature, prompting the interviewee to identify barriers that specifically affect them and which potentially have not yet been mentioned in public records. The interviews gave stakeholders the opportunity to voice their opinion on the level of interaction between different industry players. The questions also allowed for their perspectives to be shared on the future of the industry and where they believe the major barriers for economic growth lie.

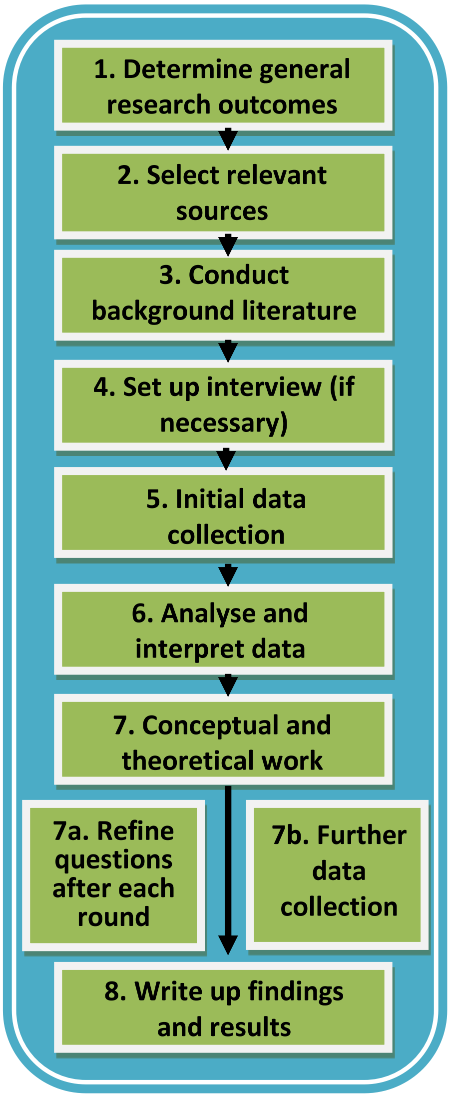


Figure 1-3: Research methodology followed for data collection

1.6 Ethical approval of research

All research comprised in the thesis complies with Stellenbosch University's guidelines on ethical aspects of scholarly and scientific research. Furthermore, all citations and references are clearly indicated throughout the report and proper acknowledgment is given to the sources used in the research.

The nature of this study and the manner in which it is conducted, is not harmful to the individuals that are affected by the research. Informed consent is ensured throughout the study to all individuals participating and providing information to be used in the study. The National Health Research Ethics Committee (NHREC) registration number for this thesis is REC-050411-032. The letter of approved application for ethical clearance for the research is provided in Appendix A – Ethical Clearance.

1.7 Thesis structure/layout

The layout of this document is designed to promote the systematic flow of the work and to guide the reader through the entire research process. The applied research methodology veers off from the traditional structure, comprised of initially conducting a complete literature study, followed by developing a full methodology, which is then applied to a suitable case study (as discussed in section 1.3). Background and literature reviews are incorporated within the various methodology design sections of this study since a significant amount of research needs to be done to develop specific framework steps, and vice versa. In other words, certain methodologies in some cases first need to be constructed before it is known what relevant literature and background analysis needs to be undertaken.

Each framework phase is developed and described in respective chapters. In these chapters, the framework's application is illustrated in the continuing case study. The concurrent description of literature review, framework design and case study application, will allow the reader to follow each step of the design phase with much less effort in comparison with discussing each independently. A brief outline of each chapter is provided below and is represented in Figure 1-4. Each phase in this figure is colour-coded to correspond with the primary framework design requirements: *Identify and describe the MVC environment* – blue, *Identify barriers in the MVC* – orange, *Prioritization of barriers* – green and research methodologies outside of the framework design – grey.

Chapter 2 – Framework design methodology

The purpose of this chapter is to define and develop the framework design methodology for the thesis. The framework design requirements and strategies required to identify the necessary framework tools are defined. The framework phases are also identified and developed.

Chapter 3 – Phase 1: Data gathering and interpretation

This chapter provides an overview of the selected mineral industry, which serves as the case study for this research. The literature review contains a comprehensive and well-integrated summary of various aspects relevant to the specific mineral industry, including the background of the mineral, its reserves, applications, production processes and local initiatives in the minerals industry of South Africa, such as beneficiation. The chapter concludes with a summary of the literature through an SWOT-analysis.

Chapter 4 - Phase 2: Defining the value chain

The process of defining the value chain is described with the use of a combination of tools primarily comprised of Porter's Value Chain and GVC analysis' input-output structure. The methodology for identifying and describing the various activities that make up the chain, as well as the role player structures for each segment of the value chain, is discussed. A process-flow diagram is developed, which provides an overview of the entire chain and the products that are produced throughout the chain. The chapter concludes with a summary of the steps required in defining the mineral value chain.

Chapter 5 – Phase 3: Determining the context of the global value chain

In this chapter, the focus is placed on integrating the mineral value chain within a global context by analysing the essential characteristics that define the chain environment. The four key attributes that investigated in this chapter are the geographic scope of the GVC, chain governance, institutional context and lastly, and a summary of key attributes of the chain.

Chapter 6 – Phase 4: Identifying and defining barriers in the value chain

This chapter describes the process of conducting interviews and surveys to identify barriers from experts within the specific mineral industry.

Chapter 7 – Phase 5: Ranking and classification of the identified barriers

During this chapter, all of the data gathered from industry experts are analysed to determine the impact that each barrier has on specific sectors within the value chain.

Chapter 8 – Phase 6: Barrier root cause analysis

The final framework phase is the review of the identified barriers to identify their origins, their influencers and possible alleviation strategies to address them. In this chapter the root cause analysis (RCA) process is developed and implemented.

Chapter 9 – Validation of framework and results

The main purpose of chapter 9 is to validate the outcomes and the assumed value of the proposed framework. Expert opinion will be used to assess the validity of the results provided by the framework on the manganese case study, as well as the methodology implemented within the framework to better understand the barriers within a mineral value chain.

Chapter 10 – Conclusion and recommendations

This chapter concludes the research. It provides summaries of each of the chapters with regards to how it addressed the research objectives or framework requirements and reached valid and relevant conclusions. This chapter also presents suggestions for improvements and recommendations for future work.

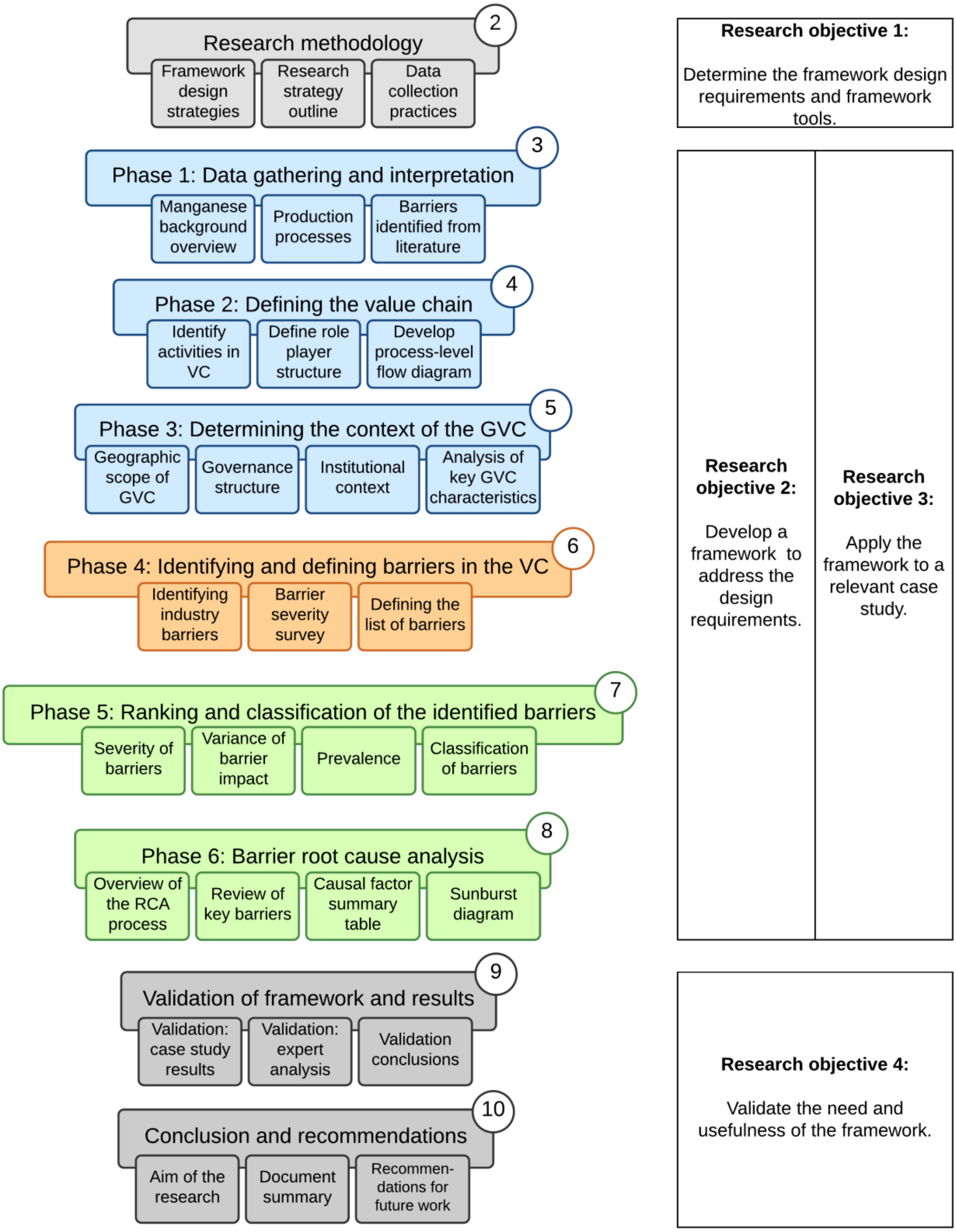


Figure 1-4: Overview of thesis and where each research objective is addressed

Chapter 2

2 Framework design methodology

Chapter 1 discussed the practical need for a framework which can be used to identify current barriers to growth in a mineral value chain and the importance to understand these barriers. This served as the foundation whereupon the research problem is constructed, from which the research objectives are developed. It is from this research problem and subsequent objectives that an appropriate framework design is constructed.

This chapter provides the processes followed to develop a framework that addresses the overall research aim as set out in Chapter 1. It elaborates on the various strategies implemented to determine the outline of the framework, as well as identifying all of the tools required to achieve each individual framework design requirement.

2.1 Overview of the framework development process

The framework to identify barriers in the MVC, will be developed in two stages, as shown in Figure 1-2. The first stage is *Framework requirement and tool identification*, which is represented in Figure 2-1. This process entails identifying the main framework design requirements, which is derived from the problem statement and research objectives, as well as the tools necessary to address these requirements. Before the tools are identified, however, strategies per framework requirement will be developed in order to determine how the specific tools to address each requirement will be selected. During this process, sub-requirements will be identified from literature, which will explicitly state the nature of the tools that are required. Each strategy will identify either primary tools, which are already established in similar fields of study, or secondary tools, which are proposed specifically for this framework. A distinct strategy will be developed for each framework requirement.

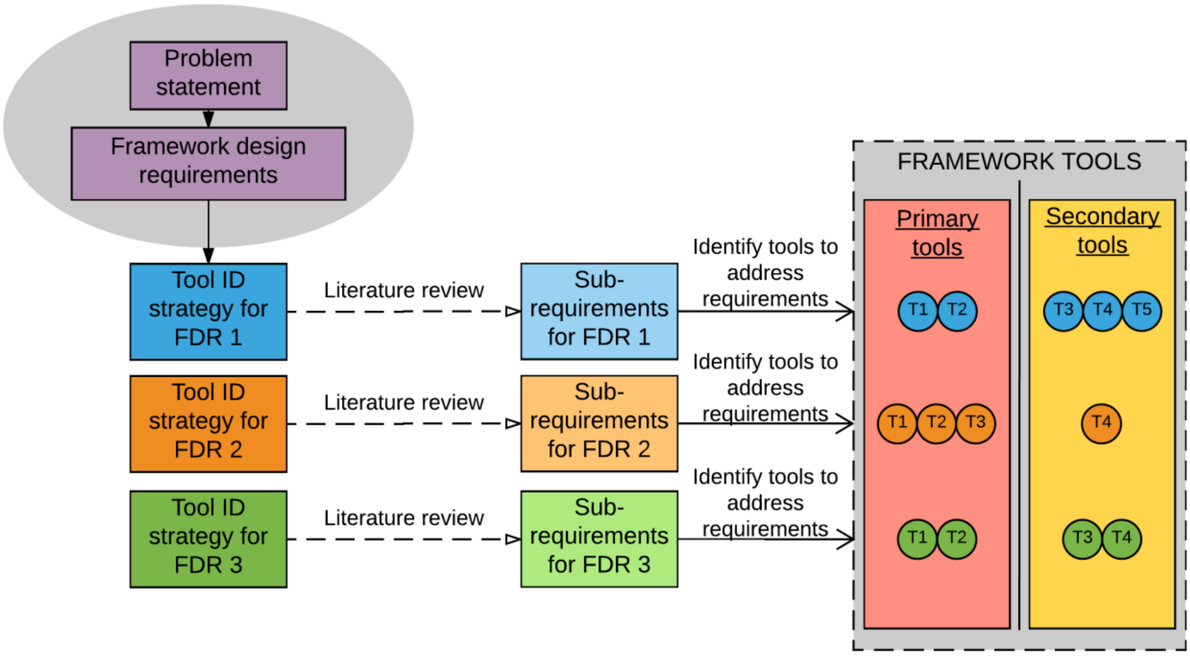


Figure 2-1: Representation of the *Framework requirement and tool identification* stage

The following stage of the framework development process, is *Framework integration*, as shown in Figure 2-2. During this stage, specific tools are grouped together to form framework phases. These phases divide the framework into specialised sections which focuses on a specific element of analysis, which makes the framework easier to digest for the user. The framework consists of six framework phases. The methodology required to implement the framework will be developed per phase and concurrently illustrated through the use of a case study, i.e. the South African manganese industry.

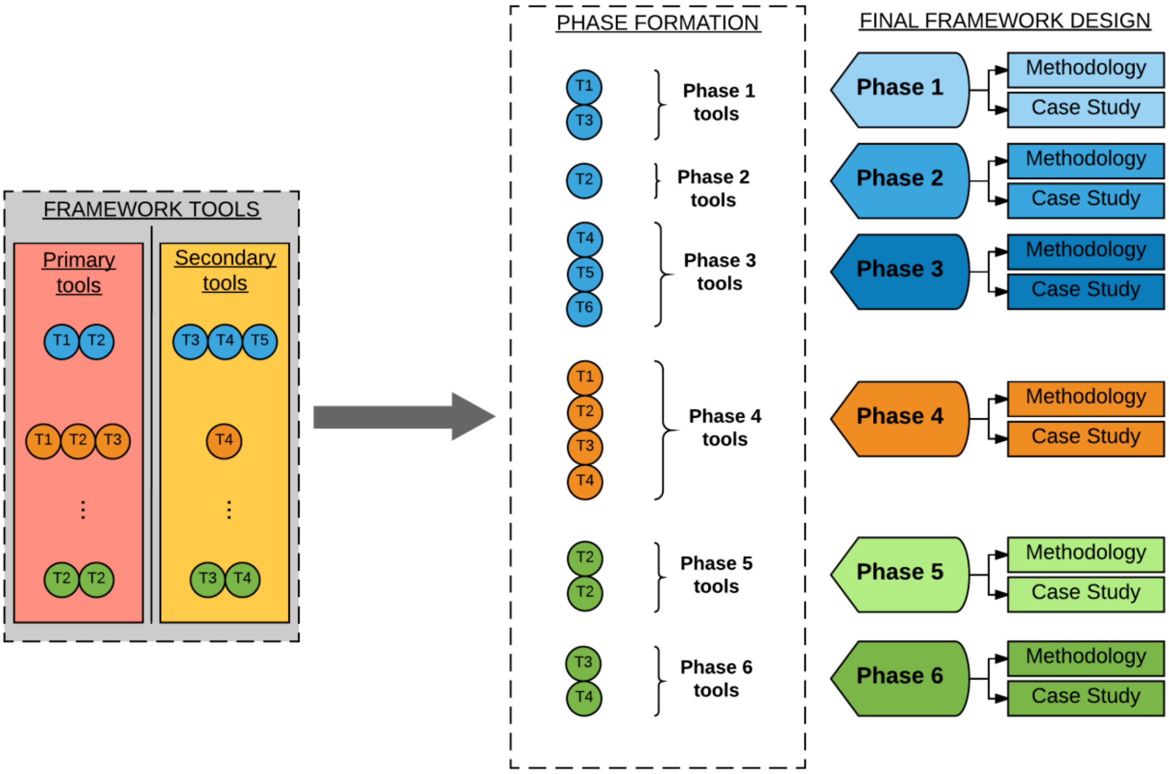


Figure 2-2: The *Framework integration* stage

2.2 Framework design requirements

The main research aim, as discussed in section 1.2.2, is developing a framework that identifies the barriers to growth for various role players within a particular mineral value chain. This framework would allow policymakers to determine what the major barriers are, how severely it impacts role players within the industry, and how they originate. It could serve as the initial step in addressing these concerns, since it is only possible to solve these problems once they have been identified. To ensure that the aim is reached and the problem statement is properly addressed, framework design requirements would need to be identified. Three primary framework design requirements were identified, as shown in Figure 2-3, and described as follows:

1. ***Identify and describe the MVC environment***

   In order to identify and understand the barriers faced within a MVC, it is imperative that the MVC environment is defined and investigated. It would seem implausible to be able to identify barriers within a value chain without understanding the chain's dynamics and the context in which it is embedded. This requirement is supported by many literature sources stating, for instance, that: "*the environment and industry in which the firm functions, is an essential element in determining the market's attractiveness in terms of present and likely future demand, ease of doing business, as well as the level of competition*" (Kaplinsky & Morris 2000).

   The environment in which a firm operates, is a significant factor in determining the firm's business strategy, the products it offers, operations and the most effective method to deliver its products and/or services (Kaplinsky & Morris 2000). In order for the entities associated with a given mineral industry to effectively reach their performance objectives and be competitive, insight into the industry value chain is imperative (Gereffi & Fernandez-Stark 2011; De Backer & Miroudot 2014; Kaplinsky & Morris 2000). By understanding the MVC and the MVC environment, it is possible to identify where the major constraining factors lie for its stakeholders and serves as the basis for identifying the barriers faced throughout the chain.

2. Identify barriers in the MVC

Many of the literature providing an overview of the South African minerals industry is relatively outdated and rely on sources which was published before many major operational impediments occurred. Examples include the sharp rise in electricity tariffs, unreliable power supply, the commodity cycle facing a record low point, increased labour disputes in the mining sector, and the implementation of new government policies affecting the industry (Gajigo et al. 2011; Basson et al. 2007; Bonga 2008; Steenkamp & Basson 2013). Alternatively, current constraints are identified in literature, but is limited to a specific sector within the value chains, such as mining (Elliot 2015b; Elliot 2014; Von Below 1992), only information of a specific minerals are available (International Manganese Institute & RPA 2015; Pooe & Mhelembe 2014; Gajigo et al. 2011), or the investigation's scope is too broad (D'Harambure 2015; Elliot 2015b).

The minerals industry often finds itself going through various changes, as mentioned above, with new barriers to growth constantly presenting themselves. Adapting to the ever-changing mineral processing environment is a common struggle for many role players involved in this complex field. Furthermore, every role player has a very specific set of barriers and opportunities which is inherent to the environment and context of their position within the chain. A custom set of barriers would thus need to be identified which addresses each role player's specific conditions. The proposed framework is consequently required to be able to identify the latest/current barriers, which are unique to the respective sectors of the chain and cater directly to the role players involved in the chain.

3. Prioritization of barriers

Simply identifying the barriers in a MVC would not contribute any practical value to government, policymakers or any other significant authoritative body, unless the barriers are analysed and prioritized according to the level of impact it has on the industry. This would include conveying information such as which barriers can be addressed as a collective, which barriers are the most severe in certain sections of the chain, recommendations as to how the barriers can be addressed and who is responsible for the barriers.

This requirement would ensure that the framework is well-rounded and makes a practical contribution to the industry. It would provide investors, analysists and other stakeholders in the value chain with a consultation tool for management queries and investing decisions, as well as provide industry perspective and insight to the dynamics which are at play in determining a firm's performance or projected performance (Rajagopalan 2015).

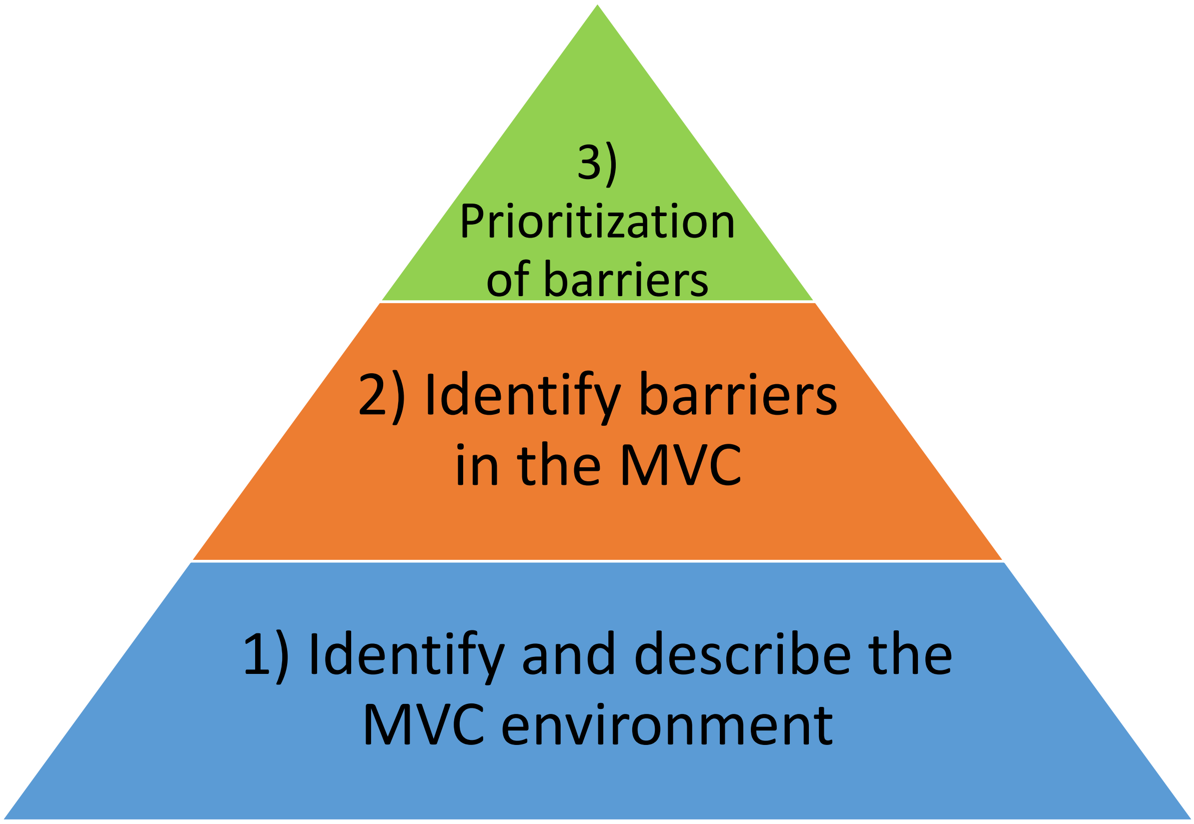


Figure 2-3: The design requirements of the proposed framework

A strategy to determine the selection of tools to address each framework requirement, is discussed in the following sections.

2.3 Strategy to identify the framework tools for describing the MVC environment

Much research has been done on various approaches to describe production chains in a variety of forms. This includes supply chains, value chains, commodity chains, global value chains and many more. Many established researchers in this field call for stringent research methodologies in the context of the chain that is studied (Gereffi 1995; Sturgeon 2001; Kaplinsky & Morris 2000). From the extensive research already done in this field, applicable approaches to describe the MVC will be identified and investigated to determine if it is suited for the research. Aspects that are lacking in these approaches will be identified and addressed in the framework. The tool identification strategy to address the first framework requirement (*Identify and describe the MVC environment*) is summarised in the following steps:

1. Compare value chain analysis approaches;
2. Select approaches to be implemented in the framework;
3. Identify limitations of the selected approaches;
4. Identify the framework sub-requirements;
5. Identify the required supplementary tools;
6. Determine if the framework sub-requirements are met.

Figure 2-4 is a visual representation of the above process to determine the tools that will be incorporated into the proposed framework to describe the MVC environment. The first step entails investigating and comparing various chain related concepts. Afterwards, the most suitable approach or hybrid of approaches are selected for describing the MVC. The selected approaches are then scrutinized to identify if these concepts have any limitations with regards to the study. If this is the case, supplementary tools will be identified to address these concerns and incorporated into the framework. Lastly, it will be verified that all the research objectives for this study are met.

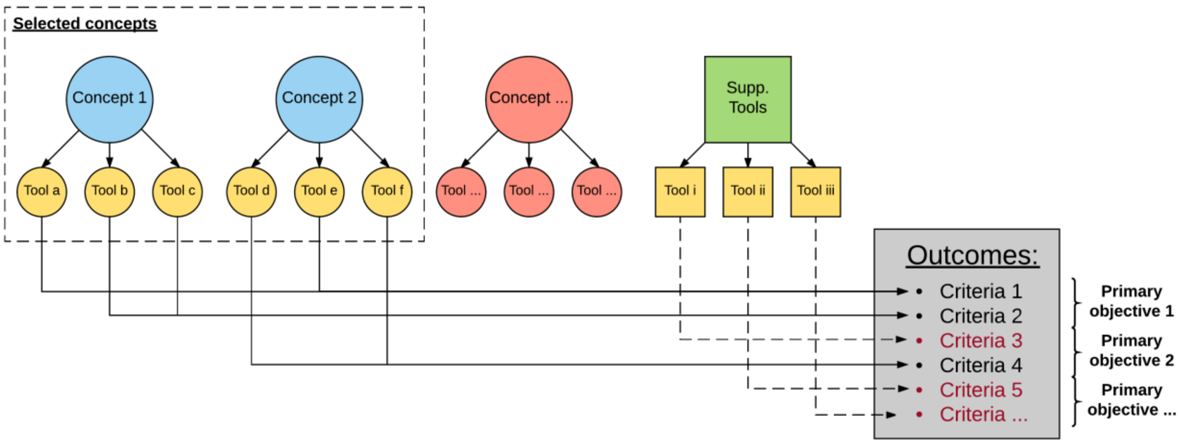


Figure 2-4: Strategy to identify the framework tools for describing the MVC environment

2.3.1 Comparison between value chain analysis approaches/methodologies

Extensive research has already been done in defining concepts and approaches to describing the various production stages and activities involved in transforming raw materials into products for the end-user. The most prominent and best suited approaches for this study are identified and discussed in this section.

2.3.1.1 The Filière concept

The French filière approach originated in the 1960s through the study of contract farming and vertical integration in French agriculture (Raikes et al. 1999). It initially dealt with local production systems and consumption, with a broader perspective only introduced in the 1980s with areas such as international trade and processing. This concept describes the flow of physical inputs and services in the production of a final product (Kaplinsky & Morris 2000). The quantitative nature of filière analysis has mainly been used to measure inputs and outputs, prices, and value-addition along a chain. The chains considered for this analysis traditionally involved primary commodities and has a strong linkage to heavily state-regulated marketing systems. The main objective of this approach is to "*map out actual commodity flows and to identify agents and activities within a filière (chain), which is viewed as a physical flowchart of commodities and transformations* (Raikes et al. 1999)".

This approach is often perceived as having a static character since it only reflects relation in the chain at a certain point in time. It does not indicate growth or decline of commodity or knowledge flows, nor the change of role players (Kaplinsky & Morris 2000). In general, the filière analysis is applied to the domestic value chain, thus stopping at national boundaries.

2.3.1.2 Commodity chains

A commodity chain can be defined as “a network of labour and production processes whose end result is a finished commodity” (Hopkins & Wallerstein 1986). Hopkins and Wallerstein see all firms as being involved in commodity chains as either producers of inputs to others or users of inputs received from others. The analysis of these chains provide insight to how the production, distribution and consumption in the different sectors and activities within a commodity chain are shaped by social relations (Drost et al. 2010). The commodity chain framework offered a new paradigm to deal with development issues, such as competition and innovation in different sections of the chain. Commodity chains are elaborated upon in the next section, Global Commodity Chains.

2.3.1.3 Global commodity chains (GCC)

Global commodity chains (GCC), which was introduced into literature by Gereffi during the mid-1990 (Gereffi 1994), has enabled important advances in the analytical and normative usage of the value chain concept. This is particularly due to the focus which was placed on the power relations which are imbedded in value chain analysis. The importance of chain governance is highlighted in this approach. Gereffi has shown through explicitly focusing on the coordination of globally dispersed, but linked, production systems, that many chains are characterised by a dominant party or parties. These lead firms determine the overall character of the chain. With the GCC approach a distinction is made between two types of governance, namely buyer-driven commodity chains and producer-driven commodity chains.

Researchers in the GCC field describe commodity chains as sets of inter-firm networks which connect manufacturers, suppliers and subcontractors in global industries to each other and ultimately to international markets (Bair 2005). The principle focus of GCC analysis is understanding how global industries are organized. It consists of identifying the full set of role players involved in the production and distribution of a particular good or service and mapping the relationships around it. GCC investigates how value is created and distributed along the chain. The GCC concept, however, is often critiqued for its minimal definition and lack of adequately incorporating regulatory issues in the framework (Raikes et al. 1999).

2.3.1.4 Supply chain approach

Supply chains often make up a core component of strategic management in business management literature. It is defined as “the alignment of firms that bring products or services to the market” (Stock & Lambert 2001), or as “all interactions between suppliers, manufacturers, distributors, and customers” (Heizer & Render 2001). This concept originated from Supply Chain Management, an integrative approach to control the transfer of information and movement of products between suppliers and end users (Drost et al. 2010). The supply chain comprises the flow of all information, products, materials and funds between the different stages of creating and selling a product. The chain includes all functions involved in receiving and filling a customer request. It is a connection of all parties, resources, businesses and activities involved in the marketing or distribution through which a product reaches the end user.

2.3.1.5 Value chain

The idea of a value chain was pioneered by Michael Porter to depict how customer value accumulates along a chain of activities that lead to an end-product or service (IMA 1996). Porter describes two major categories of business activities, primary and support activities, which provides a company with the ability to create value that exceeds the cost of providing its product or service to customers (Porter 1985). According to Porter, maximizing these activities will allow companies to gain a competitive advantage over competitors in the industry.

Thus, a value chain refers to the range of activities that add value at every step within a chain that delivers a product to the customer. Value chain analysis is the process of evaluating the activities within and around the organization and relating to its ability to provide value into its product to customers. Each activity within a value chain can be overseen by a single firm or included the involvement of multiple firms. The concept of Porter's value chain, was elaborated upon by Gereffi, as discussed in the next section.

2.3.1.6 Global value chain (GVC)

As described in the previous section, the value chain is defined as the full range of activities that firms perform to bring a product from its conception to end use (Grote & Winter 2009; Gereffi & Fernandez-Stark 2011). GVCs are established by activities executed on a global scale through inter-firm networks (Gereffi & Fernandez-Stark 2011). A comprehensive and integrated prospect of global industries are provided by GVC analysis, both from a top-down and bottom-up perspective. The GVC analysis methodology consists of fair basic dimensions (Gereffi 1995; Gereffi & Fernandez-Stark 2011):

1) An input-output structure (which describes the process of transforming raw materials into final products);
2) A geographical analysis of role players and activities;
3) A governance structure (which describes how the chain is controlled), and;
4) An institutional context in which the industry value chain is embedded.

GVCs link producers and consumers from around the world into an integrated global economy. The GVC framework provides insight as to how global firms are coordinated by investigating the structure and dynamics of the role players involved in a specific chain. This methodology is often used as a tool to trace global production, linked geographically dispersed activities and role players, and determining the roles they play within the industry (Gereffi & Fernandez-Stark 2011).

The Global Production Network (GPN) concept that is described in literature, is very similar to the GVC concept developed by Gereffi. The main difference is that the use of the *chain* metaphor is a conceptualization of the production and distribution processes as being essentially vertical and linear, while the *network* concept incorporates more dimensions, which could essentially be described as a number of intertwined chains (Henderson et al. 2011). In many cases in literature, the GVC and GPN concepts share many similarities and describe the same aspects in most cases (Grote & Winter 2009). Both of these concepts are very similar, but since both essentially consists of value chains and the GVC approach has a better suited mapping procedure, as well as additional analysis tools, the GPN concept will not be considered for this research.

2.3.1.7 Chain Notations

Various terminology and definitions are applied to value chain analysis that are quite similar, and in some cases, are even interchangeably used in literature. There are, however, subtle differences between these contending concepts. Grote and Winter summarises these notations in Table 2-1:

Table 2-1: Chain notations and definitions

Source: (Grote & Winter 2009)

Term	Definition	Scale
Input-Output Structures	The set of products and services linked together in a sequence of value adding economic activities.	Organizational
Supply Chain	A generic label for an input-output structure of value-adding activities beginning with raw materials and ending with the finished product. It is concerned with logistics rather than market development.	Organizational
Value Chain	Entire spectrum of activities needed to bring a product or a service from its initial phases, through the various stages of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers.	Organizational
Production Network	A set of inter-firm relationships that bind a group of firms into a larger economic unit.	Organizational
Global Value Chain	The sequence of activities required to produce a final product. It refers to all activities from conception of a product to its consumption. A value chain is 'global' when activities are carried out in different countries.	Spatial
International Production Network	A focus on the international production networks in which multinational corporations act as 'global network flagships'.	Spatial

2.3.1.8 Summary of the different value chain concepts

The concepts that are discussed in the previous sections, encapsulates the most prominent analysis approaches of production chains (Bair 2005; Drost et al. 2010; Grote & Winter 2009). The historic development of the discussed theories is represented in Figure 2-5:

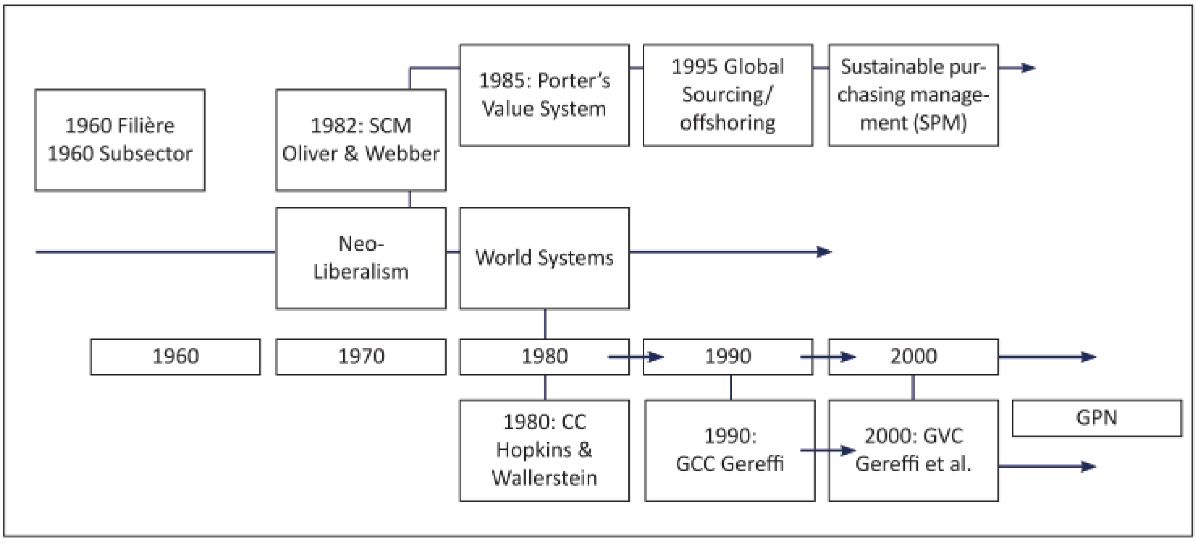


Figure 2-5: History of value chain analysis approaches
Source: (Drost et al. 2010)

During the review of these approaches, five perspectives were identified in literature in which the production chain analyses can be performed. Gereffi and Lee (Gereffi & Lee 2012) distinguishes between three perspectives: the industry perspective (how the industry is organized as well as where the companies are located), the national competitiveness perspective (whether countries can gain and maintain production, sales and research capabilities), and the international development perspective (country's participation and role in the global economy and global supply chains).

A distinction between two different perspectives, namely the strategic management perspective and the development perspective, are also made (Drost et al. 2010). The former refers to aspects that are relevant to the concept of global supply chains, while the latter is concerned with global commodity chains and global value chains. These distinctions are similar to that of Gereffi and Lee, since Drost et al.'s strategic management perspective relates to their industry perspective and the development perspective encompasses Gereffi and Lee's international development and national competitiveness perspectives.

Much research has already been done in identifying and assessing value chain-related analysis approaches (Bair 2005; Grote & Winter 2009; Drost et al. 2010). These concepts are categorised according to the aforementioned perspectives and summarised in Table 2-2. The table conveys the main characteristics of each of the identified approaches.

Table 2-2: Summary of contending chain concepts (Bair 2005; Grote & Winter 2009; Drost et al. 2010)

Analysis perspective	Concept	Theoretical foundation	Objectives	Underlying concepts	Characteristics & limitations	Level of analysis	Key contributors
Strategic management / Industry perspective	Supply chain approach	– Supply chain management	– Manages the total flow of goods from suppliers to the ultimate user	– Conveyance	– Less equipped for analysis of social and environmental sustainability issues	Lead firm	– Oliver and Webber (1982) – Hines (2004)
	Value chain	– No unified theoretical foundation – Supply Chain Management	– Focus on industrial firms – Competitive advantage by breaking down its activities into the value added – Creates a competitive advantage for a firm (through cost reduction measures and differentiation)	– Concept of in-house value added	– Restricted to production processes at firm level – No attention to international territorial arrangements – Less equipped for analysis of social and environmental sustainability issues, focusing solely on processes within one company	Individual firms	– Michael Porter (1985)
National competitiveness / International development perspective	Filière approach	– No unified theoretical approach – Agro-food studies	– Physical inputs & outputs, prices and value added in marketing chains	– No underlying concept (neutral)	– Static model – National boundaries – Most work is rather technical, lacks consistency	Local or national production level	– Raikes et al. (2000)

Analysis perspective	Concept	Theoretical foundation	Objectives	Underlying concepts	Characteristics & limitations	Level of analysis	Key contributors
			– Focus on agricultural commodities – A neutral, practical tool of analysis for use in 'down-to-earth' applied research		in the filière tradition, and focuses mainly on local and national levels of the chain (not global)		
	Commodity chain	– World systems theory derived from dependency theory	– Explanation of the World – capitalist economy	– International division of labour – Core-periphery-semi periphery	– Holistic point of view – Macro-orientated – Qualitative analysis	Local or national production level	– Wallerstein (1974)
	Global commodity chain (GCC)	– World systems theory – Organizational sociology	– Power relations of globally linked production systems (meso and micro level) – Focus on industrial goods – The commodity chain framework offers a new	– Governance (consumer-driven / buyer-driven) – Organizational Learning / Upgrading	– Focus on governance – Minimal definition – Regulation not adequately incorporated in framework – Focuses primarily on industrial commodities	Countries	– Gereffi (1994a), (1994b), (1999) – Gereffi et al. (2005)

Analysis perspective	Concept	Theoretical foundation	Objectives	Underlying concepts	Characteristics & limitations	Level of analysis	Key contributors
			paradigm to deal with development issues and focuses on the full length of global chains (appealing for scholars in development studies)				
	Global value chain (GVC)	– Global commodity chains – World System Theory	– Governance and regulation systems – Linking horizontal and vertical approaches – Better understanding of entry barriers and unequal access to markets – Notions of the power that different chain actors possess	– Governance – Transaction costs – Upgrading	– Composition of commodity chain, GCC, World Economic Triangle – Not comprehensive enough (value chains are embedded in broader relationships)	Transnational networks of companies	– Gereffi & Kaplinsky (2001) – Humphrey & Schmitz (2000a), – Gereffi et al. (2005)

2.3.2 Selection of methodologies

The selection of value chain analysis approaches is based on criteria derived from the research objectives as set out in section 1.2.2. The reasons for including the selected methodologies are discussed in this section. From the six value chain analysis methods that were identified, a single or a combination of multiple approaches will be selected to describe the specific MVC and MVC environment. It will serve as a foundation to identify the barriers to growth and ultimately to provide an understanding of these barriers.

It is important to incorporate approaches from both set of perspectives as described in section 2.3.1.8, namely the industry (or strategic management) perspective and the development (or national competitiveness and international development) perspective. The barriers will be identified on both a firm level, to obtain specific and practical issues faced by key role players in different sectors of the industry, and on an international level, to determine the effect that foreign factors have on these firms. The value chain analysis approaches will be evaluated according to the two sets of perspectives.

2.3.2.1 Analysis approaches for the strategic management / industry perspective

As indicated in Table 2-2, there are two identified approaches in the strategic management or industry perspective, namely the supply chain approach and the value chain approach. Supply chains manage the flow of goods from suppliers to the ultimate user and is a core concept for strategic management (Drost et al. 2010). Despite providing information on the physical flow of products through the chain, supply chains also convey all interactions between suppliers, manufacturers, distributors and customers. These characteristics could provide good groundwork to determine the linkages between different role players within the chain and convey the product output of each of these role players. The supply chain approach does not, however, provide significant insight on the various processes involved in product value adding.

Michael Porter's value chain is a more comprehensive approach in depicting how value accumulates along a chain of activities that lead to an end-product. Value chain analysis furthermore covers the full extent of activities within the chain, which is encapsulated in the two categories, namely primary activities (activities directly involved in transforming inputs into outputs) and support activities (secondary activities facilitating the primary activities) (Porter 1985). The various elements in Porter's value chain allows for each activity in the chain to be examined in order to determine its effect on the company's competitive advantage. A company's competitive advantage, or lack thereof, serves as a basis to identify the potential barriers to growth they face.

One of the primary differences between the two concepts, is that a supply chain involves the entire process of all parties involved in fulfilling a customer request, while a value chain is a set of interrelated activities a company uses to create a competitive advantage (Surbhi 2015). Thus, the supply chain can be described as a tool of business transformation to improve customer satisfaction by providing the right product at the right time. Conversely, the value chain is a concept of gaining competitive advantage by maximizing primary activities to fulfil customer requirements (IMA 1996). Since Porter's value chain aligns with determining and measuring a company's growth, it is better suited in this research. Porter's value chain will be used from an industry perspective for this study for the following reasons:

- It provides a comprehensive description of the entire scope of the value chain;
- Identifies all the role players involved within the chain as well as the relationship they have with one another;
- Includes all the value-added processes within the chain;
- Investigates the competitive advantage by breaking down activities into the value added, and;
- Focuses on an industry level.

2.3.2.2 Analysis approaches for the national competitiveness / international development perspective

The four methodologies of the second analysis perspective are more varied and focuses on a national and international scope of the chain. The first concept, the Filière approach, is traditionally used in agricultural studies and primarily focus on physical inputs and outputs in the chain (Raikes et al. 1999). It is a static model which is restricted within national boundaries and is ultimately not very comprehensive in describing the entirety of the chain and the complexity thereof. The commodity chain approach is also limited in describing the mineral value chain environment and its scope of analysis restricted to a national production level (Raikes et al. 1999; Bair 2005). Furthermore, the GCC approach is an extension of this approach, which takes international factors into account and makes it a more suitable option of analysis for this study (Drost et al. 2010; Grote & Winter 2009).

The two options covering this perspective both have an analytic scope extending internationally. These approaches are the global commodity chain (GCC) and global value chain (GVC) concept. The GCC approach factors in the power relations of globally linked production systems. It describes the chain's role player relationship as one of two governance structures, namely producer-driven or buyer-driven, which is very rigid. GVC analysis, on the other hand, is much more complex and takes a much larger range of factors into account when investigating the value chain. It has a transnational scope of analysis and consists of a composition of commodity chains, World Economic Triangle and GCC (Grote & Winter 2009).

Moreover, GVC factors in more complex governance structures and distinguishes between five different chain topologies in comparison to the two, less sophisticated structures, provided in GCC analysis (Gereffi 1994; Gereffi & Fernandez-Stark 2011). Gereffi's GVC approach also incorporates additional tools for analysis including, an input-output structure (similar to Porter's value chain description), investigation of the chain's geographic scope and institutional context (Gereffi & Fernandez-Stark 2011). GVC analysis also shares certain characteristics with Porter's value chain, which is already selected for analysis on an industry level. GVC is thus a very suitable approach for describing the mineral value chain for this study. GVC analysis is incorporated in the framework for the following reasons:

- It describes the value chain in a global context;
- Includes a value chain mapping structure;
- Takes chain governance structures into consideration;
- Factors in, to some degree, institutional attributes of the chain, and;
- Elaborates upon Porter's value chain.

2.3.2.3 The importance of global value chains

With globalisation more established in modern times, the global economy is becoming increasingly integrated with GVCs. This opens many more opportunities for international trade, rising GDP and employment. The progression of GVCs has made a significant impact on various markets as diverse as electronics, commodities and business services, with regards to global trade, production and employment. GVCs are also a determinant factor as to how developing country's firms, producers and workers are integrated in the global economy (Gereffi & Fernandez-Stark 2011).

According to the 2013 United Nations Conference on Trade and Development (UNCTAD), approximately 60 per cent of global trade, which at present amount to over $20 trillion, consists of trade in intermediate goods and services that are incorporated at various stages in the production process of goods and services for final consumption (UNCTAD 2013). The fragmentation of production processes and the international dispersion of tasks and activities within them, have led to the emergence of borderless production systems, which is commonly referred to as global value chains.

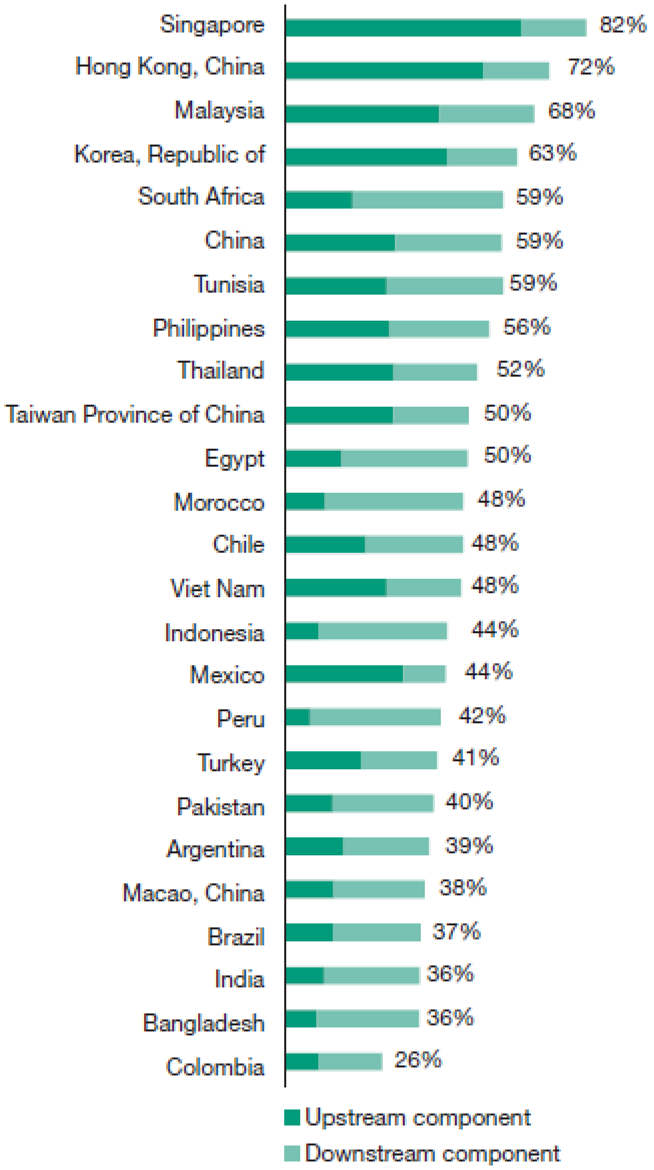


Figure 2-6: GVC participation rate of the top 25 developing economy exporters in 2010

Source: (UNCTAD 2013)

Various firms, workers and consumers from all around the world are linked through GVCs and it often provides a mechanism for firms in developing countries to consolidate a position within the international market. Gereffi (Gereffi & Fernandez-Stark 2011) describes in his research that the ability for countries to efficiently imbed themselves into global value chains, is a crucial prerequisite for the country's development, especially for low-income countries.

This is exemplified in the exponential increase in global trade over the last decade as firms expand their international production networks, trading inputs and outputs between affiliates and partners in GVCs according to UNCTAD's World Investment Report of 2013 (UNCTAD 2013). The report reveals that South Africa has the fifth largest GVC participation rate of developing economy exporters in 2010, which predominantly consists of a downstream component and significantly smaller upstream component (see Figure 2-6).

GVC participation indicates the share of a country's exports that is part of a multi-stage trade process. It is the foreign value added used in a country's exports (upstream perspective) plus the value added supplied to other countries' exports (downstream perspective), divided by total exports (Coe 2013).

Global value chains allow for a better understanding of the organisation of global industries through the examination of the structure and dynamics of the various role players involved in a given industry. GVCs is an significant tool to trace shifting patterns of global production, link geographically dispersed activities and role players of a single industry, and determine the roles they play in different countries (Gereffi & Fernandez-Stark 2011). This has become increasingly more essential with today's globalized economy which has very complex industry interactions.

2.3.3 Identifying limitations of the selected approaches

Although both Porter's Value Chain and Gereffi's Global Value Chain analysis are well-established tools for describing value chains and both taking different aspects of the mineral value chain environment into account, there are however some disparities in these approaches in terms of mapping and investigating the specific chain, especially with the goal of identifying barriers to growth. The policy recommendations provided in GVC studies are often qualitatively based and therefore very subjective. In order for this research to provide a valuable contribution, policymakers should be provided with concrete results to support the framework's barrier identification process in order to justify investments and policy changes. Sturgeon and Gereffi (Sturgeon & Gereffi 2009) concluded that:

"A major impediment to using qualitative research and conceptual theories to support specific policy interventions is the lack of comparable and detailed data on the industrial capabilities of firms, industries, and countries and the roles that they play in the global economy. The GVC framework provides a conceptual toolbox, but quantitative measures are lacking. While the development of objective, industry-neutral measures of GVC governance is a laudable goal, and survey questions are currently being fielded to collect data on the governance character of inter-firm linkages in both cross-border and domestics sourcing relationships, better information to characterize the roles of firms, regions, and countries in GVCs is urgently needed."

Frederick also identified three major limitations with regard to the GVC analysis approach (Frederick 2014):

- *Purpose*
  Frederick argues that many GVC studies are inconsistently implemented since many are either primarily focused on the mapping sections of the framework (input-output structure and geographic scope) or one of the two analysis components (governance or institutional context). In order for this approach to provide insightful analysis and recommendations, a detailed mapping process must occur. If a study only incorporates the mapping components, then it does not contribute new findings and is purely descriptive.

- *Repeatability*
  Most GVC studies are limited in terms of the ability to easily update, expand or replicate the study, according to Frederick. This could possibly be since the process is not standardized and is often open for interpretation for the researcher conducting the study. The proposed framework should thus be rigid and provide clear steps outlining how it can be adapted and applied to a specific MVCsto identify and understand its barriers.

- *Time-consuming*
  Frederik's last criticism is on the arduous and time-consuming process of GVC mapping and analysis. Since the proposed framework is specifically designed for MVCs, an outline of the generic mapping activities and analysis concepts are provided and would in most cases only require the input data that is specific to the MVC in question. This would speed up the process immensely.

Frederick continues by listing areas of GVC analysis where some improvements can be made. Firstly, mapping the industry-specific value chains need to be standardized. Each GVC researcher employs their own method in this mapping process, with the majority of the researchers basing this on their interpretation of key role players (Frederick 2014). Another improvement, is implementing industrial data (such as input-output datasets and trade data) to quantify the GVC perspective, which correlates with the suggestion made by Sturgeon and Gereffi (Sturgeon & Gereffi 2009).

In the context of this study, these two approaches face other limitations as well. The main criticism for these approaches is that it is not explanatory in nature, but rather primarily descriptive. It a suitable tool for retrospective investigation of a value chain and to identify the current extent of downstream processing, but lacks any form of foresight analysis or explanations for the barriers to growth within the chain. These methodologies were not designed to include barrier identification, which is imperative for this study and primarily describes the MVC environment in terms of the flow of products, role player relations and the scope of activities. These aspects are also pivotal, but its viewpoint needs to be adjusted to align with the specifications of ultimately not only describing the MVC, but also understanding the barriers that it faces within the industry.

The two selected analysis methodologies also lack taking attributes of the chain into consideration that do not directly pertain to production processes, such as social issues, environmental concerns, government support, legal implications, etc. Even though these factors are not directly involved in the manufacturing of goods, it has a significant impact on the growth of a company. Furthermore, where value chains on focuses on role player relationships on a trade level, other influences that has an impact on economic growth should also be factored in. Lastly, the method must ensure that all the sectors comprising the chain (within the scope of the study) should be taken into consideration to account for barriers across the whole chain of operations.

2.3.4 Identifying the first set of framework sub-requirements

Nine framework sub-requirements are derived from the limitations to describe MVCs as discussed in section 2.3.3. These sub-requirements will ensure that the selected framework tools address the shortcomings and research gaps identified in the literature review. The following framework sub-requirements were identified:

- **FSR1:** Background knowledge on the specific mineral industry;
- **FSR2:** Identification of key activities in the value chain;
- **FSR3:** Identification of the value chain role player structure;
- **FSR4:** Identification of the different sectors composing the industry;
- **FSR5:** Identification of the process-level flow of inputs, outputs and intermediate products in the value chain;
- **FSR6:** Domestic industry's global market position;
- **FSR7:** The geographic scope of operations in the mineral value chain;
- **FSR8:** Determine the power relationship between role players;
- **FSR9:** Industry's current-state-of-affairs evaluation.

2.3.5 Supplementary tools for describing the MVC

The previous section discussed disparities in Porter's Value Chain and Gereffi's Global Value Chain analysis for describing the mineral value chain environment to ultimately identify the barriers to growth. Both these approaches are primarily implemented as descriptive tools by researchers to determine a company's competitive advantage, in the case of Porter's Value Chain, and to describe the complex network relationships between firms that span wide geographic areas with GVC analysis. These tools are not, however, configured for explanatory purposes, especially for identifying barriers to growth for various key role players across a mineral value chain. In order to address the limitations of these approaches within the study, supplementary tools will also be implemented to reach the outcomes that are not yet satisfied for this research.

The tools are identified to address outcomes of the study that are not met and reconstruct the methodologies to place more focus on identifying barriers throughout the value chain. The following tools are incorporated in the proposed framework to add more dimensions of analysis to the mineral value chain.

2.3.5.1 Background review of the specific MVC

A comprehensive background and literature review is essential when conducting research at any level. It not only surveys what has already been done in the past on the topic, but it also appraises and correlates various forms of literature that directly relates to the subject. An in-depth literature review will provide an overview of the specific MVC and elaborate upon the fundamental aspects distinctive to it. Literature was gathered from various sources, including journals, company documents and publications, grey literature, conferences on specific mineral industries and news reports.

2.3.5.2 Mapping the mineral value chain

One of the main criticisms of the mapping components of the selected analysis approaches, is that it is not standardized. Researchers thus employ their own method and interpretations for this mapping process. A systematic process is set out in the proposed framework to develop a generic mineral value chain which can easily be configured by the user. Porter's Value Chain will be applied to the specific chain and merged with the input-output structure approach of GVC analysis. This will both serve as an example as to how to map the chain in question and also to provide the generic activity segments which make up a mineral value chain.

2.3.5.3 Process-level flow diagram

Designing the specific mineral value chain provides insight into the various outputs produced in the different stages of the chain. By incorporating a process-flow diagram another dimension will be added to the analysis since it will add information regarding the technical aspects of transforming materials throughout the value chain in terms of inputs and outputs. The diagram will reveal the relationships among and between the various sectors and role players comprising the mineral value chain. Barriers will be identified for each of these sectors.

The process-level flow diagram is a very useful tool when analysing a specific mineral value chain for the following reasons (Le Vie 2000):

1. The process flow diagram, together with the value chain structure layout, provides a very detailed overview of the industry. These tools make it easier to understand the various processes involved in product manufacturing and the role players involved with each respective activity.
2. The process flow diagram provides a high-level system overview, complete with boundaries and linkages to other systems.
3. It can provide a detailed representation of the different process sectors comprising the value chain.

With the aid of the process-flow diagram, not only will the procedure of transforming inputs to outputs in different stages of the value chain, but also indicate the various sectors comprising the specific industry in the MVC. Barriers can then be identified for each of these sectors, in order to group them according to specific role players within the chain.

2.3.5.4 Global market position

As part of Gereffi's GVC mapping process, the geographic scope investigates the extent of the specific mineral processing activities, both on a domestic and global level. This geographical analysis entails identifying the key role players in each sector and the activities which they are involved in. Gereffi suggests investigating the presence of lead firms in certain countries, to determine their global position within the chain by reviewing country-level data, such as industry exports.

For the proposed framework, numerous quantifiable data will be taken into account in order to determine the market presence of the main role players on an international level. This includes examining the import and export figures of different products manufactured within the chain, major producers and consumers of these products, and the total market share of the main countries involved in the chain. An analysis of this data will help determine the trade relationships between countries and identify potential competitors and customers.

2.3.5.5 Elaboration of the MVC's institutional context

Another step of the GVC analysis methodology entails identifying the local, national and international conditions and policies that shape the globalisation in each stage of the value chain. Gereffi focuses on the GVC's local economic, social and institutional dynamics. In the modern era, there are more factors that influences a company's growth from various perspectives. In order to make provision for these aspects in the study, four additional tools are added to the framework to specifically elaborate upon the GVC analysis institutional context. These tools also shift focus from a primarily descriptive to an explanatory approach.

The first supplementary tool in this regard, is a summary of specific key aspects of the mineral value chain. This summary will identify key factors from Gereffi's institutional context analysis on a smaller scale, thus deconstructing the main economic, social and regulatory aspects into specific drivers that influences local role players and operations. These key aspects include technologic requirements and usage, workforce characteristics, return to scale effects, logistical costs, etc.

When this is completed, a short and concise PESTLE analysis will be executed to investigate the mineral value chain's main macro-environmental factors which have an impact on the role players involved in the chain. These factors will be grouped according to political, economic, social, technological, legal and environmental factors. Since the many, but not all, of the aspects are already discussed in the first two steps, only an overview of the main factors will be investigated. The PESTLE analysis primarily serves as a precaution that the majority of factors influencing the MVC has been taken into account and serves as a basis for the subsequent step, namely a SWOT analysis.

The SWOT analysis is a useful technique incorporated into the proposed framework to understand the strength and weaknesses in the mineral value chain, as well as identifying both opportunities and threats in the industry. Lastly, an influence diagram will be constructed which conveys who has control over specific aspects in the value chain. The influence diagram will elaborate upon Gereffi's governance structure analysis by expanding the focus between the major role players in the value chain beyond simply their trade relationship.

2.3.6 Selection criteria for the first set of framework tools

The final step for the tool identification process, is to determine if the selected tools meet all the framework requirements associated with this step. The outcomes achieved by each of the selected tools are summarised in Table 2-3.

Table 2-3: Criteria met by each of the selected tools for the first framework design requirement

Criteria	Literature review	Porter's VC	GVC analysis (I-O structure)	GVC analysis (Geographic scope)	GVC analysis (Governance structure)	GVC analysis (Institutional context)	Process-level flow diagram	Summary of key aspects	PESTLE	SWOT	Influence diagram
FSR1: *Background knowledge on the specific mineral industry*	✓							✓			
FSR2: *Identification of key activities in the value chain*	✓	✓	✓				✓				
FSR3: *Identification of the value chain role player structure*		✓	✓				✓				✓
FSR4: *Identification of the different sectors composing the industry*		✓	✓				✓				
FSR5: *Identification of the process-level flow of inputs, outputs and intermediate products in the value chain*		✓	✓				✓				

Criteria	Literature review	Porter's VC	GVC analysis (I-O structure)	GVC analysis (Geographic scope)	GVC analysis (Governance structure)	GVC analysis (Institutional context)	Process-level flow diagram	Summary of key aspects	PESTLE	SWOT	Influence diagram
FSR6: *Domestic industry's global market position*				✓							
FSR7: *The geographic scope of operations in the mineral value chain*		✓	✓	✓							
FSR8: *Determine the power relationship between role players*					✓		✓				✓
FSR9: *Industry's current-state-of-affairs evaluation*						✓		✓	✓	✓	✓

2.4 Strategy to determine the framework tools for identifying barriers in the MVC

The second framework design requirement focuses on the identification of barriers to growth faced in the different sectors comprising the MVC. The tools identified in the previous section, lay the necessary groundwork to start this process. The desired features of the identified barriers or specifics involved in the identification process, however, is yet to be determined. Reviewing the problem statement and second framework design requirement, will provide insight on these desired outcomes and consequently aid in identifying the framework tools to address it. The tool identification strategy to address the second framework requirement (*Identify barriers in the MVC*) is as follows:

1. Determine the desired features of the identified barriers through reviewing the problem statement and second framework design requirement;
2. Identify the framework sub-requirements;
3. Select tools to address the requirements;
4. Determine how the tools will be configured/implemented in the framework, and;
5. Determine if the framework sub-requirements are met.

2.4.1 Determining the desired features of the identified barriers

The desired outcomes of the barrier identification process can be derived through reviewing the problem statement (section 1.2.1) and second framework design requirement (section 2.2), *Identify barriers in the MVC*. It becomes evident from inspection of the problem statement that:

- Many sources identifying barriers in MVCs are dated, resulting in its findings not being a true reflection of the current state of the industry investigated (Gajigo et al. 2011; Basson et al. 2007; Bonga 2008; Steenkamp & Basson 2013);
- Only a single sector of the value chain is often investigated, without consideration of the other sectors also comprising the chain (Elliot 2015b; Elliot 2014; Von Below 1992);
- Information is restricted to specific minerals only, which makes identifying barriers in lesser-known mineral value chains very difficult (International Manganese Institute & RPA 2015; Pooe & Mhelembe 2014; Gajigo et al. 2011), and;
- The scope of investigation is often too broad, restraining a full analysis of the chain and only making it possible to provide an overview of certain barriers, which does not contribute a lot of value (D'Harambure 2015; Elliot 2015b). An analysis of the extent of these barriers are often not illustrated.

The desired features to be implemented in the proposed framework to address these gaps in literature, are derived as follows:

- Identify barriers that are current and provides an accurate reflection of problems faced in the industry at present;

- Identify all the barriers faced by the different role players in various sectors comprising the chain;
- Distinctly define the identified barriers, and;
- Determine the impact of these barriers as experience by the role players.

2.4.2 Identifying the second set of framework sub-requirements

The desired outcomes of the second set of framework tools, can be summarised in two sub-requirements. These sub-requirements will ensure that the selected tools address the research gaps derived from the problem statement. The following framework sub-requirements were identified:

- **FSR10:** Identification of the latest barriers across the different sectors in the in the value chain;
- **FSR11:** Determine the severity of the barriers.

2.4.3 Selection of tools to address the requirements

Primary data to identify barriers within the MVC will be collected by conducting interviews and surveys by following the Delphi technique. This technique is widely used and is an accepted method for gathering data from respondents within their field of expertise (Hsu & Sandford 2007). The technique is aimed to achieve a convergence of opinion on a specific real-world issue through a group communication process. The Delphi process has already been used in a variety of fields, which include program planning, policy determination and resource utilization to name a few (Hsu & Sandford 2007; Okoli & Pawlowski 2004). This is often implemented to explore underlying assumptions and correlate judgements on a topic spanning a wide range of disciplines.

According to Delbecq et al. (Delbecq et al. 1975), the Delphi technique can be used to achieve the following objectives:

1) Determine or develop a range of possible program alternatives;
2) Explore or expose underlying assumptions or information leading to different judgements;
3) Find information which may generate a consensus on the part of the respondent group;
4) Correlate informed judgements on a topic spanning a wide range of disciplines, and;
5) Educate the respondent group as to the diverse and interrelated aspects of the topic.

Another significant application of the Delphi technique, which has received widespread use, is the “ranking-type” variant Delphi (Okoli & Pawlowski 2004). It is used to develop group consensus about the relative importance of issues, which is the same approach that will be applied to this study.

There are four main features that characterizes the Delphi method, namely (Rowe et al. 1991; Landeta 2006):

- Anonymity – The participants remain anonymous since they only correspond directly to the group coordinator. This avoids any negative influences that could be exercised by factors from individuals on the rest of the group such as their status in their respective fields, which could influence the results of the other participants. Anonymity also ensures confidentiality, which is particularly important for this study where different companies identify areas where they are facing bottlenecks and other economic barriers.

- Iteration – This method is a repetitive process where the experts that are approached for the study are consulted at least twice in order to reconsider their answer. The study coordinator refines the responses, identifying all the underlying barriers mentioned by the respondents, and presents in the form of a survey for a second round of input.
- Controlled feedback – The exchange of information is carried out by means of a study coordinator so that all irrelevant information is eliminated.
- Statistical group response – All opinions gathered during the process form part of the final results and conclusions which are formed through the processing of quantitative data. This data is based on the numerical ratings of the impact of the respective barriers identified during the different rounds in the research.

Thus, the Delphi process, in contrast to other data gathering and analysis techniques, employs multiple iterations which is designed to develop a consensus of opinion concerning a specific topic (Hsu & Sandford 2007). More specifically, the selected Delphi participants are allowed to reassess their initial judgements about the information provided in previous iterations through the feedback process as they are exposed to new ideas which they did not previously consider. Other notable characteristics inherent with using this technique are the ability to provide anonymity to the respondents, a controlled feedback process and the suitability of a variety of statistical analysis techniques to interpret the data.

2.4.4 Configuration/implementation of tools in the framework

The Delphi process implemented in the framework for data gathering in order to identify the barriers, are divided into four rounds:

1. Generation of initial barriers;
2. Review and finalise barriers;
3. Barrier severity survey, and;
4. Finalise survey results.

2.4.4.1 Round 1: Generation of initial barriers

In the first round, the Delphi process focuses on obtaining as much information from the company's operations as possible, in order to start the investigation of barriers in the industry. This round entails interviews with experts in the specific field, ensuring that there are representatives of each of the sectors comprising the value chain in order to cover the entire scope of barriers. The Delphi technique traditionally makes use of questionnaires sent to the respondents, but interviews in this case allows for a more in-depth investigation of the barriers through greater flexibility. The interviewer has the freedom of aligning the questions with the interviewee's responses and to delve deeper in specific areas of questioning if need be.

The semi-structured interviews consist of open-ended questions which probes to identify areas in the company that might contain barriers, using the information gathered in thus far from the framework as a guideline. According to Hsu and Sandford (Hsu & Sandford 2007), it is both an acceptable and a common modification of the Delphi process format to use a questionnaire (or in this case interviews) in round 1 that is based upon an extensive review of the literature. Topics included in the interview can range from transport and logistics to labour conditions and power consumption. This round of interviews thus serves as the pillar of soliciting information about a content area from the Delphi subjects, in order to start identifying underlining barriers faced by the respondents.

After the subjects are interviewed and all the responses are received, the investigator needs to convert the collected information into a list of barriers. These barriers may vary in terms of severity and must be as comprehensive as possible. If it was mentioned as being or potentially becoming a problem with regards to the company's progress and development, it should be listed. This list of constraining factors will serve as the survey instrument for the following rounds of data collection.

2.4.4.2 Round 2: Review and finalise barriers

In the second round, each Delphi participant receives the list of barriers and asked to review the items summarized by the investigator based on the information provided in the first round. This establishes whether the respondents agree with the barriers that are listed. According to Ludwig (Ludwig 1994), Delphi respondents may be required to rate or "rank-order items to establish preliminary priorities among items. As a result of round two, areas of disagreement and agreement are identified".

The respondents are encouraged to add to the list if they encounter other barriers not yet identified. The last step, is to rank the barriers in order for the investigator to gain a grasp of the potential outcome and to identify which are the more established and which are the lesser barriers faced in the industry. The second round allows for the list of identified barriers from the experts' perspective to be formed and for a consensus among them to start forming.

With the inputs from various experts of different sectors in the value chain obtained, the list of identified barriers in the value chain can be completed. Barriers that were identified prior to the interviews, through public records, documents and other related research in the literature review, are added to the list. Each of the barriers must be properly defined in order to avoid repetition or redundancy from occurring. Afterwards, barriers pertaining to similar factors are grouped together in clusters, such as market conditions, labour issues, infrastructure, etc.

2.4.4.3 Round 3: Barrier severity survey

The third round entails the respondents to complete a survey in order to score each barrier with regards to its severity, which would allow them to be ranked afterwards. A complete list of all of the identified barriers will need to be created. The list should contain the barriers identified during the interviews and any other form of research that was conducted, such as the literature review. Each barrier needs to be properly defined in order to clearly distinguish between different barriers and to avoid any overlap or redundancy in the list. It also provides the respondents with a clear description of what is meant by each specific barrier. After the list is completed, the survey can be drafted.

The survey should consist of three sections. Firstly, the respondent must identify which sector of the value chain they represent. This would allow the barriers to be ranked according to respective sectors within the MVC and consequently provide an in-depth analysis of the major barriers faced throughout the chain. The second section contains all the listing of all the identified barriers per cluster with a severity scoring scale, as well as an area for comments for each barrier. The respondents must score each barrier with a score between 1 and 10 (or not applicable), where a score of 1 represents a low severity, 5 a medium severity and 10 a high severity. The last section of the survey provides the respondent with the entire list of the all the identified barriers with their respective definitions, ensuring that the respondent has a clear and unambiguous understanding of each.

2.4.4.4 Round 4: Finalise survey results

The fourth and final round of the Delphi process is to ensure that a consensus has been reached. In this round the final results are presented to the respondents, i.e. the top ten barriers per sector of the value chain according to the experts in the respective fields. The respondents are then presented with the opportunity to corroborate these results, in order to determine if a consensus to a certain degree has been met. This round thus provides a final opportunity for participants to revise the list of identified barriers and its perceived impact.

2.4.5 Selection criteria for the second set of framework tools

To ensure that all the outcomes for the second framework design requirement (the identification of barriers within the MVC) is achieved, the data gathering tools and corresponding sub-requirements they address, are shown in Table 2-4.

Table 2-4: Criteria met by each of the selected tools for the second framework design requirement

Criteria	Literature review	Interviews	Survey
FSR10: *Identification of latest barriers across the different sectors in the in the value chain*	✓	✓	
FSR11: *Determine the severity of the barriers*	✓	✓	✓

2.5 Strategy to identify the framework tools for the prioritization and analysis of barriers in the MVC

After the barriers to growth for the specific MVC has been identified, these barriers will be analysed to gain a better understanding of its impact on the industry and the extent that it influences the various role players involved in the chain. The outcome of this process is to classify and rank the barriers according to their impact on the industry, as well as investigate the causes for these barriers. This would provide priority as to which barriers should be responded to first and possible solutions to address the barriers. The tool identification strategy to address the third framework requirement (*Prioritization of barriers*) is as follows:

1. Determine the desired barrier prioritization outcomes through reviewing the problem statement and third framework design requirement;
2. Identify the framework sub-requirements;
3. Identify tools/methods to address the requirements, and;
4. Determine if the framework sub-requirements are met.

2.5.1 Determining the desired outcomes of the barrier prioritization process

The desired outcomes of the barrier prioritization process can be derived through reviewing the problem statement (section 1.2.1) and third framework design requirement (section 2.2), *Prioritization of barriers*. It is evident from inspection of the problem statement and framework requirement, that the following outcomes are only partially addressed in literature regarding the prioritization of barriers in MVCs:

- Determining the level of impact of each of the barriers on the industry;
- Review barriers to illustrate their effect on role players within the chain;
- Classify the barriers according to their severity and prevalence across the chain, and;
- Prescribe recommendations as to how the barriers can be addressed.

In order to address the specified concerns, the framework will include the following features:

- Barrier impact assessment;
- Classification of barriers;
- Review major barriers per sector, and;
- Determine the causal factors of major barriers.

2.5.2 Identifying the third set of framework sub-requirements

Six framework sub-requirements are derived from the desired outcomes to prioritize barriers in MVCs, as discussed in the previous section. These sub-requirements will ensure that the selected framework tools/methods address the shortcomings and research gaps identified in the problem statement. The following framework sub-requirements were identified:

- **FSR11:** Determine the severity of the barriers;
- **FSR12:** Determine the prevalence of the barriers;
- **FSR13:** Analysis of cross-sector results;
- **FSR14:** Categorization of barriers;
- **FSR15:** Determine the causes of major barriers, and;
- **FSR16:** Review major barriers.

2.5.3 Identifying tools/methods to address the requirements

Seven tools/methods were identified to address each of the desired outcomes, as stated at the end of section 2.5.1, and thus also indirectly addressing the framework sub-requirements. Each of the selected tools are described per outcome.

2.5.3.1 Barrier impact assessment

From the feedback gathered from the survey conducted during the Delphi process with industry experts, as described in section 2.4.4.3, the identified barriers can be evaluated in terms of their severity and prevalence. The top ten barriers in each sector of the value chain will be identified and compared to determine if there are any overlapping constraints faced across the chain. Apart from investigating the frequency of a barrier across the chain, the severity of the barriers are also evaluated and compared across sectors.

2.5.3.2 Classification of barriers

After the severity and prevalence of the identified barriers in the specific mineral industry has been determined, the barriers will be classified in one of four groups. The groups are divided by high or low prevalence and severity. By grouping these barriers together, it is possible to provide a level of priority to each barrier, which in turn could serve policymakers, government or other authoritative bodies as guide to suggest which barriers to approach first when searching for possible solutions. The barrier classification thus makes it possible to clearly convey which barriers has the largest constraining effect on the industry.

2.5.3.3 Review major barriers per sector

Through the review of major barriers the most pressing concerns in each sector of the value chain are scrutinized and addressed. The effects of these barriers on the industry, as well as the various role players involved in its activities, are investigated and discussed. This step will quantitatively illustrate the extent of the barriers on specific role players through an example. It will provide a comprehensive overview of the major barriers and place the impact on the industry into context.

2.5.3.4 Determine the causal factors of major barriers

In order for policymakers to address these issues, it is important to know why these barriers occur. A root cause analysis will be performed on the major barriers in the industry to determine their origins and also trace the causes to the relevant influencers or parties responsible for them. Potential alleviation strategies will be identified, which could possible address these issues.

2.5.4 Selection criteria for the third set of framework tools

To ensure that all the outcomes for the third framework design requirement (*the prioritization of barriers within the MVC*) is achieved, the analysis tools and corresponding sub-requirements that they address, are shown in Table 2-5.

Table 2-5: Criteria met by each of the selected tools for the third framework design requirement

Criteria	Barrier severity analysis	Barrier prevalence analysis	Top 10 barriers per sector	Barrier variance analysis	Classification of barriers	Review of major barriers	Barrier root cause analysis
FSR11: *Determine the severity of the barriers*	✓						
FSR12: *Determine the prevalence of the barriers*		✓					
FSR13: *Analysis of cross-sector results*			✓	✓	✓		
FSR14: *Categorization of barriers*			✓		✓		
FSR15: *Determine the causes of major barriers*						✓	✓
FSR16: *Review major barriers*						✓	

2.6 Defining the framework phases

All the selected tools which are implemented within the framework, is shown in Figure 2-7. The three framework design requirements, are now populated with the tools specifically identified to address each of these requirements. Now that all the framework requirements and tools are identified, the framework phases can be developed.

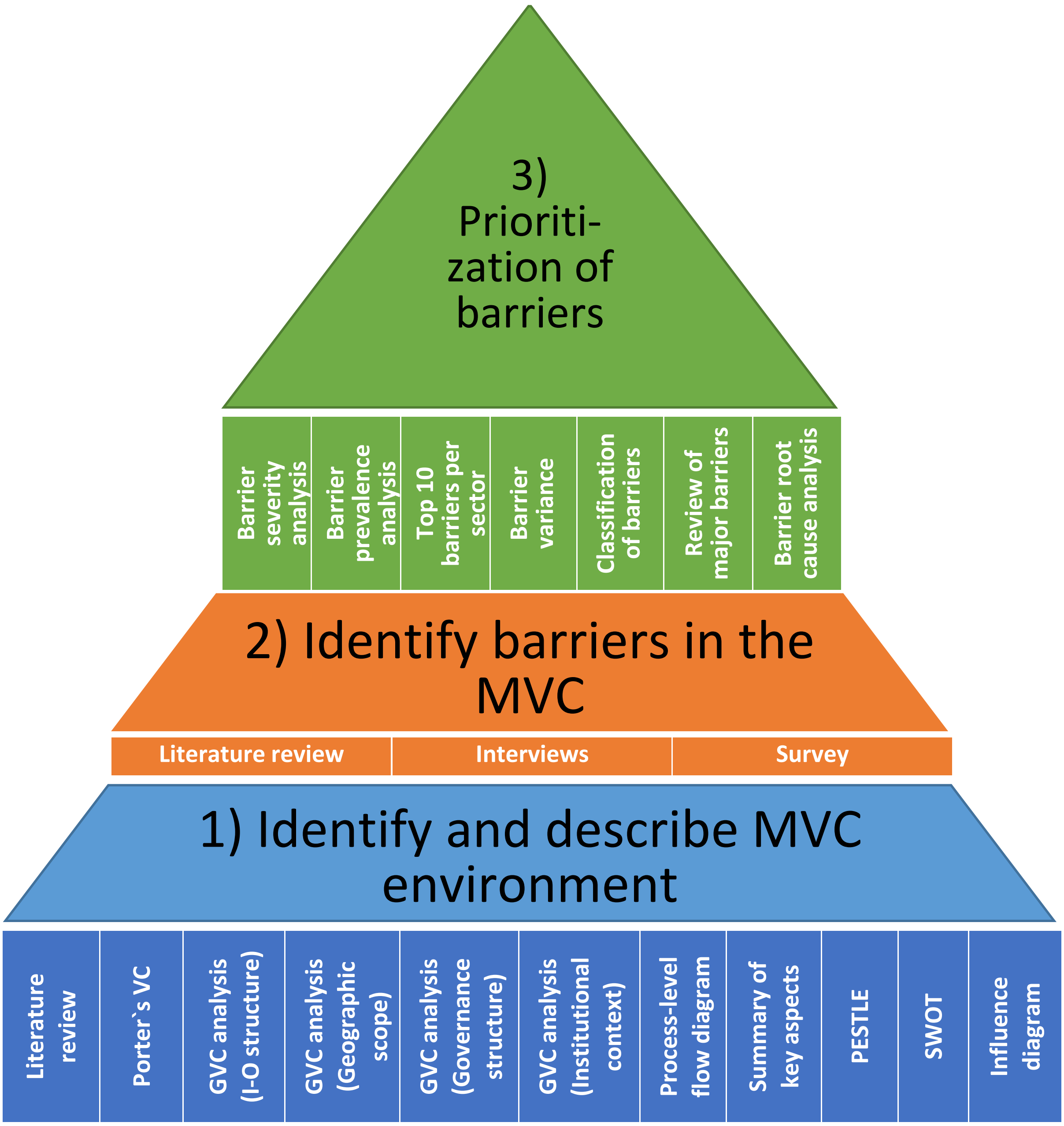


Figure 2-7: The outline of the framework requirements and tools

2.6.1 The conceptual framework design

As stated in the problem statement, a framework is required which presents a systematic approach to identify the major barriers faced by key role players in a mineral value chain. It is decided that an adapted approach to Jabareen's method to building a conceptual framework would be followed. He defines this procedure as a qualitative method for building a conceptual framework for phenomena that are linked to multidisciplinary bodies of knowledge (Jabareen 2009). For this instance, multidisciplinary can be described as: "*Combining or involving several academic disciplines or professional specializations in an approach to a topic or problem*" (Oxford Dictionaries 2016). This definition encapsulates the intricacy of a mineral value chain and captures the dynamic nature of the various sectors, role players and fields which comprises such an integrated system.

Since a mineral value chain is complex and linked to multiple bodies of knowledge and disciplinary fields, it is well suited for this approach. Jabareen's adapted method allows for a qualitative and multidisciplinary approach which is an adequate tool to identify the constraints faced by the various role players involved in MVCs. Jabareen refers to this approach as *conceptual framework analysis*, which he describes as: "*a grounded theory techniques, or tactic, that aims to generate, identify, and trace a phenomenon's major concepts, which together constitute its theoretical framework*" (Jabareen 2009). The conceptual framework analysis will be used to create a framework that is designed to identify barriers to economic growth faced by different role players in a mineral value chain.

2.6.2 The procedure of conceptual framework analysis

With the aid of Jabareen's conceptual framework design methodology, six phases are developed for the framework. These phases group specific tools together to make the framework easier to understand and simpler to implement. Each phase forms specialised sections, which focus on a specific element of analysis. The framework's phases align with the overall research strategy, as indicated in Figure 2-8.

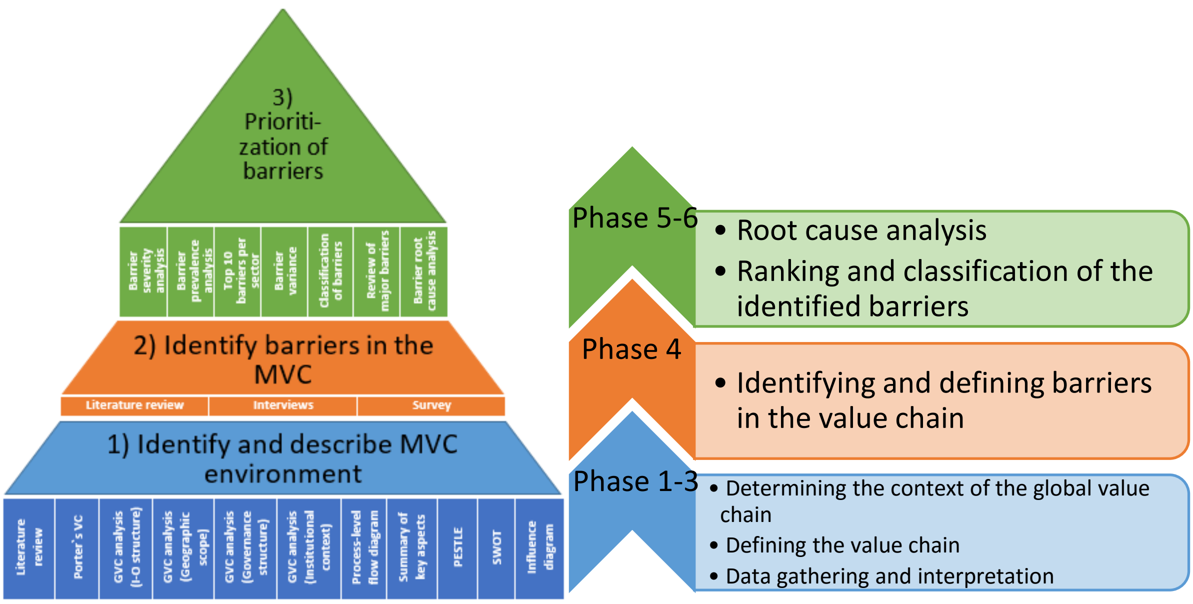


Figure 2-8: Research strategy outline with corresponding phases

2.6.2.1 Phase 1: Data gathering and interpretation

Aim: Review literature regarding the specific mineral value chain.

Description: The first step entails gathering and investigating various sources of literature regarding significant aspects of the mineral value chain in question. The literature review will provide a better understanding of the specific industry and explore key aspects in the value chain and the current problems it faces. It should contain updated information from previous publications and conclude with a comprehensive analysis of the literature.

Sources of the literature includes:

- Related companies' annual reports;
- Research related to the selected industry;
- Discussions with industry experts;
- Relevant news articles, and;
- Journal articles.

The data sources should cover all significant aspects relevant to the mineral value chain. It should include, but is not limited to: background information on the mineral, the mineral's context in the scope of geographic region that is being investigated, the mineral's various applications, its market trends, the various production processes in the value chain to convert the mineral to value-added products, an overview of the current role players participating within the selected geographic region.

These sources should provide empirical data that is both conclusive and current to ensure that comprehensive and complete scoping of the literature has been done to facilitate a holistic mapping of the data.

Outcome: Comprehensive literature review on key aspects relevant to the specific value mineral chain.

2.6.2.2 Phase 2: Defining the value chain

Aim: Identify the main activities/sectors in the value chain.

Description: Once an overview of the mineral industry has been established, different sectors of the chain can be distinguished by the value they add to each output in the process. A general representation of the various sectors/segments comprising the value chain is provided in this framework phase. This provides an understanding of the structure of the chain, the inputs and outputs in each activity and lastly, the different role players involved in each process.

Outcome: A general representation of the various sectors/segments comprising the value chain.

2.6.2.3 Phase 3: Determining the context of the global value chain

Aim: Expanding the mineral value chain to include a global context.

Description: This phases focuses on integrating the complexities of a mineral value chain to analyse the characteristics which are unique to the chain in question. During this phase the chain's geographic scope of activities, role player relationships and positions within the chain, as well as its institutional context are investigated. This would provide insight on the key attributes which has a significant impact on the specific mineral value chain.

Outcome: Complete representation of the mineral value chain with the analysis of its geographic scope, governance structure and institutional context.

2.6.2.4 Phase 4: Identifying and defining barriers in the value chain

Aim: Identifying barriers faced by role players in different sectors of the value chain.

Description: After sufficient knowledge of the industry has been collected and investigated, the barriers in the value chain are identified. During this phase interviews are conducted with industry experts which represents specific sectors of the value chain. A survey will be provided afterwards that allows the experts to score the major barriers they face in terms of severity. After the feedback from the industry experts have been reviewed, all the identified barriers will be listed and defined.

Outcome: A list of all identified barriers to economic growth faced by role players per sector in the value chain.

2.6.2.5 Phase 5: Ranking and classification of the identified barriers

Aim: Determining the major barriers in each sector of the value chain and prioritizing them per severity and prevalence.

Description: After the barriers are identified, they are ranked according to their severity and prevalence in the industry. The barriers are categorised in groups that have a specific priority assigned to each which relates to the size of its impact on the industry. The extent of the barrier impact on specific role players, and the industry as a whole, are determined.

Outcome: Top barriers per sector in the value chain which are ranked and categorised according to severity and prevalence in the industry.

2.6.2.6 Phase 6: Root cause analysis

Aim: Determine the causes of major barriers in the mineral value chain.

Description: The main barriers in each sector are comprehensively reviewed and discussed. Afterwards a root cause analysis is performed on each major barrier to determine its origin. Furthermore, each barrier will be traced to the specific influencer or multiple parties responsible for each barrier. Lastly, a possible alleviation strategy will be provided for each barrier.

Outcome: Root cause analysis performed on the major barriers, which identifies the origin, influencer and possible solution for each barrier.

2.6.3 Overview of the proposed framework

Once all of these phases are integrated, a basic overview of the proposed framework can be presented, as seen in Figure 2-9. Each of these phase will be further elaborated through the development of their respective implementation methodologies and application of a case study in the following chapters (Chapter 3 - Chapter 8).

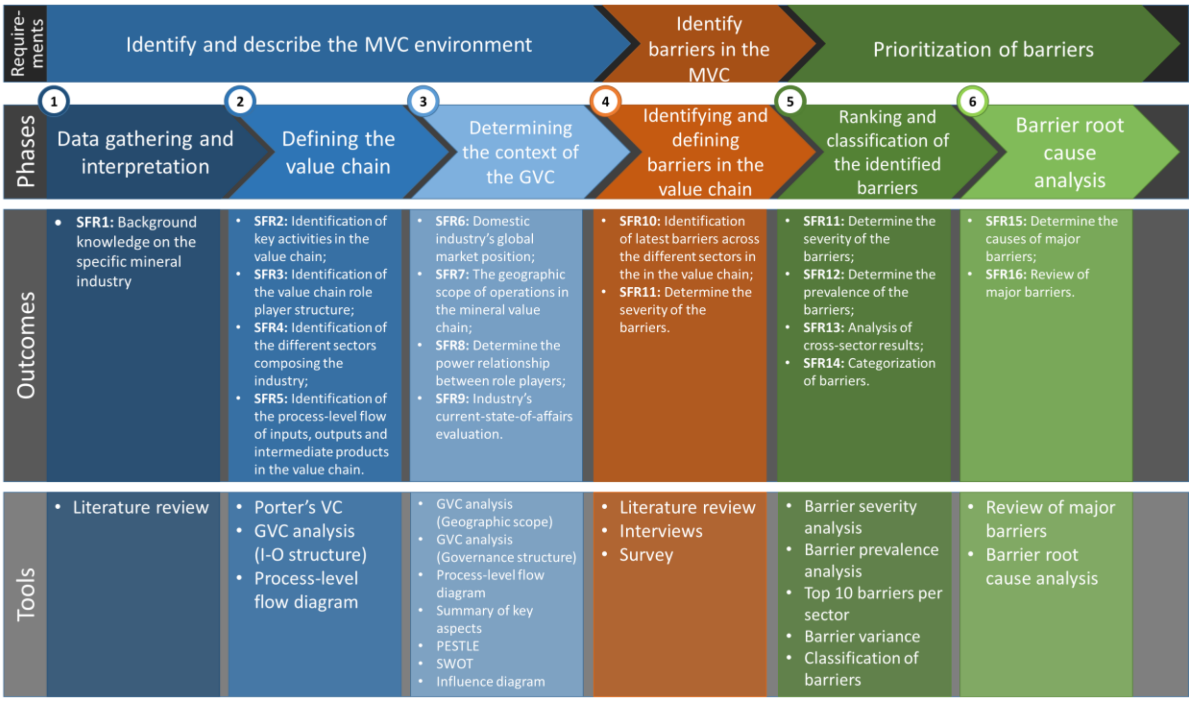


Figure 2-9: Overview of the proposed framework to identify barriers in MVCs

2.6.4 Design questions in the context of the framework phases

Table 2-6 provides a comprehensive list of design questions that will be addressed by the corresponding framework phases.

Table 2-6: Framework phases with corresponding design questions

Framework Phase	Design Questions
1. Data gathering and interpretation (Chapter 3)	**1. DQ1 – What is the current state-of-affairs of the mineral industry in question?** ○ *DQ1.1* – What are the main applications of this mineral? ○ *DQ1.2* – Where are these mineral reserves located? ○ *DQ1.3* – How are the mineral related products manufactured? ○ *DQ1.4* – What are the factors influencing this specific industry?

Framework Phase	Design Questions
2. Defining the value chain (Chapter 4)	**2. DQ2 – What is the structure of the specific mineral value chain?** ○ *DQ2.1* – What are the main activities that compose the value chain? ○ *DQ2.2* – What is the major role player structure in the industry? ○ *DQ2.3* – What is the process flow within the industry?
3. Determining the context of the global value chain (Chapter 5)	**3. DQ3 – What are the main characteristics of the specific global mineral value chain?** ○ *DQ3.1* – What is the geographic scope of the global value chain? ○ *DQ3.2* – What is the governance structure of the global value chain? ○ *DQ3.3* – What is the institutional context of the specific mineral value chain? ○ *DQ3.4* – What are the main attributes that influence operations in the specific mineral value chain?
4. Identifying and defining barriers in the value chain (Chapter 6)	**4. DQ4 – What are the barriers within the specific mineral industry?** ○ *DQ4.1* – How will the barriers be identified? ○ *DQ4.2* – How will the identified barriers be defined? ○ *DQ4.3* – How will the final barrier list be determined? ○ *DQ4.3* – What is the sample strategy for the barrier identification sources? ○ *DQ4.4* – What measurements will be put in place to analyse the barriers?
5. Ranking and classification of the identified barriers (Chapter 7)	**5. DQ5 – What are the primary barriers to growth faced by the different role players within the specific mineral industry?** ○ *DQ5.1* – How severe is each of the identified barriers on the respective sectors in the value chain? ○ *DQ5.2* – What are the top ten barriers per sector in the value chain? ○ *DQ5.3* – How prevalent is each barrier across the value chain? ○ *DQ5.4* – How do the barriers vary between the sectors in the value chain?

Framework Phase	Design Questions
	○ *DQ5.5* – What barriers have the biggest impact on the industry? ○ *DQ5.6* – How are the impact of the barriers categorised?
6. Barrier root cause analysis (Chapter 8)	**6. DQ6 – What are the causes of the barriers?** ○ *DQ6.1* – How are the barrier's causal factors determined? ○ *DQ6.2* – What are the major concerns for the barriers? ○ *DQ6.3* – How do the barriers effect the role players in the chain? ○ *DQ6.4* – Who are the main influencers responsible for the barriers? ○ *DQ6.5* – How can die barriers be addressed?

2.7 Chapter 2 summary

The purpose of this chapter was to define and develop the framework design methodology for the thesis by designing the proposed framework for understanding the barriers in a MVC. The main outline of the framework consists of the three framework design requirements. A strategy to identify the tools and processes required to achieve each design requirement is described and implemented in this chapter. The framework outline illustrates all the tools that will be implemented in the framework, as shown in Figure 2-7. Each framework tool's reason for inclusion is discussed and the specific criteria they address are summarised in Table 2-3, Table 2-4 and Table 2-5.

The conceptual framework design process is also discussed in this chapter, which describes the six phases comprising the framework and their respective outcomes. The outline of the thesis is structured according to these phases, which group specific framework tools together that will analysis a specific element of the MVC and MVC environment.

Chapter 3

3 Phase 1: Data gathering and interpretation

An overview of the South African manganese mineral industry is provided in this section. This industry serves as the case study for this research and it is thus important to build a foundation of knowledge in this particular field. The background information will aid in understanding the different role players within the industry, various production activities and other key factors which has a significant impact on the value chain. The literature review investigates information gathered from related research and provides current information from interviews, company reports, news articles and other sources.

This chapter contains a comprehensive and well-integrated summary of various aspects relevant to the manganese industry, including the background of manganese, its reserves, applications, production processes and local initiatives in the minerals industry of South Africa, such as beneficiation. The chapter concludes with a short analysis of the literature through a SWOT-analysis.

Research Question 1 – What is the current state-of-affairs of the mineral industry in question?

- *Research Question 1.1*
  What are the main applications of this mineral?
- *Research Question 1.2*
  Where are these mineral reserves located?
- *Research Question 1.3*
  How are the mineral related products manufactured?
- *Research Question 1.4*
  What are the factors influencing this specific industry?

3.1 Chapter overview

An overview of this framework phase is provided in Table 3-1 and a step-by step representation of the phase is shown in Figure 3-1.

Table 3-1: Overview of Phase 1

Phase 1: Data gathering and interpretation		
Description: The literature review provides an overview of all the relevant background information, disciplines and theories relating to the specific mineral industry. This information is used, firstly to provide a solid platform to understanding the various aspects of the industry, and secondly, to ensure that new contributions are made through this research and not merely duplication work that has already been done.		
Key objectives:		
• Mineral background information • Mineral reserves / resources data • Related mineral products and applications • Processes involved in product manufacturing	• Outline of industry practices • Information on specific acts / policies which affect industry • Investigate constraining factors	• News in the industry • Information on different role players involved • Gain better understanding of the industry
Framework tools / Outputs:		
Literature review		

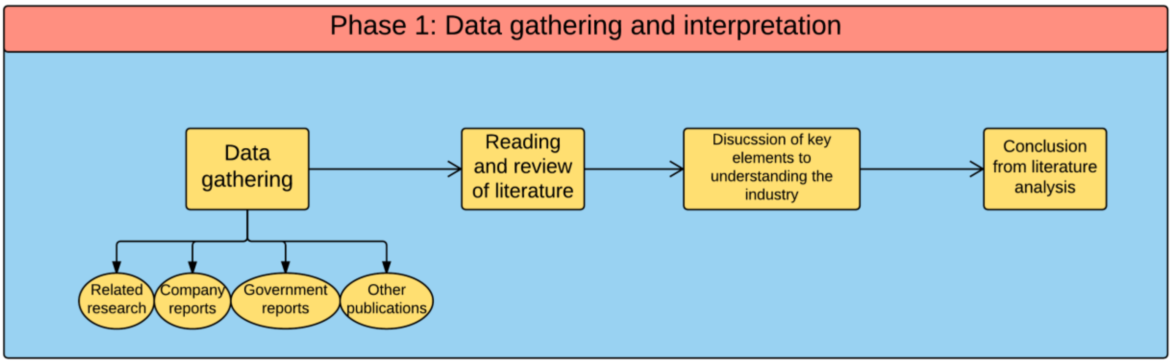


Figure 3-1: Methodology for Phase 1 of the proposed framework

3.2 Manganese Background

Manganese is a naturally-occurring element with the symbol Mn on the periodic table. It is a metal which is extensively used in everyday life and is also an essential nutrient. Manganese oxides have been used throughout history, initially as a pigment in the Stone Age and later for chemical uses and eventually for steelmaking since the beginning of the 19th century. It is the 12th most abundant element in the earth's crust and the 4th most abundant of the metals in commercial use (Sverre E. Olsen et al. 2007).

Manganese plays an important role in our daily lives and has many applications ranging from the use in steel manufacturing to aluminium and other metal alloys as well as in portable batteries. In all these cases manganese is used to improve the properties of the alloys and compounds involved in each specific application. Manganese is also an essential element in maintaining human health and recommended daily dietary intake levels have been established by US regulatory authorities.

Manganese is primarily used in the steel manufacturing industry and has played a significant role in the development of various steelmaking processes with approximately 90% of all manganese consumed annually used as in steel and as an alloying element (International Manganese Institute 2014b). No satisfactory substitute for manganese in steel has been identified which combines its relatively low price with outstanding technical benefits. After steel, the second most important use for manganese is in portable dry cell batteries.

3.3 Manganese Reserves

South Africa contains between 75 to 80 per cent of the world's identified manganese resources and approximately 24 per cent of the world's reserves. Over 90 per cent of the reserves are located in the Kalahari Manganese Fields (KMF) located in the Northern Cape and has an estimated 4 billion tons of manganese reserves. There are two main types of manganese ore present in the Kalahari deposit, namely low-grade primary sedimentary Mamatwan-type ore and high-grade Wessels-type ore (Ratshomo 2013).

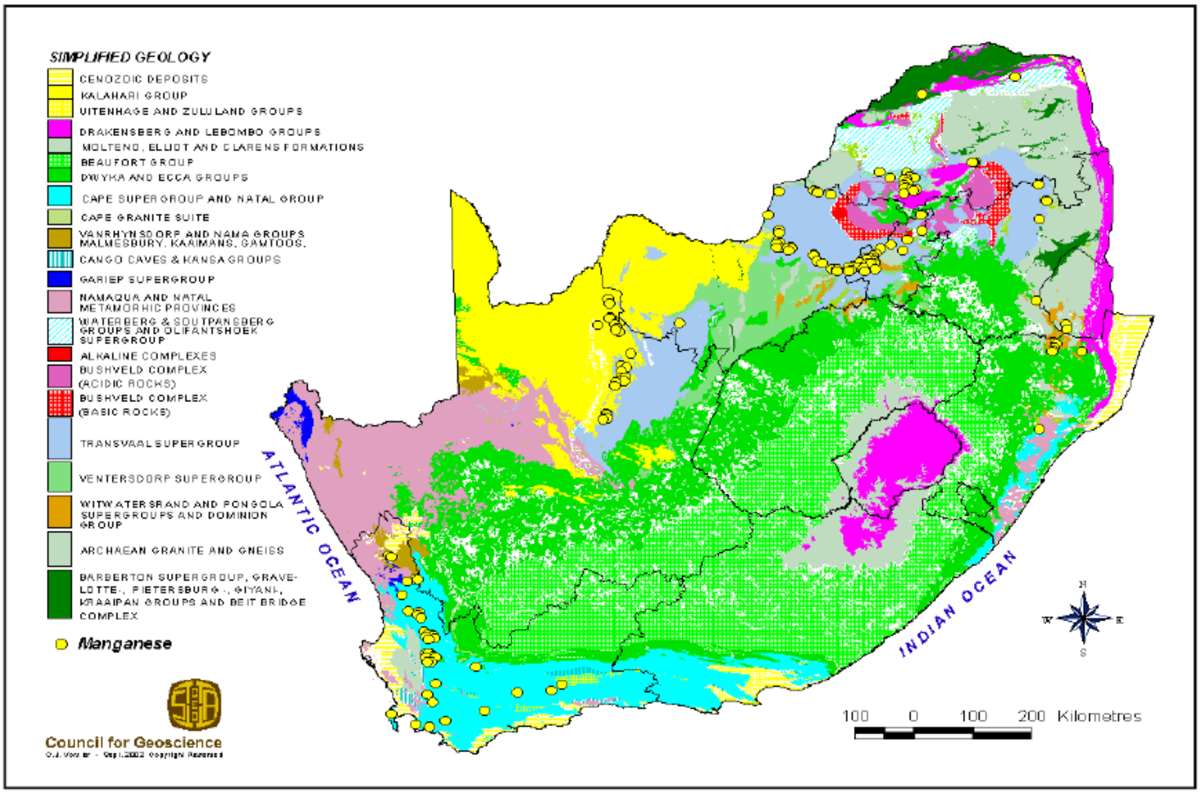


Figure 3-2: Simplified geology of South Africa's manganese deposits

Source: (Ratshomo 2013)

The Mamatwan type contains between 20 to 38 per cent of manganese in its ores, while the Wessels type, which only makes up 3 per cent of the total ore body, contains 45 to 60 per cent manganese (Van Averbeke et al. 2005; Cairncross et al. 1997). The manganese ores of the KMF are characterized by their low phosphorus content, which makes it a suitable feedstock for the steel industry.

The country produces high-grade ore, features increasing mining operations and is a major producer of manganese alloys. The manganese supply and demand closely follows the iron and steel market trends due to manganese's primary use in steel manufacturing, but is also used in numerous other applications.

3.4 Manganese Applications

Manganese has various uses today spanning over various applications in different fields. Its main use is in the industrial and metallurgical process of steelmaking, but also features in chemical and agricultural applications. The main uses of manganese are discussed in this section.

3.4.1 Steel production

Manganese plays a significant role in the steel production industry due to its sulphur-fixing, deoxidizing and alloying properties. Manganese is the fourth most abundant mineral in commercial use and approximately 90% of all manganese produced is consumed in the steel industry as an alloying element (Sverre E. Olsen et al. 2007). There is no other acceptable mineral substitute for manganese in steel has been identified which combines its relatively low price with outstanding technical benefits (Kalagadi Manganese 2006; Sedumedi & Pan 2014; Gajigo et al. 2011).

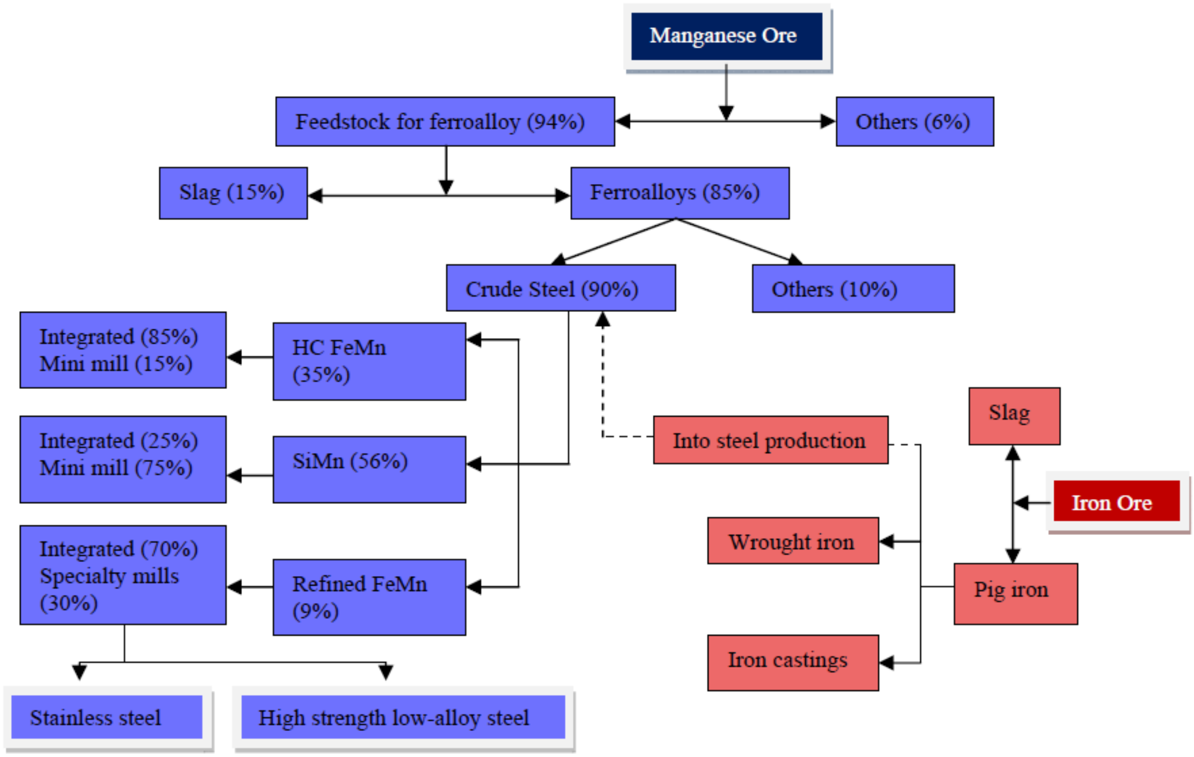


Figure 3-3: Structure of manganese ore in steel industry

Source: (Gajigo et al. 2011)

3.4.2 Aluminium alloys

After the use in steel manufacturing, manganese also plays an important role in the alloying of aluminium. Small amounts of manganese are found in aluminium alloys as to enhance the metal's corrosion resistance (Kalagadi Manganese 2006). Aluminium-manganese alloys have been applied in various products such as beverage cans, kitchenware, roofing, car radiators and transportation (Asia Metal 2014).

3.4.3 Copper alloys

Manganese alloys is one of the most versatile elements which can be added to copper alloys. Small additions of manganese, as low as 0.1 to 0.3 %, are used to deoxidise the alloy and improve its mechanical strength. Many commercial copper alloys contain manganese to improve strength and workability in high heat. Manganese is also used to replace part of nickel in nickel-silver alloys in order to reduce costs (Kalagadi Manganese 2006; Asia Metal 2014).

3.4.4 Batteries

Portable dry cell batteries are the second most important market for manganese after steel. Dry cell consumption currently exceeds 20 billion units per year globally (International Manganese Institute 2014b).Two different types of these batteries are made using separate processes, namely EMD (electrochemical manganese dioxide) made through electrolysis and CMD (chemical manganese dioxide) produced by a purely chemical process. The natural grade battery ores are manganese dioxide and are primarily produced in Gabon, Brazil, China, Mexico and India (International Manganese Institute 2014b).

Manganese is also used for the following chemical applications:

Table 3-2: Other uses of manganese

Source: (International Manganese Institute 2014b)

Potassium permanganate	Potassium permanganate is one of the best known manganese products. It is a powerful oxidizing agent with bacterial properties which enables it to be used to purify drinking water and treating waste water. It is also used for odour control especially for deodorizing discharges from paint factories, fish processing plants etc.
Agriculture	Manganese-ethylene bis-dithiocarbamate commonly referred to as "maneb" is a chemical compound which serves as an agricultural fungicide that is used for controlling crop and cereal disease. Manganese sulphate is used as an end-product in fertilizers and animal feed.
Human health	Manganese is found in many medications and is an essential element in maintaining human health.
Other applications	- An organic manganese compound known as MMT (methylcyclo-pentadienyl manganese tricarbonyl) is used to improve oil combustion. - Manganese dioxide is used as a catalyst in the production of artificial flavours like vanilla. It is also used as an oxidizing agent in treating uranium ore. - Manganese is used for the colouring of bricks and tiles, driers and as a pigment for paints, etc. - Manganese ferrite is widely used in electronics. - Manganese is used in the process of making electrolytic zinc. - Manganese phosphatation is used to produce surface films which can protect steels for internal or mild outdoor use.

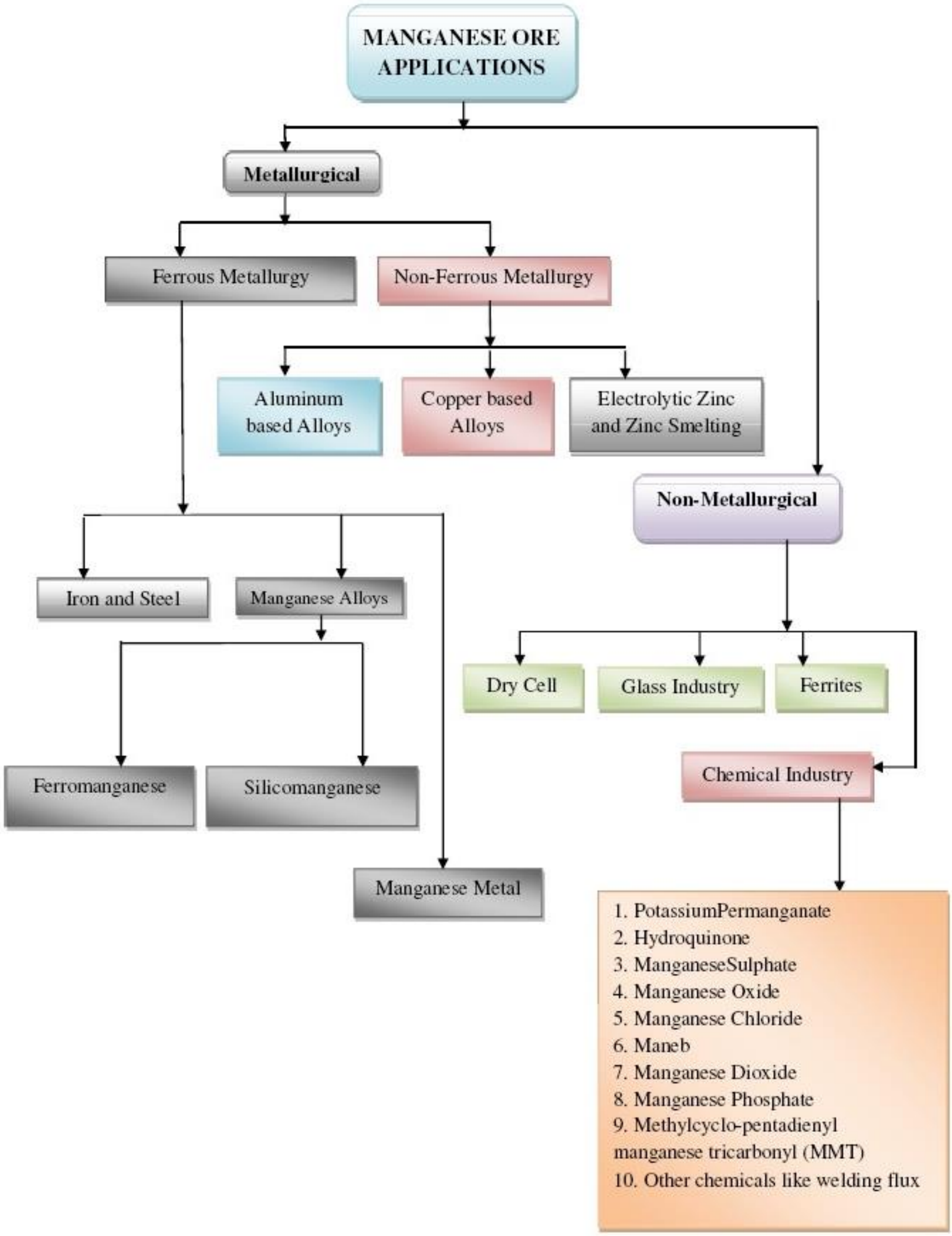


Figure 3-4: Different applications of manganese

Source: (Asia Metal 2014)

3.5 Manganese Alloy Production Processes

A ferroalloy is an alloy of iron with another element other than carbon. Ferroalloys are used during the manufacture of steel to physically carry that element into molten metal and the industry is closely associated with the iron and steel industries, the two largest users of ferroalloys.
Ferroalloys are generally used as an additive in steel production to improve on certain properties, especially tensile strength as well as wear and corrosion resistance. These properties are transferred through one or more of the following (Fichte 2000):

- A change in the chemical composition of the steel
- The removal or the tying up of harmful impurities such as oxygen, nitrogen, sulphur or hydrogen
- A change in the nature of the solidification

Ferroalloys contribute distinctive properties to steel and cast iron which serve very important functions during the iron and steel production cycles. The main ferroalloys are those containing chromium, manganese and silicon. Manganese is essential to counteract the detrimental effects of sulphur in the production of virtually all steels and cast irons and also serve as a deoxidizing agent (U.S. Environmental Protection Agency 1995).

The principal chemistry of the primary and secondary process to produce ferroalloys, is as follows (European Integrated Pollution Prevention and Control Bureau 2014):

Primary process:
Oxidic metal ore + iron ore/scrap + reducing agent → ferroalloy + reducing agent oxide + slag

In the case of ferromanganese the process can be rewritten as follows:
Manganese oxide ore + iron ore + coke (or coal / charcoal) → ferromanganese + carbon monoxide + slag

Secondary process:
Metal scrap + iron scrap → ferroalloy

Primary ferroalloys are produced by either carbothermic of metallothermic reduction of oxidic ores. Carbothermic reduction is a more important process and utilizes a source of carbon in the form of coke, coal or charcoal as a reducing agent. Metallothermic reduction is mainly carried out with either silicon or aluminium as the reductant. The two processes in relation with the production of ferromanganese are as follows (Sverre E. Olsen et al. 2007; European Integrated Pollution Prevention and Control Bureau 2014):

Carbothermic reduction:
Manganese oxide + carbon source → ferromanganese + carbon monoxide

Silico-thermic reduction:

Manganese oxide + silicon → ferromanganese + silicon oxide

3.5.1 Ferromanganese and Manganese Alloys

Ferromanganese and silicomanganese are both bulk alloys which accounts for the majority of the total production of ferroalloys together with ferrochrome, ferrosilicon and ferronickel. Ferromanganese is mainly used in the steel and stainless steel industries and was initially employed as a deoxidising and desulphurising agent. It is now primarily used to improve the hardness and wear resistance of steel. The important manganese alloys can be classified as (Klingspor & Stripple 2008):

- High-carbon ferromanganese (HC FeMn) with max 7.5 % C
- Medium-carbon ferromanganese (MC FeMn) with max 2.5 % C
- Low-carbon ferromanganese (LC FeMn) with max 0.75 % C
- Silicomanganese (SiMn) with max 2.0 % C
- Low-carbon silicomanganese (LC SiMn) with max 0.10 % C

The raw material requirements for these processes play a crucial part in the manufacturing of these alloys. The production of ferromanganese and silicomanganese requires a blend of ores that contain manganese as primary raw material. To ensure high process efficiency, the manganese ore are in lump or sinter form. Iron ore and fluxing agents, such as limestone and dolomite, are other raw materials that are required for the smelting process. Coke and low volatile coal is used as a reducing agent. For the production of silicomanganese, rich ferromanganese slag, ferrosilicon scrap, silicon skulls and quartz are needed (European Integrated Pollution Prevention and Control Bureau 2014).

For many years South Africa has been self-sustaining in terms of the supply of reductants used for the production of ferroalloys. Recently, however, metallurgical coke had to be imported from China and Zimbabwe for the manufacturing of chrome and manganese alloys respectively (Basson et al. 2007). There are numerous factors that contributed to this, including the stagnation of coke production capacity, the accelerated increase in ferroalloy production, and the growing trend for closed furnaces which require more coke (Basson et al. 2007).

Various forms of pre-treatment techniques are implemented for the production of the alloys. Fine ores used in the production of ferromanganese undergo pre-treatment techniques such as agglomeration, pelletizing and sintering. Fuels such as coke and coal fines are also incorporated as well as fluxes like limestone and dolomite. Sintering is used to create a more suitable size and to reduce the natural ore to an intermediate metallurgical grade raw material. The main advantages of agglomeration and the sinter process are (Ullmann's Encyclopedia 1996):

- Fine ore, which has a limited application and value in conventional smelting, is agglomerated and converted to a superior product;
- Reduced gas volumes which results in fewer furnace eruptions when smelting sinter;
- Furnace availability and operating loads are increased;
- Improved porosity of the burning material with easier penetration and elimination of the gas generated by the reduction reactions.

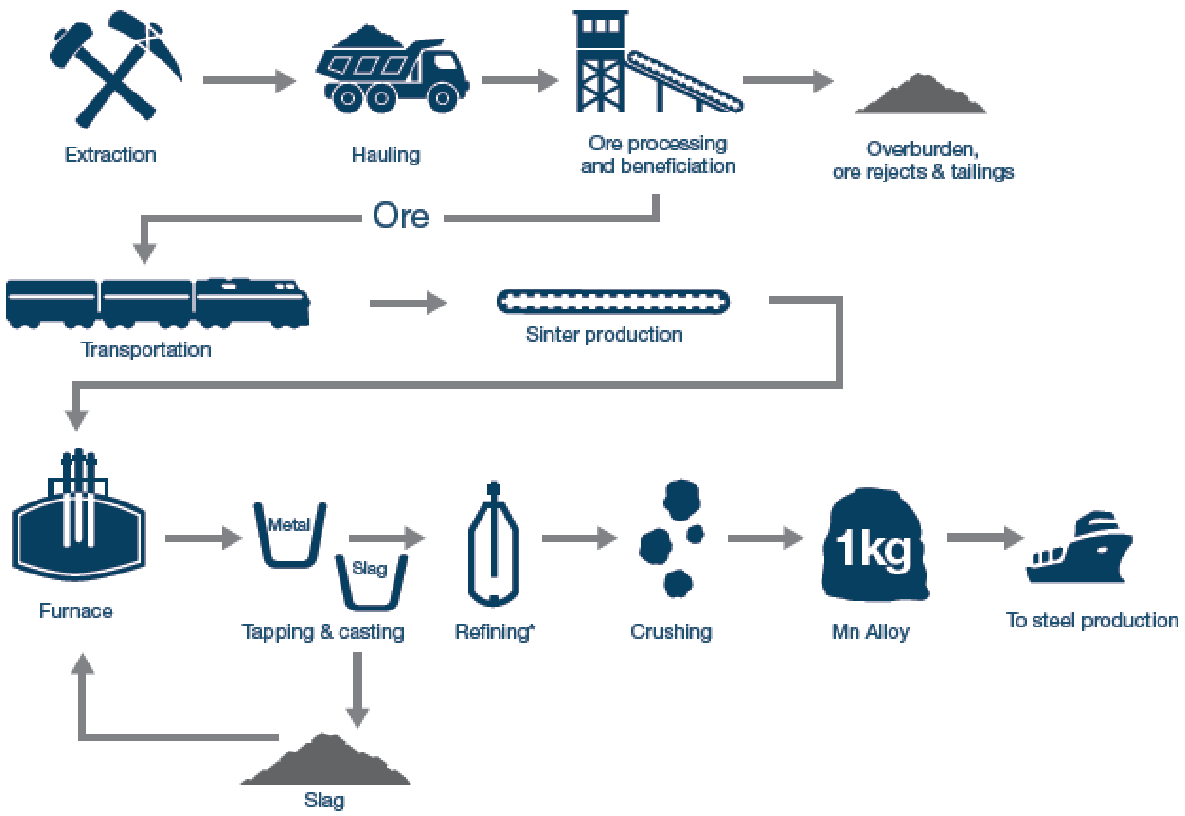


Figure 3-5: Cradle-to-Gate production of manganese alloys
Source: (International Manganese Institute 2014d)

3.5.2 Outline of the Industrial Practice

Manganese ferroalloys are commercially produced by the reduction of manganese oxide ores in either blast furnaces or the electrical smelting process. For these processes a carbon source is required to serve as a reducing agent and is the primary source of energy in the case of the blast furnace process. In the production of ferroalloys in submerged arc furnaces (SAFs), coke, coal and charcoal is the most commonly used reductants (Pistorius 2002). For this type of furnace, electrical energy supplies the heat requirement and the coke is both a reducing agent as well as an electrical resistance element (Sverre E. Olsen et al. 2007).

A ferromanganese furnace's main objectives are (Sverre E. Olsen et al. 2007):

- Operate on a stable and high load
- Minimize coke and energy consumption
- Produce metal and slag of the required composition
- Secure a high yield of manganese
- Minimize greenhouse gas emissions

Today electric submerged arc furnaces are preferred over blast furnaces due to the latter having high coke consumption and high losses of manganese in slag an off-gases. The coke consumption is approximately 2 tons per ton of alloy, which is five to six times higher than that used in electric furnaces. After World War II most blast furnaces where replaced by electric furnaces due to the scarcity and high cost of blast furnace coke as well as the relatively low capital investment in electric furnaces (Sverre E. Olsen et al. 2007).

Electric furnaces offer several advantages over blast furnaces, primarily a higher overall yield of manganese from the ore, less carbon consumption and lower quality reductants required. It also offers greater flexibility since it can be utilized both for the production of HCFeMn and SiMn (Sverre E. Olsen et al. 2007). There has been an increase in the production of ferromanganese in SAFs. In 2006 approximately three-quarters of the world production is with the use of electric furnaces and the rest is done via blast furnaces (Sverre E. Olsen et al. 2007). The relative cost of the two processes depends mainly on the price of electricity and coke usage for production.

3.5.3 Production of High-carbon ferromanganese

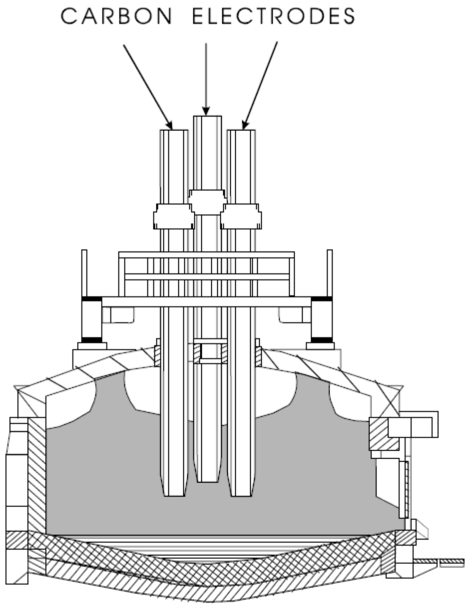
High-carbon ferromanganese (HCFeMn) is commercially produced by the reduction of manganese oxide ores using a source of carbon as the reducing agent. Furnaces that are more recently built and used for the production of ferromanganese have capacities ranging from 75-90 MVA (Sverre E. Olsen et al. 2007). There exists an increasing trend to refine the metal to medium or low carbon ferromanganese.

Manganese alloys are generally produced in electric furnaces with a circular design and contains three electrodes each connected to a separate electrical phase. The electrodes are submerged into the furnace where the electric current runs through the electrode tips and electrical energy is converted to heat. Electric arc furnaces for the operation of ferromanganese are operated only with self-baking Soderberg electrodes. The electrodes consist of a steel or stainless steel casing with internal fines and filled with a carbon paste (Ullmann's Encyclopedia 1996).

High-carbon ferromanganese is produced by reducing lumpy or sintered manganese ore in a three-phase submerged electric arc furnace (SAF). The furnaces are commonly closed, semi-closed or open types which affect the gas composition, flow rate and the metal recovery system used. Raw material is fed from storage bins above the furnace with feeding tubes placed around the electrodes to ensure an even distribution of raw material to the furnace (European Integrated Pollution Prevention and Control Bureau 2014).

Both slag and metal is produced, which can be tapped simultaneously from the same tap-hole or separately (Sverre E. Olsen et al. 2007; European Integrated Pollution Prevention and Control Bureau 2014). Since the slag has a lower density than the metal, it will float on the metal when tapped from the same tap-hole. The top layer can then be removed to separate the slag from the manganese alloy. As mentioned before, coke is the common source of carbon for the ore reduction and limestone and dolomite are commonly used as fluxes. Fluxes are added to give the slag suitable chemical properties and smelting temperature in order to ensure more efficient furnace operation and a high manganese yield (Sverre E. Olsen et al. 2007).

There are some facilities where the CO-rich off-gas is used to produce electricity. This is a growing tendency at many facilities and many furnaces have been upgraded to utilise off-gas to generate power. This process has become increasingly useful, especially amidst the electricity supply problems which South Africa is currently facing (European Integrated Pollution Prevention and Control Bureau 2014).



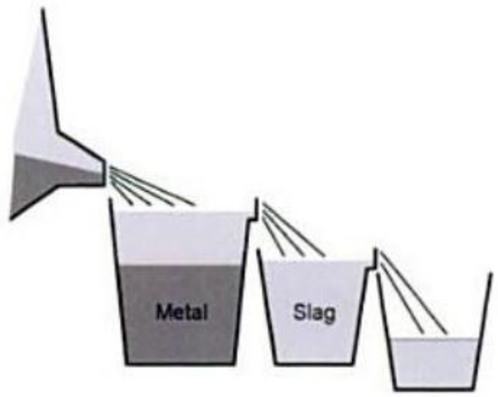


Figure 3-6: Typical submerged arc furnace design (left); Illustration of cascade tapping (right).
Source: (U.S. Environmental Protection Agency 1995); (Sverre E. Olsen et al. 2007)

3.5.4 The Production of Silicomanganese

Silicomanganese is used as an alloying element in the steel industry as well as a raw material for the production of medium-carbon and low carbon ferromanganese (MCFeMn and LCFeMn). Silicomanganese is produced with manganese ore or sinter and quartz as raw material. Instead of manganese ore, a rich ferromanganese slag can be used as a manganese source like that produced in HC, MC and LC FeMn production (European Integrated Pollution Prevention and Control Bureau 2014). This process is illustrated in Figure 3-8.

Silicomanganese (SiMn) is produced by the reduction of manganese oxide ores in only electric submerged arc furnaces. The same type of furnaces is used as for the production of high-carbon ferromanganese which makes it quite easy for producers to switch between the two products. The size of the SiMn furnaces is usually in the 15 to 40 MVA range and can produce between 80 to 220 tons of alloy per day (Olsen & Tangstad 2004). Due to the higher process temperature required to attain the wanted silicon specification of the metal, the operation of the SiMn process is usually considered to be more difficult than the ferromanganese process (Olsen & Tangstad 2004).

Three different processes are used to create ferroalloys (S E Olsen et al. 2007):

- HCFeMn production using a discard slag practice Figure 3-7 (a).
- SiMn production utilizing only ore as source of manganese Figure 3-7 (b).
- HCFeMn production using a high slag practice, with subsequent SiMn production Figure 3-8, also referred to as the duplex process. This process is described in more detail in Figure 3-9.

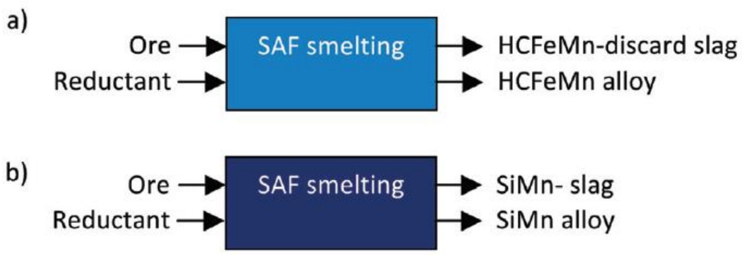


Figure 3-7: (a) HCFeMn and (b) SiMn production methods applied in South Africa

Source: (Steenkamp & Basson 2013)

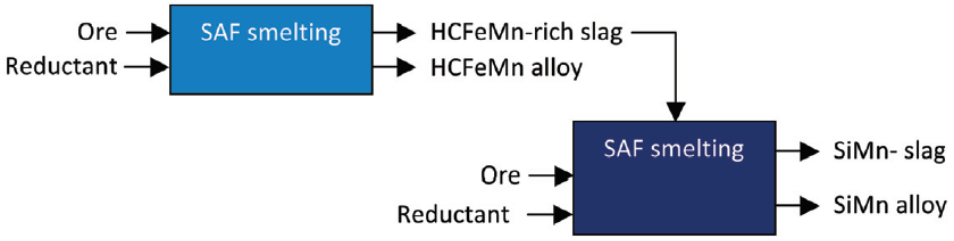


Figure 3-8: HCFeMn and SiMn production methods applied in countries other than South Africa.

Source: (Steenkamp & Basson 2013)

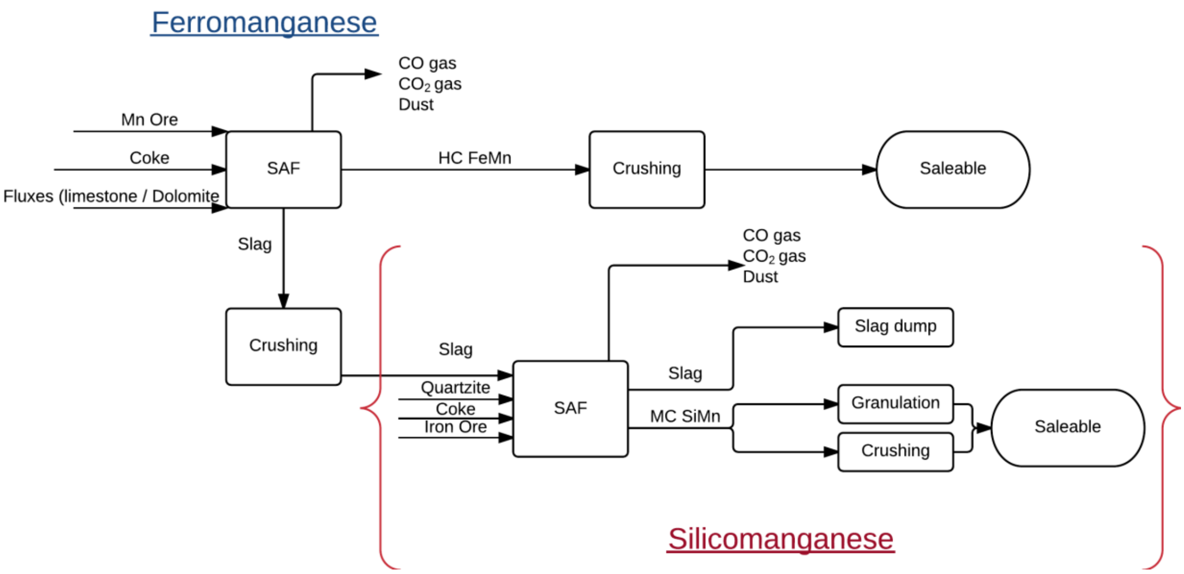


Figure 3-9: Process flow diagram of ferro- and silicomanganese.

Data gathered from: (Steenkamp & Basson 2013; Callaghan 2013; S E Olsen et al. 2007)

The power consumption for production of SiMn through the use of HCFeMn slag and silicon as input, is typically between 3 500 and 4 500 kWh/ton of metal (Olsen & Tangstad 2004). The power consumption is increased when higher silicon content is present in the produced metal.

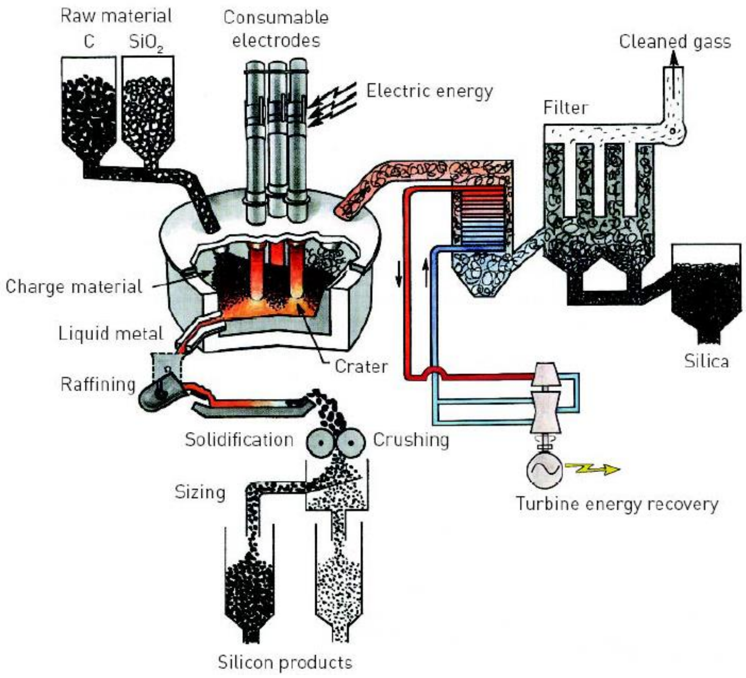


Figure 3-10: Electric reduction furnace process.
Source: (Klingspor & Stripple 2008)

3.5.5 Ferroalloy slag in South Africa

The HCFeMn and SiMn processes are generally integrated, as seen in Figure 3-8, so that the slag from the manufacture of HCFeMn is reprocessed in the production of SiMn. This process is referred to as duplex production and ensures a very high total yield of manganese is achieved. The separate production of HCFeMn and SiMn is implemented in South Africa, since the local ore do not have a manganese-iron relationship of ideally 8 or higher (Steenkamp & Basson 2013). Hence, the ore is not ideal for the usage in a duplex process.

The economic viability of silicomanganese smelting is improved by reducing the loss of manganese as metal composition and the manganese oxide which is dissolved in the slag. The slag from the process normally contains 5% to 10% manganese monoxide and in order to reduce the overall losses of the process, the slag is processed to extract its manganese contents (Olsen & Tangstad 2004).

In South Africa the slag that is created as a by-product during ferroalloy production, is discarded on slag dumps (Steenkamp & Basson 2013). It is estimated that approximately 20 Mt of HCFeMn and SiMn slag is discarded on dumps in South Africa and that an average amount of 0.5 Mt of slag is added yearly (Kazadi et al. 2013). Commercially viable options to reduce the size of these slag dumps are currently being investigated by various interested and affected parties (Kazadi et al. 2013; Van Reenen et al. 2004; Reuter et al. 2004; Parker & Loveday 1996). The use of steel slag as an aggregate is considered a standard practice in many jurisdictions, with applications that include its use in granular base, embankments, engineered fill, highway shoulders, and hot mix asphalt pavement (US Department of Transportation: FHWA 1997).

3.6 Beneficiation initiatives in South Africa

Beneficiation can be defined as any further processing of a mineral beyond the stage where it represents a saleable raw material. Mineral ores are the first saleable product of metallic minerals that occur in nature in the form of oxides, e.g. manganese and chromium. Any further processing such as separation processes that produce a more refined product or chemical and pyro-metallurgical processes which change the chemical composition of the material, represents beneficiation and adds value to the product (Robinson & Von Below 1990).

There are several definitions relating to the concept of beneficiation. The concepts of physical metallurgy, chemical or metallurgical beneficiation and economic beneficiation are as follows (Dworzanowski 2013):

- *Physical metallurgy* is the transformation of metal products into alloys and/or semi-fabricated products such as wire, coil, plate, pipe, etc.
- *Chemical beneficiation* or beneficiation as related to metallurgy is the treatment of raw material (such as iron ore) to improve its physical or chemical properties, especially in preparation for smelting.
- *Economic beneficiation* is the transformation of mined ore into a higher value product that can be consumed locally or to exported markets.

For this research beneficiation will refer to economic beneficiation as defined above. During the review of literature on the beneficiation process, also referred to as downstream processing of resources, different conceptualisations of this process arose. The process was either described in terms of the steps involved in beneficiation or the form the resource takes on in each step, or both as shown in Table 3-3.

Table 3-3: Conceptualisations of steps in the downstream processing of resources

Source: (Dworzanowski 2013; Robinson & Von Below 1990; TIA 2012; Baxter 2013; Maia 2015; Department of Trade & Industry 2015; Callaghan 2013; International Council on Mining and Metals 2006)

Authors	Dworzanowski (2013)	Robinson and Von Below (1990)	Technology & Innovation Agency (2012)	Baxter (2013); Maia (2015)	Department of Trade & Industry (2015)	Callaghan (2013); International Council on Mining and Metals (2006)
Steps of beneficiation	1. Exploration 2. Mining 3. Extractive metallurgy 4. Physical metallurgy 5. Semi-fabrication		1. Exploration 2. Mine design and development 3. Mining 4. Mineral processing 5. Mineral upgrading and value-adding 6. Mine rehabilitation and closure 7. Post-closure social and labour plans	1. Mining and producing ore / concentrate 2. Conversion to bulk tonnage intermediate 3. Conversion to refined products suitable for small or sophisticated industries 4. Manufacturing of final saleable products	1. Mining 2. Conversion to bulk tonnage intermediate 3. Higher value added processing 4. Maximum value added processing	1. Society's need 2. Exploration 3. Discovery and development 4. Mining 5. On-site concentration and extraction 6. Off-site refining 7. Production of semi-manufactured goods 8. Production of fabricated products 9. Product use 10. Disposal / recycling / re-use / re-manufacture
Form of resources	1. Mineral deposits 2. Ore 3. Metal / Mineral product 4. Steel / Alloy 5. Wire / coil / pipe / other semi-fabricated items	1. Ore 2. Saleable smelted / refined products 3. Fabrication of alloys 4. Semi-manufactured articles 5. Fabricated articles		1. Ore 2. Smelted / refined products 3. Fabrication of alloys and metals 4. Semi-manufactured articles 5. Fabricated articles	1. Unbeneficiated minerals (ore / concentrate) 2. Somewhat beneficiated (metal / alloy) 3. Semi-fabricated products 4. Finished goods ready for sale	

South Africa with its abundant mineral resources has predominantly featured as a resource economy. According to an independent evaluation done by Citibank in May 2010 (Oxford Business Group 2013), South Africa's non-energy mineral wealth is estimated at US$ 2.5 trillion, which makes the country the wealthiest mining jurisdiction. South Africa's mineral resources are, however, exported as raw ores or only partially processed.

The government has implemented the New Growth Path (NGP) in 2009 in order to create more inclusive economic growth with increase job opportunities. The NGP identified mineral beneficiation as the sector with the highest potential for job creation. According to the DMR, the strategy is aligned to (Department of Mineral Resources RSA 2011):

- Enhance the quantity and quality of exports;
- Promote creation of sustainable employment;
- Diversification of the economy;
- Increase sources for consumption of local content;
- Promote a green economy.

This policy framework prioritises the mining value chain and especially mineral beneficiation, as one of the key economic activities that present the highest value proposition towards the attainment of its objectives. Currently South Africa's economy has low levels of mineral beneficiation as most of its minerals are exported as ores or semi-processed minerals rather than high value intermediate to finished products (Department of Mineral Resources RSA 2011).

Multi-stakeholder structures which support various aspect of beneficiation have been created to identify and investigate specific value chains or aspects thereof. The existing structures which are outlined in Figure 3-11 complement the objective of the strategy (Department of Mineral Resources RSA 2011):

Figure 3-11: Beneficiation implementation framework as proposed by the DMR.
Source: (Department of Mineral Resources RSA 2011)

According to Robinson & Von Below and Maia, beneficiation has several obvious advantages (Robinson & Von Below 1990; Maia 2015):

- With each succeeding stage of beneficiation value is added
- Beneficiation increases employment
- Increased fabrication provides a greater scope for product diversification, which creates the choice of products best suited to penetrate export markets
- Beneficiation builds industrial competitiveness
- It enhances balanced economic development and growth
- It promotes the development of high-tech sectors
- Beneficiation increases further investment and capital formation

3.7 Constraints identified from literature

A few barriers were identified through the course of the literature review. These barriers are briefly discussed in this section.

3.7.1 Logistics (Transport: Railways and Ports)

The South African freight system is currently suffering from inefficiencies rendering most of the manganese ore and alloy products incapable of being optimally distributed to domestic and international markets. Since the country's transport infrastructure has been found inadequate of supporting higher export volumes to the international market, Transnet has made a greater effort to enhance the South African port and rail utilities. Rapid economic growth and lack of proper maintenance and upgrading, however, have rendered the transport system in urgent need of improvements.

According to the DMR South Africa has the potential to drastically increase its manganese exports if the country's rail infrastructure is improved (Ratshomo 2013). Mining houses prefer to transport its ore to smelters for further processing or the export destination through the rail network due to the cost and logistics advantages for freight transport as compared to road transport.

In 2014, South Africa was ranked 52nd out of 60 countries in the IMD's world competitiveness ranking with the country's infrastructure being ranked even lower at 55 (Department of Government Communication and Information Systems 2015).

"*The freight system in South Africa is fraught with inefficiencies at system and firm levels. There are infrastructure shortfalls and mismatches; the institutional structure of the freight structure is inappropriate, and there is a lack of integrated planning. Information gaps and asymmetries abound; the skills base is deficient, and the regulatory frameworks are incapable of resolving problems in the industry*". This statement was made by South African Minister of Transport J.T. Radebe (Radebe 2005).

With regards to ferroalloy industry, most of the existing manganese producers are experiencing constraints to the delivery of their product. This is primarily due to increasing logistics costs, delays at ports, and unreliable rail transport (Basson et al. 2007).

Manganese ore in the Northern Cape are logistically linked by rail to ports in Saldanha, Port Elizabeth and Durban. These resources are not only manganese ores, but other minerals as well, including chrome and iron ore. There is a limited rail capacity available on some of the rail sections on these routes, which causes constraints in terms of port infrastructure to handle additional volumes.

The PE terminal was refurbished in 2010 which allowed for its current maximum throughput capacity of 5.5 Mtpa, but due to rail limitations the actual capacity is 4.2 Mtpa. The Durban Manganese Ore Port Terminal has a current maximum throughput capacity of 1 Mtpa which is also constrained by rail capacity (Ratshomo 2013).

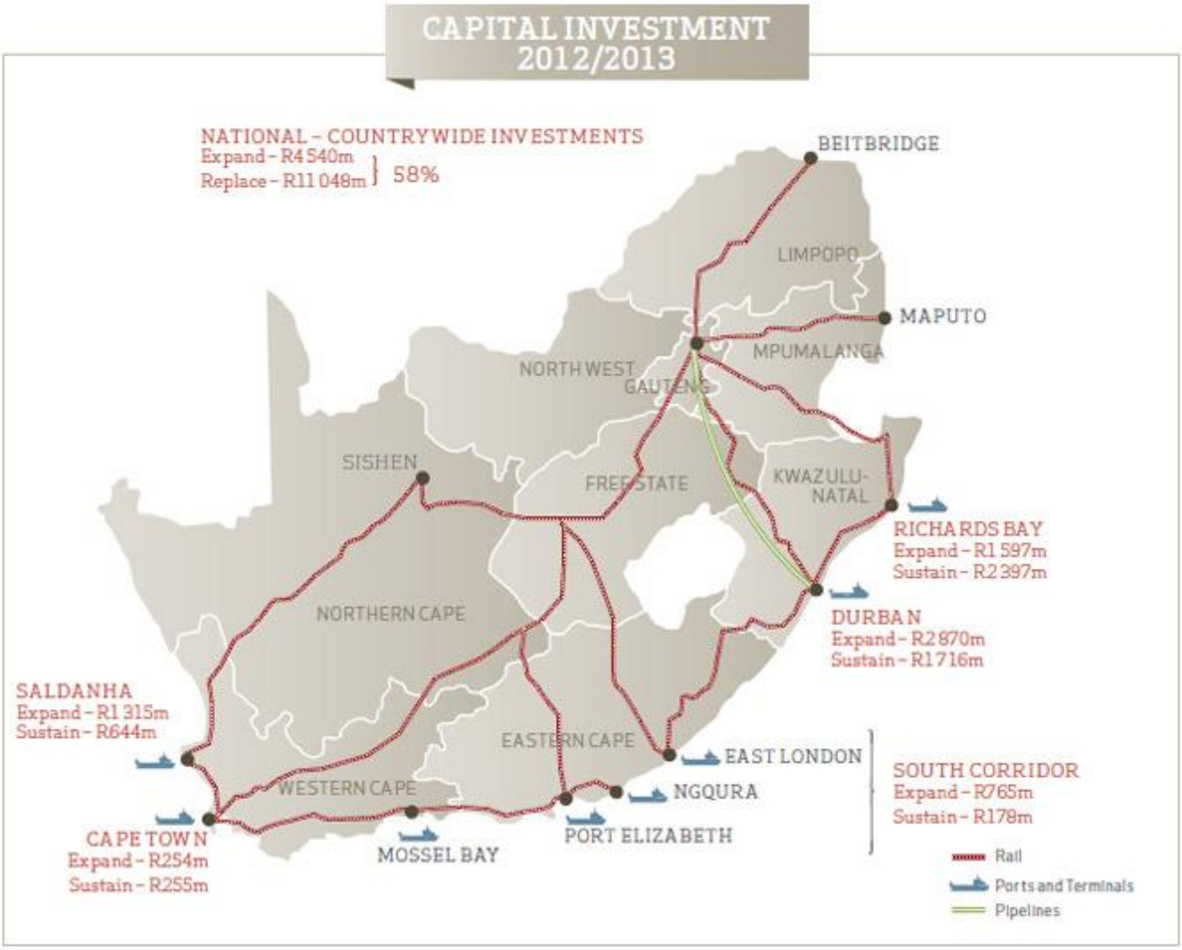
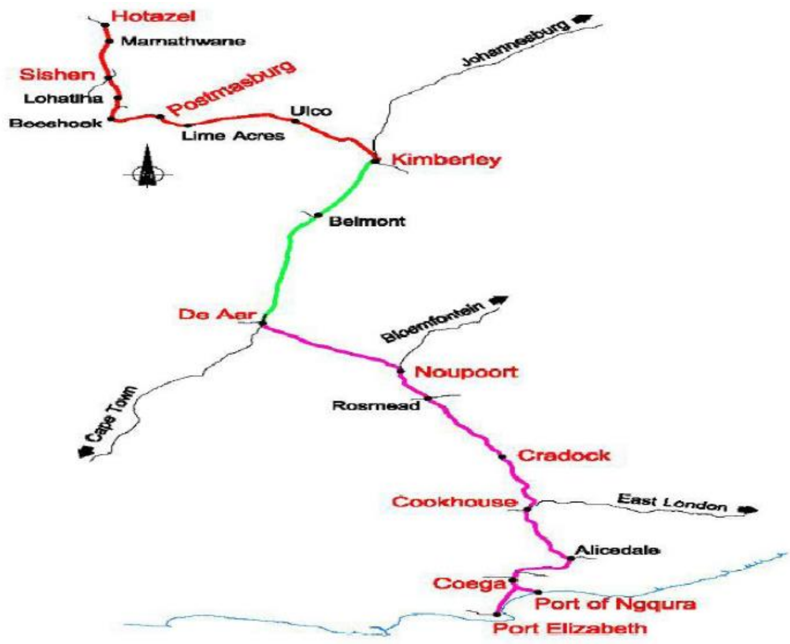


Figure 3-12: Transnet's capital investments in rail and port expansion
Source: (Transnet 2013)



Capacity Utilisation (%) = Trains needed/ Slots Available	
(red)	*Heavy Congestion - 105-130%* *New Infrastructure needed*
(green)	*Moderate Traffic - 60-80%* *Operational Re-engineering*
(magenta)	*Network Collapse - 130%* *Doubling or new lines needed*

Figure 3-13: Transet railway capacity utilization

Source: (Ratshomo 2013)

3.7.2 Unreliable Electricity Supply and Rising Costs

South Africa could increase its production and exports of its beneficiated manganese products if the power supply to processing plants is improved. Since 2008, the mining sector has faced electricity rationing that limited production due to electricity shortage in South Africa. The establishment of any new manganese alloys smelter plants is dependent on the availability of electricity. The power limitations have been one of the largest constraints of manganese industry in South Africa and are effecting all the major role players on a large scale.

The processing of alloys is particularly energy intensive and the smelters in ARM's (part owner of Assmang) Ferrous Division consume nearly half of the group's total electricity. According to ARM excessive energy costs will affect the profitability of all businesses and ultimately undermine job creation, social development and the flow of revenue to the government (African Rainbow Minerals 2014). Furthermore, unscheduled electricity supply interruptions affect many businesses' ability to achieve their production targets.

South Africa's electricity demand has at present more than caught up with the state energy supplier, Eskom's electricity-generating capacity. An increasing number of global commodity businesses have reservations about supporting major planned investments in new production facilities and believe that South Africa will no longer remain a low cost electricity supplier (Ratshomo 2013). These perceptions have caused many attractive potential ferroalloy production projects to be implemented at alternative areas.

3.7.3 Proximity to Markets

South African alloy producers have not always found it economic to exploit rising demand for manganese products due to its distance from the markets, despite the existing excess production capacity to do so. Competitors that ate located closer to the markets have traditionally had a competitive advantage over local producers. Mogale Alloys' silicomanganese, for example, has been very limited to the European market, primarily due to the low prices of the same alloy from India which is located closer to market (Afarak Group 2014).

Thus, even though many local producers are well established as global commodity producers with efficient marketing machinery, they are currently facing the prospect of a shrinking market share due to a variety of factors, including increased transport costs, product and international taxes, as well as a longer delivery time.

3.7.4 Labour Cost and Efficiency

South Africa's weak economic growth, rising costs, high unemployment and numerous socio-economic challenges have resulted in many problems and unrest in labour cost and efficiency. This extreme financial pressure has been evident in extended strikes in the platinum and metal industries. Unrest in workers has led to decreased labour productivity which undermines companies' profitability and threaten the sustainability of the business. The current perception that mining is high-risk is discouraging potential investors in the industry.

3.7.5 Raw Materials

For many years South Africa has been self-sustaining in terms of the supply of reductants used for the production of ferroalloys. Recently, however, metallurgical coke had to be imported from China and Zimbabwe for the manufacturing of chrome and manganese alloys respectively (Basson et al. 2007). There are numerous factors that contributed to this, including the stagnation of coke production capacity, the accelerated increase in ferroalloy production, and the growing trend for closed furnaces which require more coke (Basson et al. 2007). ArcelorMittal Coke & Chemicals is addressing this problem with coke batteries located in Pretoria, Newcastle and Vanderbijlpark producing commercial coke with a capacity of 700 000 tpa for the ferroalloy industry (ArcelorMittal 2015).

3.7.6 Fluctuations in Commodity Prices

Commodity prices are often affected by external factors which many times cannot be controlled by producers. All commodities are subject to wide fluctuation, especially minerals used for alloy and steel manufacturing. Manganese supply and demand are closely dependent to the iron and steel market with all manganese products following a similar trend to these resources.

This causes price volatility which can have adverse effects on a company's operating results, asset values and cash flows. If commodity prices remain weak for sustained periods, growth projects could not be longer perceived as viable options.

3.7.7 Other Barriers and Constraints

There are many other factors which contribute to the prevention of better beneficiated manganese products in South Africa. These barriers include, but are not excluded, the following:

- Lack of proper research and development in the field
- Skills sought for the expediting of local beneficiation
- Carbon tax and other environmental policies and regulations
- Rising mining and production input costs
- National policies and legislation on ownership and management

3.8 Analysis of the findings from literature

The literature and theory provides background information of all the relevant disciplines, fields and theories relating to the South African manganese. This information is used to ensure that new results are provided and not simply duplicating research that has already been completed. The aim of the literature review is to be able to provide supporting information that can be used to analyse the current state of the industry and to develop approaches to promote solutions for current constraints in South Africa.

The following SWOT analysis is used to determine the current and potential position of manganese beneficiation in South Africa:

Table 3-4: SWOT analysis of the South African manganese industry

Strengths	• Abundant manganese resources • Availability of high-grade ore • High foreign direct investment • Advanced mining techniques and technologies • Government supported beneficiation legislation and polices • Low electricity tariffs
Weaknesses	• Mining and producing is capital intensive • South Africa's distance from manganese markets • Limited R&D funding • Coke for manufacturing is not locally produced and thus imported • Weak infrastructure, especially railways and ports • Unreliable electricity demand is affecting profitability in the industry • Shortage of proper skills • Unrest in mining community is affecting productivity and efficiency
Opportunities	• Manganese industry is expanding in South Africa with many new manganese mining and production projects

	• Beneficiation initiatives could lead to increase job creation • Possible market for manganese and steel products for development projects in Africa • National infrastructure expansion of railways and ports could increase manganese transport capacity
Threats	• Increased international pressure, especially from China • Electricity prices may rise • More mines purchased by businesses outside South Africa • National infrastructure developments might take longer than expected • New policies and legislation could affect businesses' profitability

3.9 Chapter 3 summary

A comprehensive overview of the manganese value chain is provided in this chapter. Focus was placed on the background of the mineral, ore reserves, its applications and production processes. South Africa is a dominant producer of the mineral, possessing between 75 to 80 per cent of the world's identified manganese resources and approximately 24 per cent of the world's reserves. Over 90 per cent of the reserves are located in the Kalahari Manganese Fields (KMF) located in the Northern Cape and has an estimated 4 billion tons of manganese reserves.

The application of manganese is primarily used in alloy manufacturing, which is used in steel production. High-carbon ferromanganese, refined ferromanganese and silicomanganese, are the major alloys produced from manganese in South Africa. The mineral is also used to a lesser extent in the production of batteries and very small quantities in numerous chemical products.

The chapter also discussed the proposed beneficiation initiatives in South Africa, discussed the constraints identified in the literature that are faced in the industry and concluded with a short SWOT analysis of the findings in the literature.

Chapter 4

4 Phase 2: Defining the value chain

The first framework design requirement entails defining and describing the mineral value chain and its environment. In this chapter, the process of defining the value chain is described with the use of specific tools, such as Porter's Value Chain. The various activities comprising the value chain is identified, as well as the role player structures for each segment of the chain. A process-flow diagram is developed, which provides an overview of the entire chain and the products that are produced throughout. The chapter concludes with a summary of the steps required in defining the mineral value chain.

Research Question 2 – What is the structure of the specific mineral value chain?

- *Research Question 2.1*
  What are the main activities that compose the value chain?
- *Research Question 2.2*
  What is the major role player structure in the industry?
- *Research Question 2.3*
  What is the process flow within the industry?

4.1 Chapter overview

An overview of this framework phase is provided in Table 4-1 and a step-by step representation of the phase is shown in Figure 4-1.

Table 4-1: Overview of Phase 2

Phase 2: Identifying and defining activities in VC		
Description: Once an overview of the mineral industry has been established, different sectors of the chain can be distinguished by the value they add to each output in the process. A general representation of the various sectors/segments comprising the value chain is provided in this framework phase. This provides an understanding of the structure of the chain, the inputs and outputs in each activity and lastly, the different role players involved in each process.		
Key objectives		
• Identify the activities in the VC • Define the primary and support activities • Define the output flow of the VC	• Develop the basic layout of the VC • Determine the role player structure in the VC	• Develop complete mineral VC • Develop the product roadmap of the industry
Framework tools / Outputs:		
• Porter's value chain • GVC analysis (I-O structure)	• Definition of VC activities • Manganese role player structure	• Manganese product roadmap • Identification of main sectors comprising the manganese VC

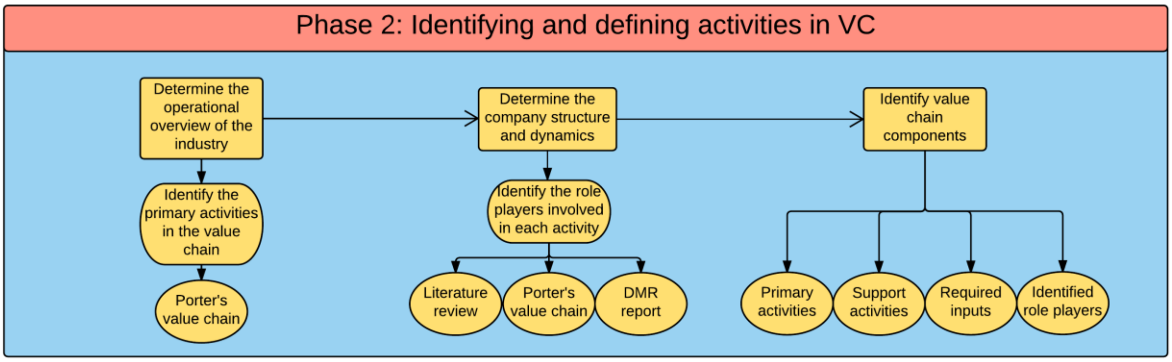


Figure 4-1: Methodology for Phase 2 of the proposed framework

4.2 Identify the activities/segments in the value chain

A value chain represents the entire input-output process involved in developing a product or service from an initial conception to the final development experienced by the consumer (Gereffi & Fernandez-Stark 2011). The major segments or sectors comprising the chain vary from industry to industry, but typically include: research and design, inputs, production, distribution and marketing, processing, sales, discarding and in some cases the recycling of products after use (Baartjes 2011; Gereffi & Fernandez-Stark 2011; Dicken 2011; Callaghan 2013). A range of supporting industries are also included in the input-output structure together with both goods and services involved in the various segments of the chain.

According to Gereffi and Fernadez-Stark's input-output structure in their GVC analysis method, a set of boxes are used to represented the structure of the chain, which illustrates the flow of tangible and intangible goods and services (Gereffi & Fernandez-Stark 2011). They explain the importance of determining the input-output structure to GVC analysis by stating that it is vital to conveying the value added at the different sections of the chain. In order to gain an understanding of the complete chain, it is utterly important to analyse the progression and transformation of the industry, the trends that have shaped it and its organization. Aim of phase 2 is to identify the mineral value chain and the activities of which it is composed. With phase 1 providing insight on the overview of the industry, sectors of the value chain can be identified and distinguished by the value they add to the products.

During this phase the various pieces of information gathered in the literature review is used to develop a coherent chain that illustrates the primary activities of the industry. The sectors of the chain will convey how various value adding processes contribute to the product or service, as well as the varying returns captured by the role players behind them. The input-output structure diagram is effective in providing these findings, as shown in Figure 4-4 and elaborated upon further in Figure 4-6. The first step of this phase is to identify the primary activities of the mineral value chain.

4.2.1 Identifying the primary activities of the manganese industry with Porter's Value Chain

The idea of a value chain is based on the process view of organisations and seeing a manufacturing organisation as a system, which is comprised of different subsystems each having its own inputs, transformation processes and outputs (IFM 2016). During this process of converting inputs to outputs, most organisations engage in numerous of activities which can generally be classified as either a primary or support activity according to Porter's Value Chain (Porter 1985). These primary activities are:

1) **Inbound Logistics** – These activities involve relationships with suppliers and the activities required to receive, store, and distribute inputs.
2) **Operations** – Activities required to transform inputs into outputs.
3) **Outbound Logistics** – Activities required to collect, store, and distribute the output.
4) **Marketing and Sales** – Activities that inform buyers about products and services, induce buyers to purchase them from your company instead of your competitors and facilitate their purchase.
5) **Service** – Activities related to maintaining the value of your product or service to your customers, once it has been purchased.

Porter's generic value chain be elaborated upon in order to cater for more specialized cases, such as for this instance, mineral value chains. The basic structure of the mineral value chain, illustrated in Figure 4-2, is compiled from the various sources summarised in Table 3-3, with the exception of the last two steps. These steps, namely *Distribution of Product* and *Supplier/Consumer Relationship,* were not mentioned in the processes summarised in the table, but are essential to complete the scope of the value chain explored in this study. These phases, just as the others listed in Figure 4-2, serve as intermediate steps in the development of the final description of activities for the mineral value chain as listed in Figure 4-3.

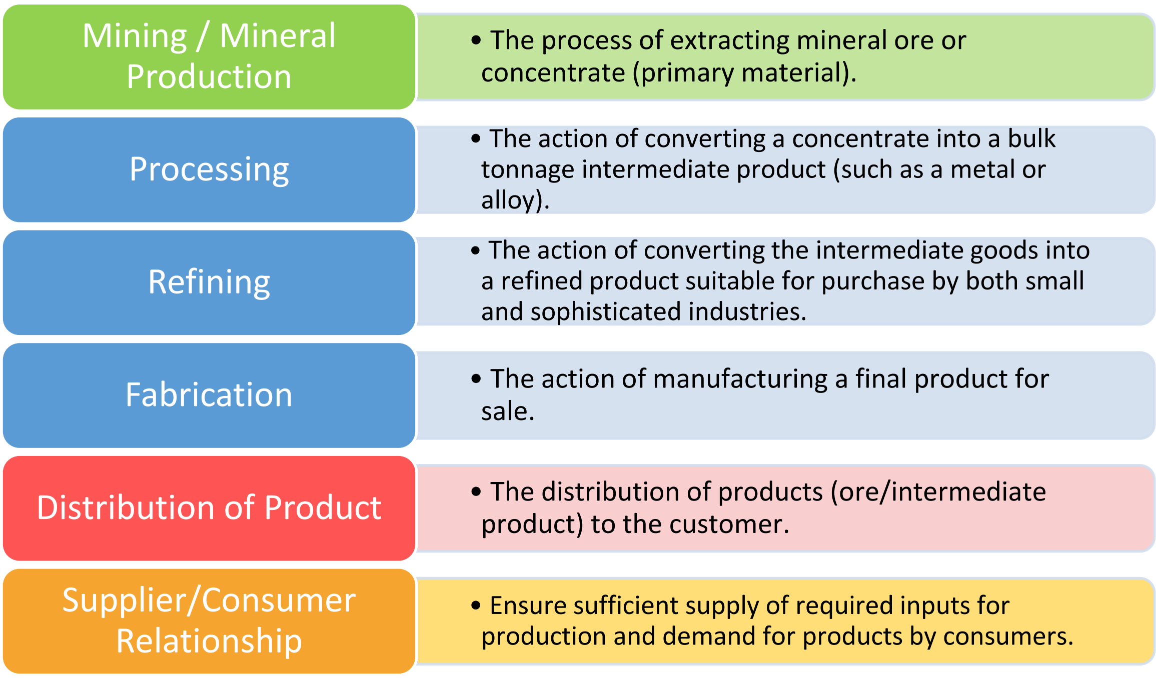


Figure 4-2: Initial description of activities in the mineral value chain, developed from the summary in Table 3-3.

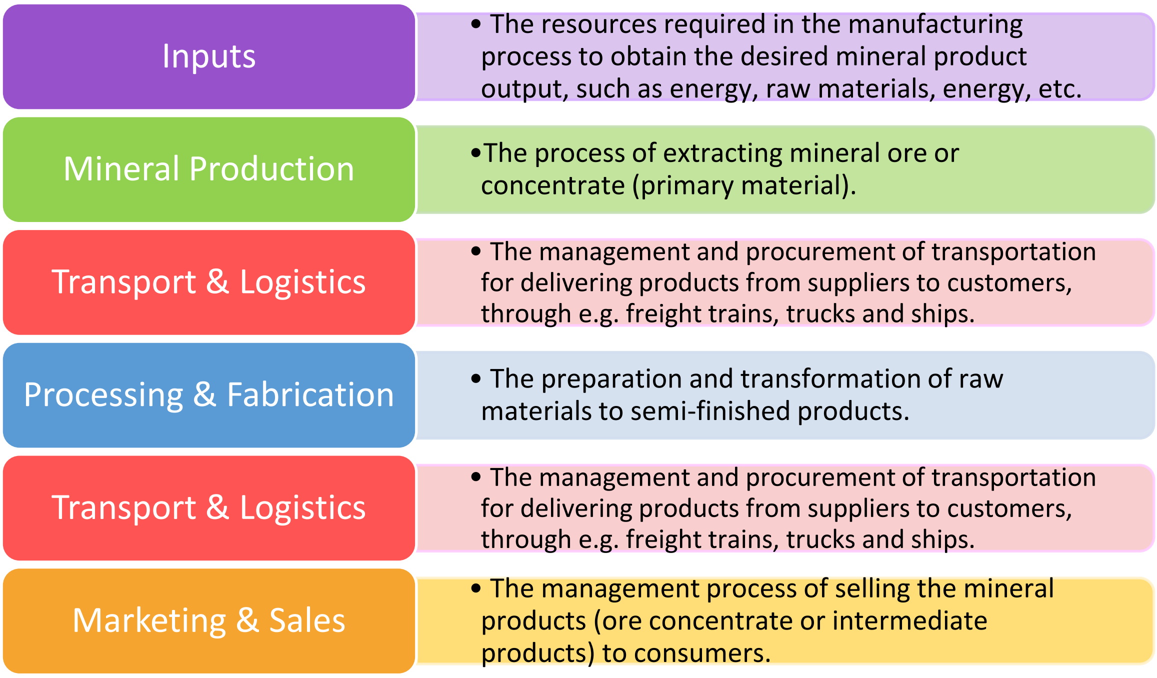


Figure 4-3: Final description of activities comprising the mineral value chain.

The list presented in Figure 4-3 serves as the final primary activities comprising the mineral value chain structure, which is elaborated on in Figure 4-6. The iterations detailing the development of the final activities are indicated in Figure 4-4. Each level in this figure shows the progression of developing the activities involved in a mineral specific value chain. The process started with Porter's value chain, which evolved through the incorporation of different concepts from Table 3-3. The final conceptualization of activities comprising the value chain are displayed at the bottom of Figure 4-4. Boxes with a broken outline represents activities which fall outside of the scope of the value chain investigated for barriers. Faded boxes represent activities that are not listed in literature, but serve as intermediate steps for the development of the final primary activities.

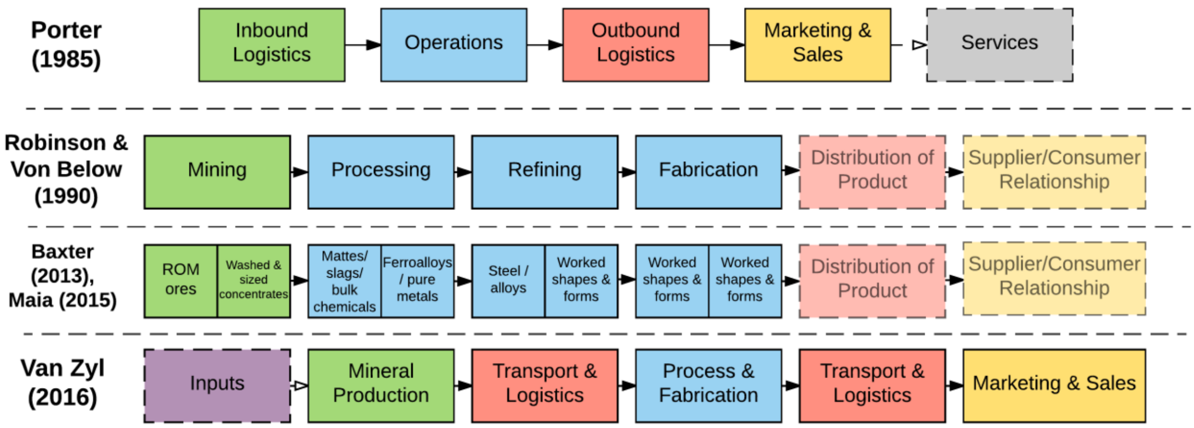


Figure 4-4: Generic overview of the main activities and products in the mineral value chain
Data gathered from: (Baxter 2013; Maia 2015; Porter 1985; Robinson & Von Below 1990)

4.3 Identifying the structure of firms under each segment of the VC

The sectors identified in the previous step have specific characteristics and attributes, such as particular sourcing practices or preferred suppliers (Gereffi & Fernandez-Stark 2011). For example, alloy manufacturers might receive their required manganese ore from independent mining companies or be part of an integrated company that are involved in both the mining and alloy production sector and thus supply their own ore.

As part of this analysis of the value chain, it is important to identify the types of companies involved in each sector in the industry as well as their key attributes: global or domestic, state-owned or private, size of the company, etc. (Gereffi & Fernandez-Stark 2011). Identifying the types of firms involved and participating in the value chain will help to determine its governance structure later on (see Governance structure of the value chain).

4.3.1 Determining the structure of each segment in the value chain

To provide guidance in this step, Porter's Value Chain is used once more. The primary value chain activities, which are described in the previous step, are facilitated by support activities. Porter identified four categories of support activities (Porter 1985):

1) **Firm infrastructure –** These are the company's support systems and the functions that allow it to maintain daily operations and includes accounting, legal, administrative and general management.
2) **Procurement** – The acquisition of inputs, or resources, for the firm.
3) **Human Resource management –** Activities associated with recruiting, developing, compensating and retaining and dismaying its workers.
4) **Technological Development –** Activities relating to managing and processing of information, as well as protecting a company's knowledge base. This includes staying current with technological advancements, research and development and other technology developments used to support the value chain activities.

Porter's four support activities are important to keep in mind when determining the structure of the value chain, as representatives from all the activities (primary activities included), need to be present. This ensures that all of the main aspects and stakeholders in the specific industry is accounted for and plays a significant role in determining the buyer-supplier relationship later on.

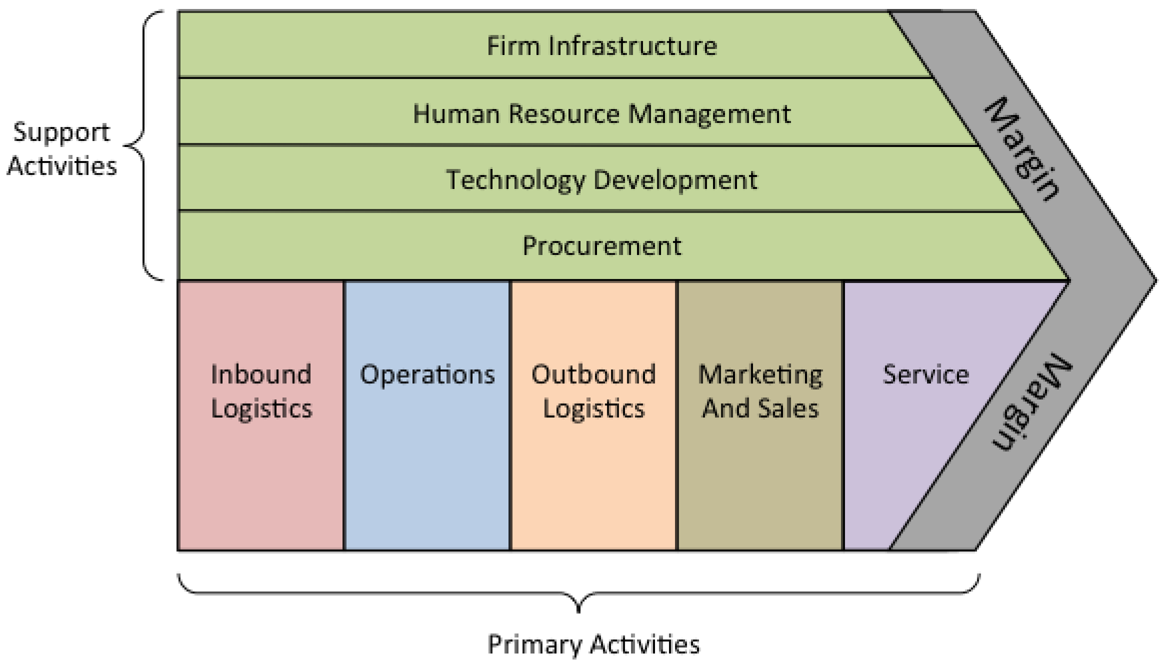


Figure 4-5: Porter's Generic Value Chain
Source: (Porter 1985)

Porter's Value Chain, which served as the foundation for developing the mineral value chain, is shown in Figure 4-5. With this tool, it was possible to develop a specific input-output model for the manganese value chain as indicated by the initial concepts shown in Figure 4-4, which was developed to the final representation in Figure 4-6. It conveys the various segments of the South African manganese value chain and the types of role players involved in each step. It provides a representation of the local structure of the industry, the required inputs for the processes and the activities involved in each segment.

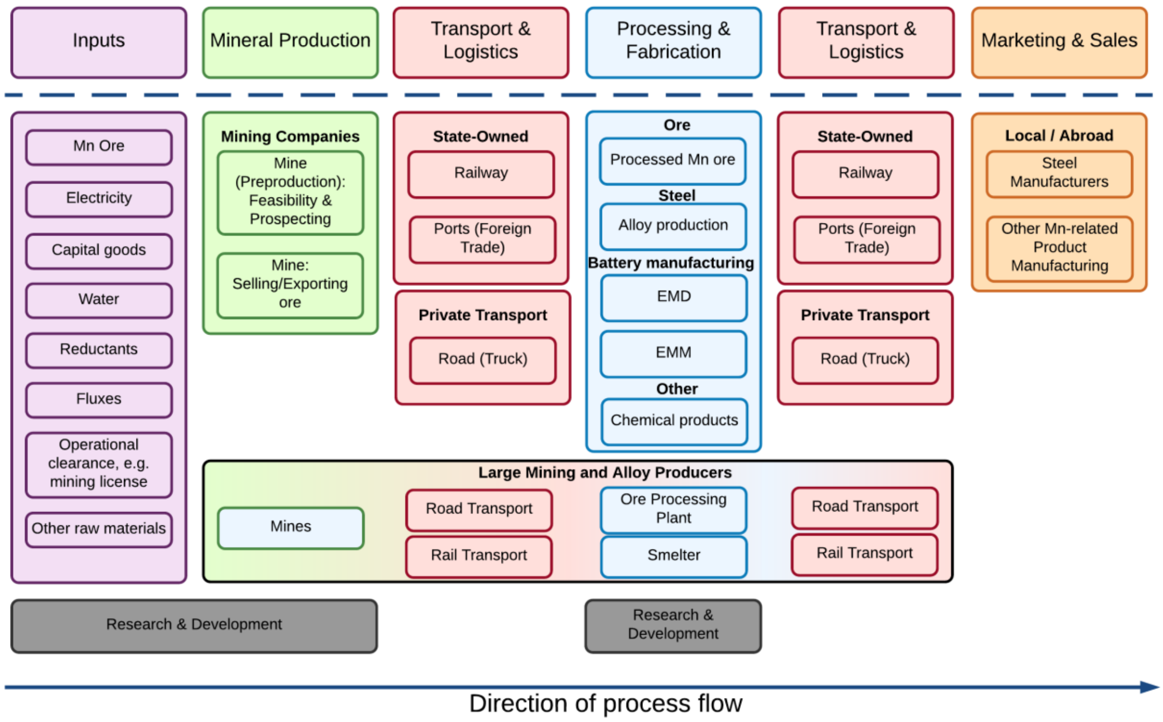


Figure 4-6: The South African manganese value chain

4.4 The process-level flow diagram of the industry

A process-level flow diagram illustrates how materials are transformed throughout the value chain in terms of inputs and outputs. These diagrams reveal the relationships among and between the various sectors and role players in the manganese mineral industry. The flow diagram is an important technique for modelling industry's high-level detail by conveying how inputs are processed to form outputs through a sequence of value-adding transformations.

4.4.1 Creating the process-level flow diagram

The process flow diagram makes use of different components in representing the processes implemented in the industry. The small white blocks represent a specific output or product, which in turn, in most cases, is the input to the next process. These products are grouped together in coloured areas that represent different product types. These product type groups contain products that often share similar attributes, such as undergoing similar manufacturing processes and consumers. The products are connected through arrows which indicate the process flow. It is very useful to add the size of the volume of each output to the diagram, if it is available, in order to place the proportion of these outputs into perspective. The final process-level diagram is shown in Figure 4-7.

4.4.2 Importance of creating the process-level flow diagram

As stated in section 2.3.5 while identifying supplementary tools to be incorporated within the framework, the process-level flow diagram is a very useful tool when analysing a specific mineral value chain for the following reasons (Le Vie 2000):

1. The process flow diagram, together with the value chain structure layout, provides a very detailed overview of the industry. These tools make it easier to understand the various processes involved in product manufacturing and the role players involved with each respective activity.
2. The process flow diagram provides a high-level system overview, complete with boundaries and linkages to other systems.
3. It can provide a detailed representation of the different process sectors comprising the value chain.

The various sectors of the manganese industry are clearly indicated in coloured blocks in Figure 4-7. The industry consists of:

- Ore / Mineral production;
- Non-ferrous / EMD and EMM production;
- Ferrous / Alloy manufacturing;
- Slag related product manufacturing;
- Steel manufacturing, and;
- Other chemical product manufacturing.

Since only approximately 1% of the produced manganese ore goes into the manufacturing of chemical specific products and since ferro-slag must be discarded on slug dumps in South Africa, these two sectors will be excluded from the study. Since steel manufacturing makes use of a variety of different alloys as input and is used to produce vast array of products, it falls too far downstream to remain within the scope of the study. This sector will only be interpreted as an end-user of manganese alloys.

Due to fact that the majority or manganese is used for metallurgical purposes (with 90% to 95% used in alloy manufacturing and approximately 5% used in EMD and EMM production), the sectors that will be investigated in this industry are: mineral production (mining sector), alloy manufacturing, EMD production and EMM production.

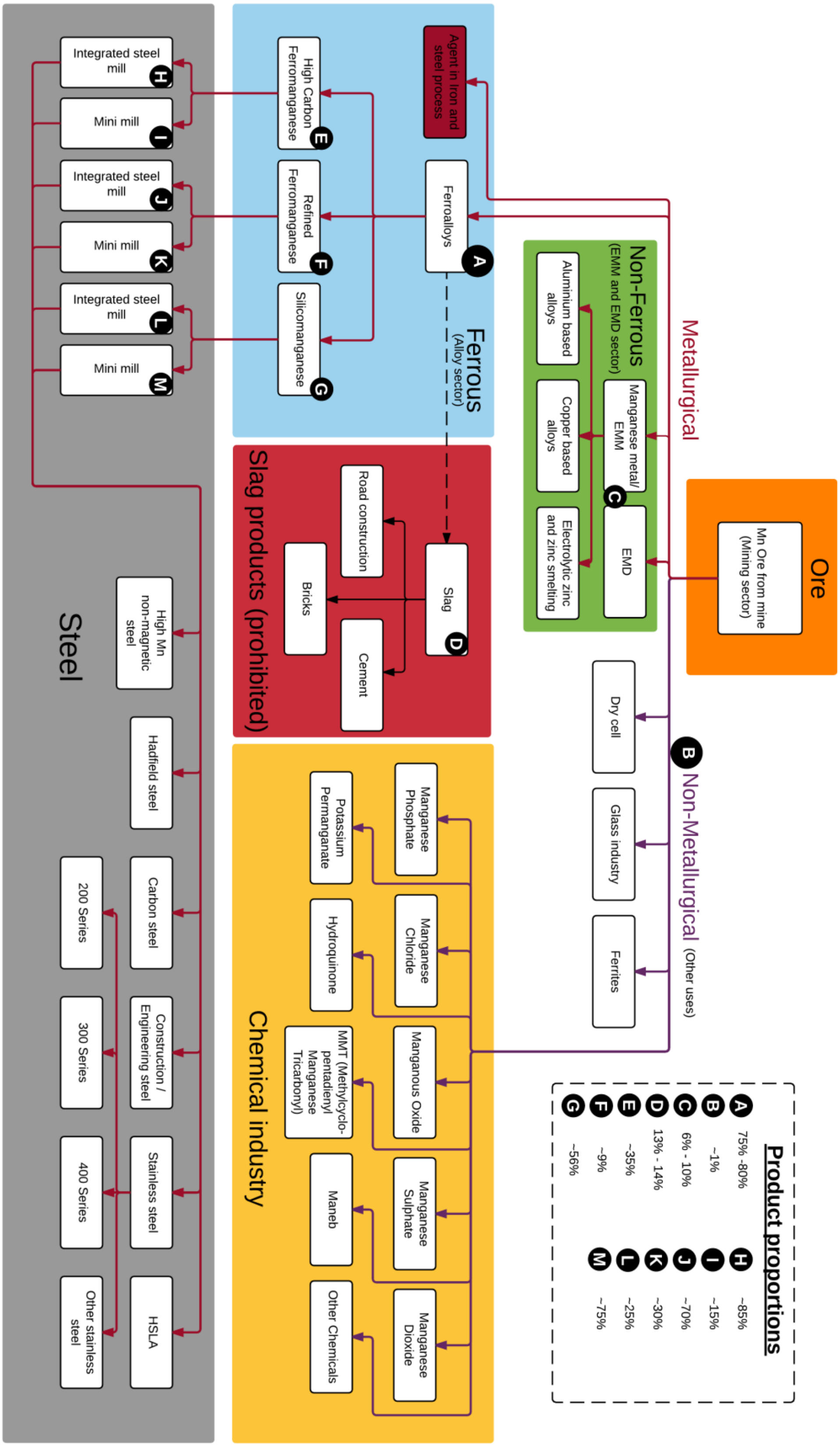


Figure 4-7: Manganese industry process-level flow diagram.

Source: (Van Zyl et al. 2016)

4.5 Summary of steps to defining the value chain

In order to gain a better understanding of the activities that lead to a better competitive advantage and economic growth, a generic value chain should first be determined, which should then be followed by identify the relevant firm-specific activities. Process flows from the value chain can then be mapped in order to isolate the individual value-creating activities. Once these discrete activities are defined, linkages between these various activities can be made. This linkages exist where the performance or cost of one activity affects another (QuickMBA 2010).

The following summary provides a guideline to expanding Porter's Value Chain to define a mineral value chain (Mind Tools 2016):

1. **Identify primary activities and their corresponding sub-activities**
   Sub-activities which leads to value creation is identified after the primary activities are determine that comprise the value chain. There are three types of sub-activities (Mind Tools 2016):
   - **Direct activities** – which create value by themselves.
   - **Indirect activities** – that allow direct activities to run fluently.
   - **Quality assurance** – activities that ensure that direct and indirect activities meet the necessary standards.
2. **Identify support activities and their corresponding sub-activities**
   Similar to the first step, support or secondary activities are identified with their respective sub-activities. Porter's support activities as mentioned earlier, include firm infrastructure and technology development. This step completes the outline of the value chain.
3. **Identify the links between activities**
   Find the connections between all of the identified activities. This will provide information pertaining to the process flow and which activities share resources or involve the same role players.
4. **Develop the process-level flow diagram**
   Determine the processes that inputs undergo to form specific outputs throughout the value chain. Identify the various sectors and role players involved in these processing activities.

4.6 Chapter 4 summary

With the aid of Porter's Value Chain the primary and supplementary activities were identified for a mineral value chain. An initial description was defined for each activity in the chain, which was refined to develop a generic structure for MVCs. This was applied to the manganese industry case study, which indicated the different role players involved in the various activities throughout the chain. A process-level flow diagram was developed to model the industry's high-level production detail by conveying how inputs are processed to form outputs through a sequence of value-adding transformations. The diagram identified four key sectors of the manganese value chain that will be investigated throughout the study, namely: mining, alloy manufacturing, EMD production, and EMM production. The chapter concluded with a summary of the process used to define a MVC.

Chapter 5

5 Phase 3: Determining the context of the global value chain

This chapter focuses on integrating the mineral value chain within a global context by analysing the essential characteristics that define the chain environment. There are four key attributes that will be investigated in this chapter. The first is the geographic scope of the GVC, which takes a look at the international supply and demand of the mineral products and who are the major local and global role players in the industry. The second attribute, is the governance structure of the chain which explains the dynamics between the inter-firm relationships in the chain and how the different role players affect one another. The third aspect that will be investigated in the chapter, is the institutional context in which the chain is placed. It focuses on the economic, social and institutional dynamics that the GVC is embedded within, which has a significant impact on local, national and international conditions, role players and policies. The final aspect focuses on integrating all these factors to identify key attributes of the chain, through the use of various analysis tools, namely a summary of key aspects of the GVC, PESTLE analysis, SWOT analysis and an influence diagram of the local manganese value chain.

Research Question 3 – What are the main characteristics of the specific global mineral value chain?

- *Research Question 3.1*
  What is the geographic scope of the global value chain?
- *Research Question 3.2*
  What is the governance structure of the global value chain?
- *Research Question 3.3*
  What is the institutional context of the specific mineral value chain?
- *Research Question 3.4*
  What are the main attributes that influence operations in the specific mineral value chain?

5.1 Chapter overview

An overview of this framework phase is provided in Table 5-1 and a step-by step representation of the phase is shown in Figure 5-1.

Table 5-1: Overview of Phase 3

Phase 3: Determining the context of the global value chain		
Description: This phases focuses on integrating the complexities of a mineral value chain to analyse the characteristics which are unique to the chain in question. During this phase the chain's geographic scope of activities, role player relationships and positions within the chain, as well as its institutional context are investigated. This would provide insight on the key attributes which has a significant impact on the specific mineral value chain.		
Key objectives		
• Determine geographic scope of activities • Investigate the market of the mineral (supply and demand) • Identify the global role players in the VC	• Determine the hierarchy of role players in VC • Domestic industry's position in global context • Determine governance structure of VC	• Determine attributes of VC and institutional context (Economic, social and regulatory) • Analysis of key features of VC • PESTLE factor analysis • SWOT analysis
Framework tools / Outputs:		
• Geographic scope analysis • Investigation of economic, social and regulatory institutional context of the SA manganese industry	• Supply and demand analysis • Value chain governance structure analysis • PESTLE analysis of the SA manganese industry	• SWOT analysis of the SA manganese industry • VC influencer diagram

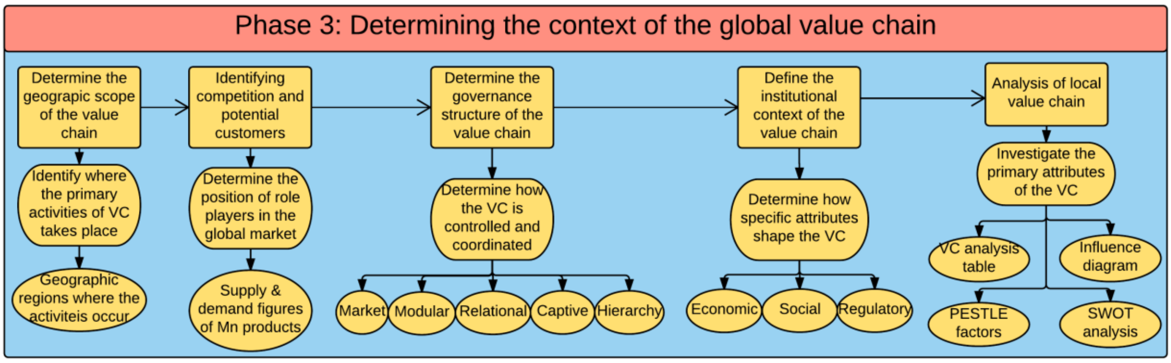


Figure 5-1: Methodology for Phase 3 of the proposed framework

5.2 Geographic scope of the GVC

Globalisation has become imperative in recent years for most industries and various value-adding activities with the advancement of technology, logistics and telecommunications infrastructure. It is compelled by an ever-increasing need for the most competitive inputs in each sector of the VC, especially in the case of the mineral value chains which are currently facing trying times.

Value chains are globally dispersed with various activities often taking place in different parts around the world. Different countries have different services or resources that they can bring to the table, which results in countries in the global economy participating in industries by using their particular competitive advantages in assets a bargaining tool (Gereffi & Fernandez-Stark 2011). This is illustrated with developing countries usually offering cheap labour and raw materials, while more developed countries often contribute to research and development and product design due to having better skilled or educated citizens. This has resulted in firms from around the world, affecting one another on different levels of the value chain (Globalvaluechains.org 2016).

This phase also incorporates one of Gereffi's steps for GVC analysis, namely geographical analysis. This would allow the researcher to trace the changes in the geographic scope of global industries, since global value chains operate at different topographic scales (local, national, regional, and global) (Gereffi 1995; Gereffi & Fernandez-Stark 2011). Table 5-2 illustrates the scope of the terminology associated with the geographic analysis of a value chain.

Table 5-2: Value chain / Production network spatial scale
Source: (Sturgeon 2001)

Name	Scale of operations	Other Names
Local	Commute area, SMSA	• Industrial district • Specialized industrial cluster • Regional economy
Domestic	Single country	• Supply-base • National system
International	More than one country	• Cross-border production network
Regional	Confined to a multi-country trade bloc (e.g. NAFTA, EU, MERCOSUR, ASEAN, AFTA)	• Regional production system
Global-scale	Actors integrate activities across, at least, each region of the "triad"	• Global commodity chain • Global production network

Analysing the geographic scope of the value chain is based on firstly identifying the lead firms in each segment of chain. This is done by using information already compiled in the previous phases of the proposed framework through secondary sources such as firm data, specialized industry publications, and interviews with industry experts. The country-level positions within the chain becomes evident through the number of these leading firms which are present within particular countries (Gereffi &

Fernandez-Stark 2011). Furthermore, it is possible to determine the contributions made by the different countries present within the chain by examining country-level data, such as the imports and exports within the various sectors of the chain.

It is clear that the world demand for manganese and ferromanganese products has a direct dependence on the outlook of the steel industry, which in turn is driven by housing construction, the automobile industry and general infrastructural constructions (Gajigo et al. 2011). To understand South Africa's position in this industry, the context of the country's role and where the barriers lie against economic growth, the global value chain of manganese and manganese related products is examined. According to Gereffi (Gereffi & Fernandez-Stark 2011), for many countries, especially low-income countries, the ability to effectively insert themselves into the global value chain is a vital condition for their development. South Africa's global position in the manganese product related markets is indicated in Table 5-3.

Table 5-3: South Africa's global production and consumption of manganese products
Source: (International Manganese Institute 2014c; World Steel Association 2014)

Product	Production			Consumption		
	Global rank	**Volume (mt)**	**% of Total**	**Global rank**	**Volume (mt)**	**% of Total**
Mn Ore	1	4.64	24.9	9	0.325	1.8
HC FeMn	3	0.457	10.1	28	0.27	0.56
Ref FeMn	5	0.102	5.9	31	0.10	0.59
SiMn	14	0.134	1.0	30	0.30	0.22
Steel	21	7.22	0.45	22[1]	5.40	0.36

Where Vol = Volume (mt Mn Units), % = Percentage of global total, Rank = Global ranking
[1]*Could be lower. Rank according to (World Steel Association 2014).*

By inspecting the manganese global value chain it is evident how the industry is organized by examining the structure and dynamics of the different role players involved. Since this mineral commodity, like so many, is globally integrated with complex industry interactions, examining the value chain is a useful tool to trace the shifting patterns of global production. It is furthermore convenient for associating geographically dispersed activities and role players, and determine the role they fulfill (Gereffi & Fernandez-Stark 2011). The global value chain focuses on the sequences of the value added within the industry and examines the technologies, standards, regulations, products, processes and markets, which provides a holistic view of the global industry.

Figure 5-2: Manganese ore and manganese alloy producing countries.
Source: (International Manganese Institute 2014d)

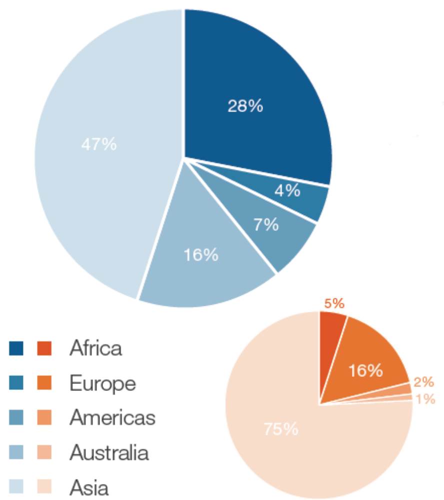


Figure 5-3: Global ore and alloy production 2010.
Source: (International Manganese Institute 2014d)

The first step of investigating the geographic scope of a mineral value chain, is determining the supply and demand figures for the ore. Mining and ore production entails all extraction operations and basic processing of the ore. Afterwards, upstream processing further along the chain, such as alloy production, will be investigated. It will then be concluded by investigating the production and demand figures of other products related to the mineral, which in this case is manganese.

5.2.1 Supply and demand of manganese ore

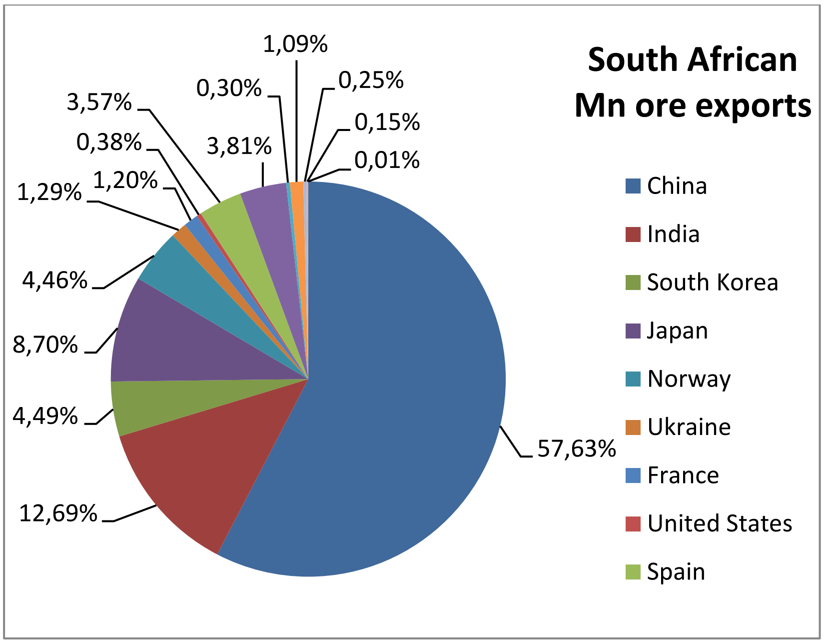


Figure 5-4: South African manganese exports in 2013.
Source: (International Manganese Institute 2014a)

SA Mn Ore Exports (wet tons)	
China	5 185 292
India	1 141 688
South Korea	403 835
Japan	782 671
Norway	401 694
Ukraine	115 643
France	107 681
United States	34 417
Spain	320 805
Russia	342 855
Slovakia	27 007
Australia	98 382
Brazil	22 085
Italy	13 360
Others	591
TOTAL	**8 998 006**

Table 5-4: The top 10 manganese ore producers and consumers in 2013 (000 mt Mn Units).
Source: (International Manganese Institute 2014a)

Production				Apparent Consumption			
Rank	**Country**	**Volume**	**% of Total**	**Rank**	**Country**	**Volume**	**% of Total**
1	South Africa	4 640	24,9%	**1**	China	10 830	61,2%
2	China	4 140	22,2%	**2**	India	1 683	9,5%
3	Australia	3 161	16,9%	**3**	Ukraine	752	4,2%
4	Gabon	1 967	10,5%	**4**	South Korea	619	3,5%
5	Brazil	1 058	5,7%	**5**	Russia	477	2,7%
6	India	920	4,9%	**6**	Japan	451	2,5%
7	Ghana	533	2,9%	**7**	Kazakhstan	441	2,5%
8	Ukraine	523	2,8%	**8**	Norway	434	2,5%
9	Kazakhstan	469	2,5%	**9**	South Africa	325	1,8%
10	Malaysia	389	2,1%	**10**	United States	251	1,4%
	Others	*860*	*4,6%*		*Others*	*1 440*	*8,1%*
TOTAL		**18 659**		**TOTAL**		**17 703**	

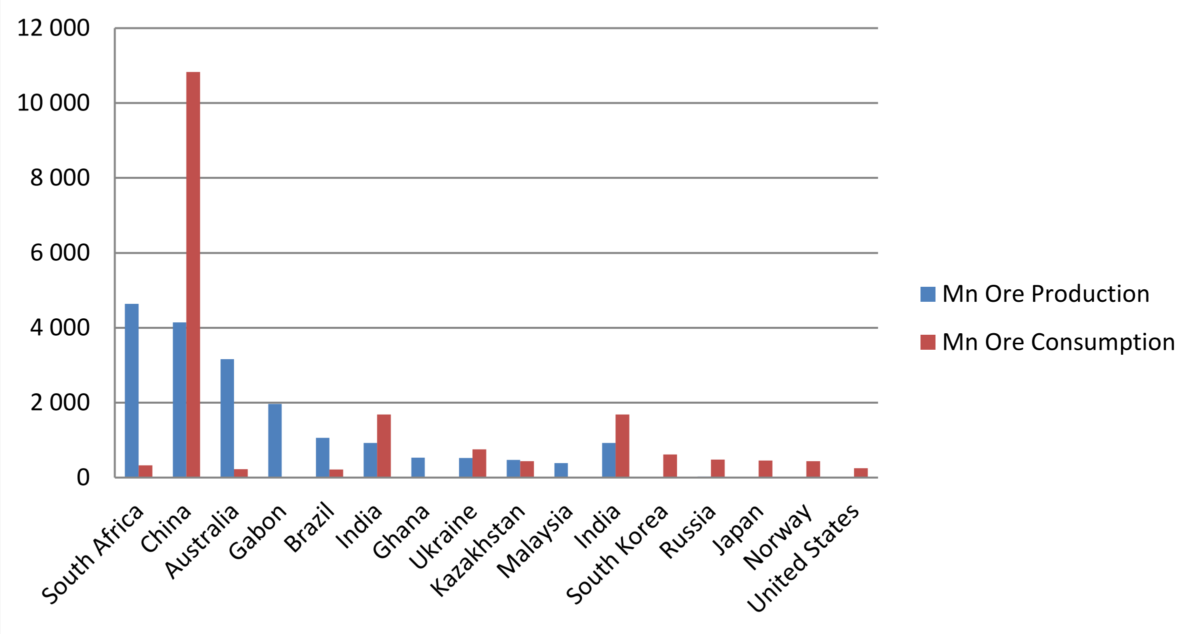


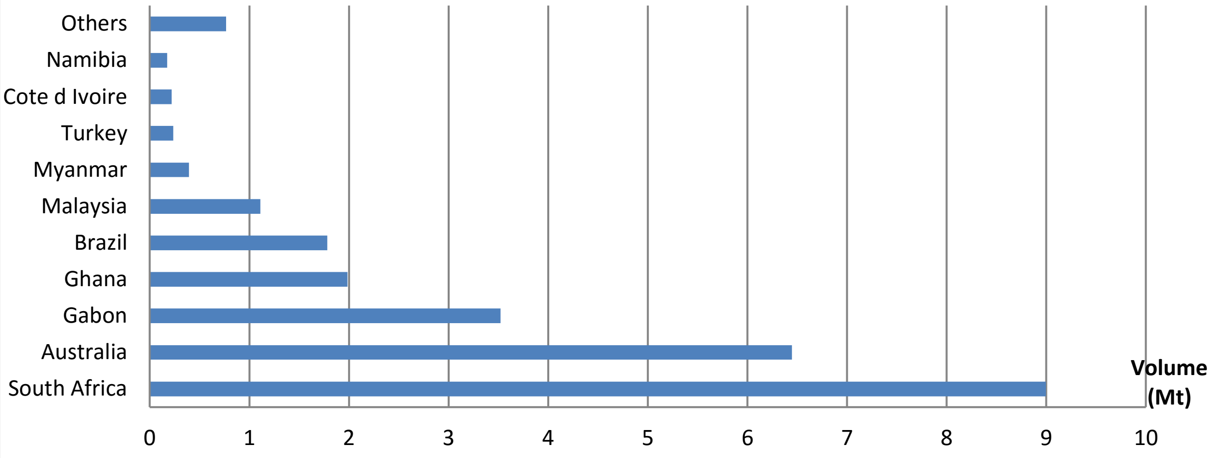
Figure 5-5: Countries' manganese ore production versus its apparent ore consumption in 2013

Source: (International Manganese Institute 2014a)

Table 5-5: Manganese ore production per grade (000 mt wet tons)

Source: (International Manganese Institute 2014a)

Country	≥ 44% (High)	≥30% and <44% (Medium)	< 30% (Low)	Total
China	0	0	23 000	23 000
South Africa	3 544	7 993	0	11 537
Australia	5 873	1 438	0	7 311
Gabon	3 697	600	0	4 297
Brazil	2 252	71	116	2 440
India	370	1 513	381	2 264
Ghana	0	0	1 912	1 912
Ukraine	0	1 353	0	1 353
Kazakhstan	0	1 202	0	1 202
Malaysia	0	1 111	0	1 111
Others	*407*	*1 626*	*23 210*	*25 244*
Total	**16 143**	**16 907**	**25 619**	**58 669**



	South Africa	Australia	Gabon	Ghana	Brazil	Malaysia	Myanmar	Turkey	Cote d Ivoire	Namibia	Others
Tons	8 998 006	6 448 560	3 521 363	1 986 901	1 781 956	1 110 671	393 791	235 164	220 329	174 381	767 510

Figure 5-6: The top manganese ore exporters in 2013

Source: (International Manganese Institute 2014a)

5.2.2 Summary of global manganese supply and demand

- In terms of manganese content (Mn units, not wet tons), South Africa is the largest producer of manganese ore.
- South Africa is also the largest exporter of manganese ore with nearly 9 Mt (wet tons) exported in 2013, about 2.5 Mt more than the second largest exporter, Australia.
- Nearly 60% of South Africa's 2013 exported ore went to China and nearly 13% went to India.
- Of the nearly 11.5 Mt (wet tons) of Mn ore produced in 2013 in South Africa, only about 2.5 Mt (wet tons) was kept domestically. Thus approximately 78% of the ore was exported without being beneficiated.
- China's Mn ore production is also very close to South Africa's. Australia, Gabon and Brazil are also major Mn ore producers.
- South Africa only produces high to medium manganese ore, in comparison to China that produces very high quantities of only low grade ore.
- South Africa, Australia, Gabon and Brazil are the only significant producers of high grade manganese ore.
- China consumes more than 60% of the total manganese ore, 6 times more than the closest consumer, India.
- Despite being the largest consumer of Mn ore in terms of Mn content, South Africa consumed less than 2% of the overall ore produced. An indication of how little beneficiation of manganese is done in the country.

5.2.3 Supply and demand of manganese alloys

Table 5-6: Top 10 HCFeMn producers and consumers in 2013 (000 mt)

Source: (International Manganese Institute 2014a)

Production			Apparent Consumption		
Rank	**Country**	**Volume**	**Rank**	**Country**	**Volume**
1	China	2 139	**1**	China	2 164
2	India	521	**2**	Japan	456
3	South Africa	457	**3**	India	395
4	Japan	332	**4**	United States	258
5	South Korea	221	**5**	Germany	130
6	Australia	144	**6**	South Korea	116
7	Russia	123	**7**	Iran	104
8	France	104	**8**	Russia	99
9	Spain	80	**9**	Ukraine	82
10	Norway	79	**10**	Taiwan	80
	Others	*302*		*Others*	*917*
	TOTAL	**4 502**		**TOTAL**	**4 720**

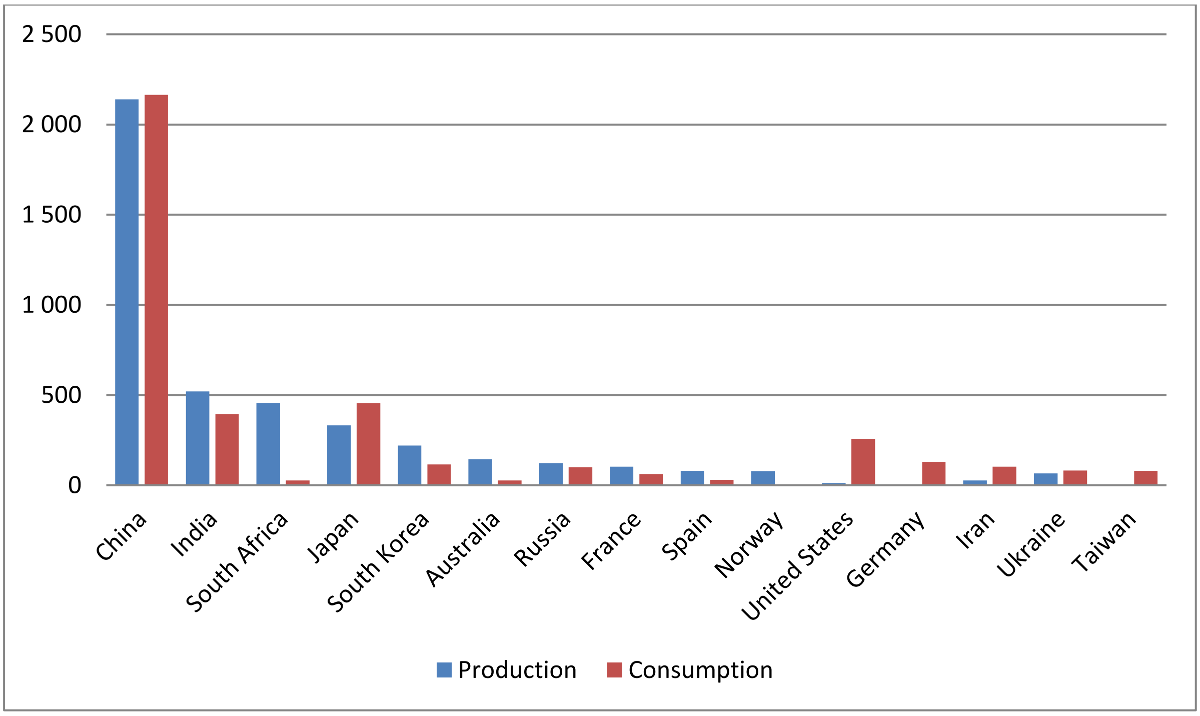


Figure 5-7: HCFeMn producers versus consumers in 2013

Source: (International Manganese Institute 2014a)

Table 5-7: Top 10 HCFeMn exporters in 2013 (000 mt)

Source: (International Manganese Institute 2014a)

Rank	Country	Volume	%
1	South Africa	483	35,7%
2	Netherlands	124	9,1%
3	Australia	118	8,7%
4	Korea, South	112	8,3%
5	Norway	86	6,4%
6	France	86	6,3%
7	India	83	6,1%
8	Russia	61	4,5%
9	Spain	57	4,2%
10	Ukraine	20	1,4%
	Others	*125*	9,2%
	TOTAL	**1 355**	

Table 5-8: Top 10 refined FeMn producers and Consumers in 2013 (000 mt)

Source: (International Manganese Institute 2014a)

Production			Apparent Consumption		
Rank	**Country**	**Volume**	**Rank**	**Country**	**Volume**
1	China	914	1	China	914
2	Norway	227	2	Japan	137
3	South Korea	140	3	United States	134
4	Japan	129	4	Germany	64
5	South Africa	102	5	Brazil	55
6	United States	73	6	India	53
7	India	43	7	South Korea	42
8	Spain	27	8	Canada	35
9	Brazil	24	9	Iran	28
10	Mexico	22	10	Italy	23
	Others	*13*		*Others*	*250*
	TOTAL	**1 714**		**TOTAL**	**1 734**

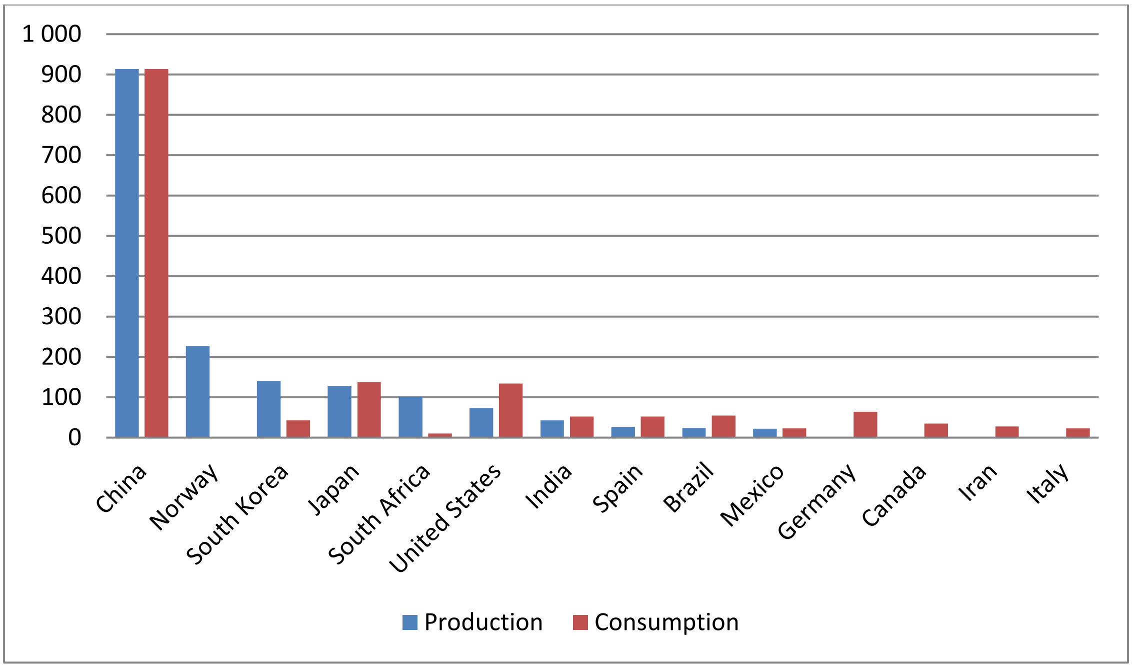


Figure 5-8: Refined FeMn producers versus consumers in 2013

Source: (International Manganese Institute 2014a)

Table 5-9: Top 10 refined FeMn exporters in 2013

Source: (International Manganese Institute 2014a)

Rank	Country	Volume	%
1	Norway	221	36,8%
2	South Africa	99	16,5%
3	Korea, South	80	13,4%
4	Netherlands	54	9,0%
5	Spain	25	4,1%
6	Mexico	16	2,6%
7	Poland	14	2,4%
8	China	11	1,9%
9	France	11	1,8%
10	United Kingdom	9	1,6%
	Others	*59*	9,9%
	TOTAL	**600**	

Table 5-10: Top 10 SiMn producers and consumers in 2013 (000 mt)

Source: (International Manganese Institute 2014a)

Production			Apparent Consumption		
Rank	**Country**	**Volume**	**Rank**	**Country**	**Volume**
1	China	8 992	**1**	China	8 988
2	India	1 643	**2**	India	851
3	Ukraine	602	**3**	United States	395
4	Norway	301	**4**	Russia	349
5	South Korea	248	**5**	Japan	310
6	Kazakhstan	191	**6**	South Korea	278
7	Russia	166	**7**	Turkey	242
8	Brazil	163	**8**	Ukraine	217
9	Georgia	154	**9**	Germany	199
10	Mexico	152	**10**	Italy	158
	Others	*732*		*Others*	*1 570*
	TOTAL	**13 344**		**TOTAL**	**13 556**

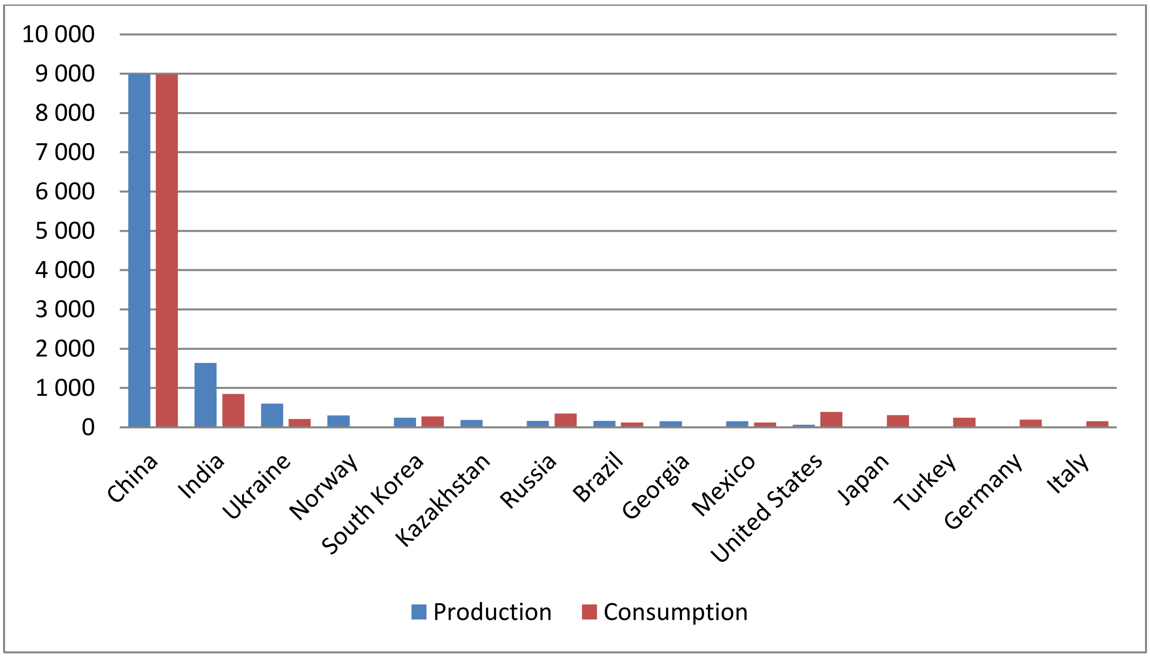


Figure 5-9: SiMn producers versus consumers in 2013

Source: (International Manganese Institute 2014a)

Table 5-11: Top 10 SiMn exporters in 2013

Source: (International Manganese Institute 2014a)

Rank	Country	Volume	%
1	India	793	29,9%
2	Ukraine	392	14,8%
3	Georgia	189	7,1%
4	Norway	189	7,1%
5	Netherlands	163	6,1%
6	Non-EU Suppression	138	5,2%
7	South Africa	98	3,7%
8	Australia	95	3,6%
9	Kazakhstan	82	3,1%
10	France	68	2,6%
	Others	*447*	16,9%
	TOTAL	**2 653**	

Table 5-12: Top 10 importing countries of South African produced manganese alloys

Source: (International Manganese Institute 2014a)

HCFeMn alloys			Ref FeMn alloys			SiMn alloys		
Rank	Country	Vol	Rank	Country	Vol	Rank	Country	Vol
1	USA	197 226	1	Netherlands	24 337	1	USA	56 857
2	Netherlands	128 348	2	USA	16 411	2	Netherlands	16 252
3	Italy	17 810	3	Brazil	13 567	3	France	7 586
4	Taiwan	15 385	4	India	10 588	4	Italy	4 514
5	Brazil	14 975	5	Sweden	8 158	5	Germany	4 131
6	Canada	14 457	6	Turkey	5 577	6	Canada	2 701
7	Japan	13 934	7	Belgium	4 383	7	Spain	2 687
8	Germany	11 422	8	Russia	1 381	8	Japan	442
9	China	9 507	9	Canada	1 123	9	Malaysia	142
10	Sweden	9 424	10	Italy	1 054	10	Poland	25
	Others	*50 987*		*Others*	*12 657*		*Others*	*2 421*
	TOTAL	**483 475**		**TOTAL**	**99 236**		**TOTAL**	**97 758**

Where Rank = Global ranking, Vol = Volume (kt Mn Units)

5.2.4 Summary of global manganese alloy supply and demand

- South Africa is the 3rd largest producer of HCFeMn and 2nd largest producer of refined FeMn.
- HCFeMn is the most produced and consumed manganese alloy, while refined FeMn is the smallest.
- South Africa is not listed as one of the top ten consumers of any of the manganese alloys.
- South Africa is not listed as one of the top producers of SiMn.
- South Africa is the largest exporter of HCFeMn, 2nd largest exporter of refined FeMn and the 7th largest exporter of SiMn.

- Approximately all of South Africa's manganese alloys are exported and thus none is used domestically.
- China is both the largest producer and consumer of the manganese alloys, which serve as an indication of the dominance in the steel manufacturing industry. In all of these cases they produce and consume four to six times more than the nearest contender.
- None of the major alloy consumers are on the African continent, meaning all South Africa's alloy products needs to be shipped very far away.
- South Africa has strong trade relations in the manganese alloys market with the USA and Netherlands. These two countries are the top two importers of each of the three manganese alloys manufactured in South Africa.

5.2.5 Global producers of steel

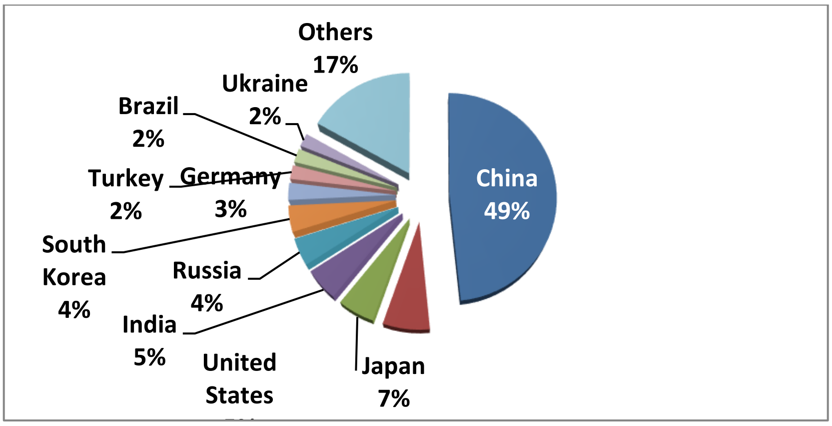


Figure 5-10: Top steel producing countries in 2013

Source: (International Manganese Institute 2014a)

Table 5-13: Top 10 steel producers in 2013 (000 mt)

Source: (International Manganese Institute 2014a)

Production		
Rank	**Country**	**Volume**
1	China	779 040
2	Japan	110 573
3	United States	86 955
4	India	81 213
5	Russia	69 402
6	South Korea	66 008
7	Germany	42 645
8	Turkey	34 658
9	Brazil	34 178
10	Ukraine	32 824
	Others	*270 220*
	TOTAL	**1 607 715**

5.2.6 Summary of global steel supply

- With nearly 50% of the market share, China is the largest steel producer in the world. The rest of the market is fragmented into many small producers.
- Japan is the second largest producer of steel, yet produce seven times less than China.
- None of the major steel producers are on the African continent, meaning that even though South Africa is a major alloy producer, most steel products are manufactured and imported from other continents.

5.2.7 Local role players in the manganese industry

It is evident from Figure 4-6 that the manganese industry consists of various sectors, each utilizing specific types of ore, intermediate products, processes, upstream inputs and consisting of various role players. There are currently five major manganese mining companies in South Africa according to Gajigo and the Department of Mineral Resources RSA, namely: South32 (formerly BHP Billiton/Samancor Manganese), Assmang Limited, Kalagadi Manganese, Tshipi Manganese and United Manganese of the Kalahari (UMK) (Gajigo et al. 2011; Department of Mineral Resources RSA 2015a). BHP Billiton is the world's largest manganese producer while Assmang Limited is fourth and together dominate the local manganese production market in South Africa (Gajigo et al. 2011). Smaller producers include Kudumane, Metmin and National Manganese Mines, as well as many other BBBEE companies that have entered the market (Department of Mineral Resources RSA 2015a).

The country has four manganese alloy producers that are classified as stage 2 role players in Maia's beneficiation process. These ferroalloys producers are: Metalloys (South32), Assmang, Transalloys and Mogale Alloys (Steenkamp & Basson 2013; Department of Mineral Resources RSA 2015a). Of these four, Transalloys is the largest producer of silicomanganese (SiMn) in Africa and Mogale Alloys a smaller thereof. The others supply ferromanganese. With the increase in electricity tariffs and unreliable supply thereof in recent years, together with the oversaturated market, many of these suppliers have drastically slowed down production or halted their operations altogether (Creamer 2015). South Africa also features electrolytic manganese dioxide (EMD) and electrolytic manganese metal (EMM) producers.

The latter generally accounts for between 6% to 10% of the total manganese ore usage (RPA 2012). All of South Africa's manganese resources are located in the Northern Cape Province in a zone stretching northwards over a distance of 150km, from south of Postmasburg to the Wessels and Black Rock Mines north of Hotazel, known as the Kalahari Manganese Field (KMF) (Bonga 2008). It is the largest single manganese depository in the world and accommodates all of the country's manganese mines. The manufacturers of manganese related products that are higher in the value chain, however, are situated closer to the eastern coast in industrial areas around the Mpumalanga, Gauteng and Kwa-Zulu Natal provinces.

5.2.8 Global role players in the manganese industry

After the domestic industry structure has been investigated, it is important to determine how local operations compare to role players from abroad. This allows us to understand the global scope of operations and where all the different role players fit into the global value chain. Table 3-2 provides a list of the major global producers of manganese related products and the total of number of countries producing each respective product.

Table 5-14: Countries producing manganese related products

Country	Ore			Alloys			Slag products	Steel	EMD	EMM
	Low	Med	High	HCFeMn	Ref FeMn	SiMn				
South Africa	X	✓	✓	✓	✓	✓	X	✓	X[1]	✓
China	✓	X	X	✓	✓	✓	✓	✓	✓	✓
USA	X	X	X	✓	✓	✓	✓	✓	✓	X
Australia	X	✓	✓	✓	X	✓	✓	✓	✓	X
Brazil	✓	✓	✓	✓	✓	✓	✓	✓	X	X
Ukraine	X	✓	X	✓	✓	✓	✓	✓	X	X
Gabon	X	✓	✓	X	X	X	✓	X	X	X
Japan	X	X	X	✓	✓	✓	✓	✓	✓	X
India	✓	✓	✓	✓	✓	✓	X	✓	X	X
South Korea	X	X	X	✓	✓	✓	✓	✓	X	X
Total producing countries	**9**	**16**	**6**	**21**	**11**	**21**	**-** [2]	**91**	**8**	**2**

Sources: Ore and alloys (International Manganese Institute 2014a); slag (FICCI 2014; Global Slag 2015); Steel (World Steel Association 2014); EMD (US International Trade Commission 2003); EMM (MMC 2016), Interviews.

[1] *SA stopped EMD production in 2015.*

[2] *No data available on countries that manufacture products from ferro-slag.*

South Africa is a dominant producer across the industry with the only exception being the usage of slag in construction materials such as concrete. Until recently it was also a large producer of EMD, but stopped production in 2015. South Africa is also one of the few countries that can produce manganese ore on a big enough scale to make the operation economically viable and is part of an even smaller group of countries that contain high-grade ore.

There are many countries which produce steel. A likely reason for this is that steel is a major element in the construction and is a basic requirement for the development of infrastructure. It is thus economically advantageous for countries to have local steel producers. This could be the same reason behind for the relatively large group of alloy manufacturers as well, since these alloys are required in the production of steel. Further downstream, niche products such as EMD and EMM have less global producers and is primarily situated in countries that are large suppliers of dry cell batteries as well.

Since more than 90% of all manganese produce is consumed in the steel industry as an alloying element (S E Olsen et al. 2007), a closer look is given to its specific global role players. Figure 5-11 is a process flow and role player proportions diagram which illustrates the manganese ore to steel production process with the major countries involved in the process. The figure provides a clear view of each country's presence in each specific step, as well as their market presence.

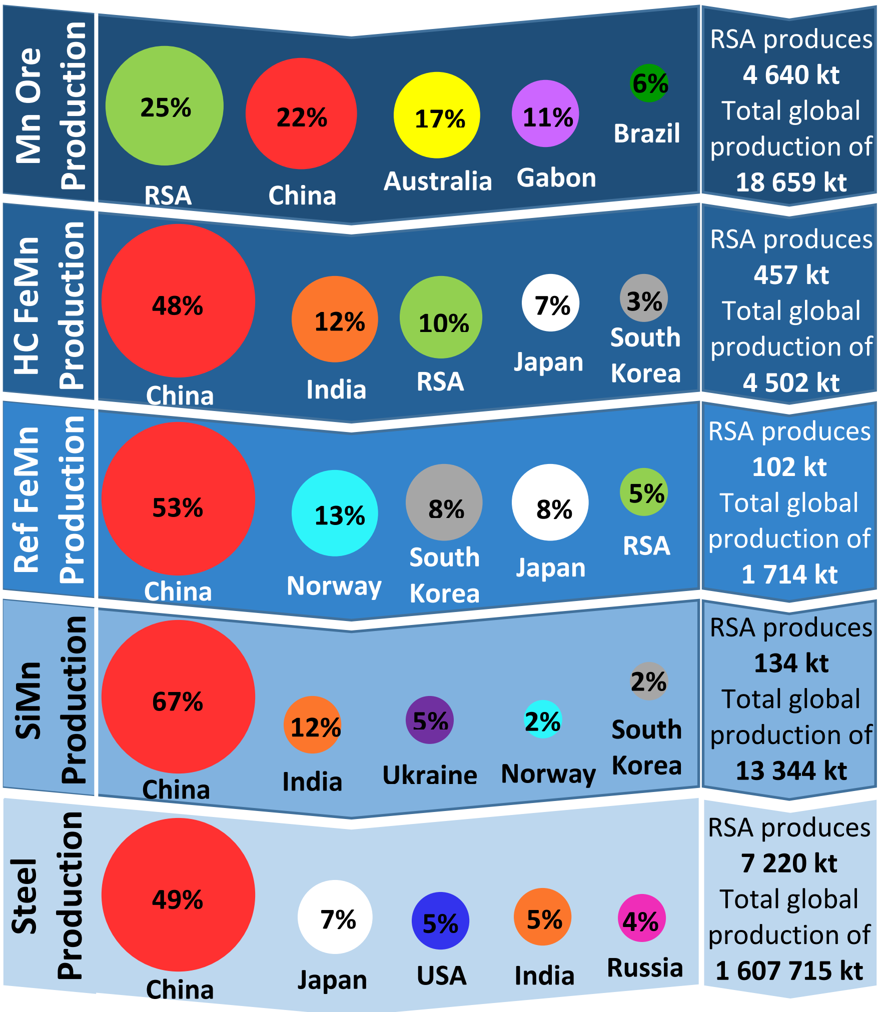


Figure 5-11: Manganese ore to steel production process flow and market share proportion diagram

Data gathered from: (International Manganese Institute 2014a)

Figure 5-11 illustrates China's dominant position in the manganese market. Apart from the production of ore (where it is a close second largest producer with almost 25% of the market), it overshadows the other producers in all other sectors in the steel manufacturing with approximately 50% share in the market for each of the intermediate products. Despite South Africa being the largest producer of manganese ore, it is a relatively small player in the downstream product market. India, Japan and South Korea are also quite prominent players in the market, but are all immensely small in comparison with China.

5.3 Governance structure of the value chain

One of the most important attributes or dimensions of a value chain is that of governance style, which Humphrey and Schmitz (Humphrey & Schmitz 2001) briefly describes as relating to the exercise of control along the chain and further elaborates on this by defining it as: "*The inter-firm relationships and institutional mechanisms through which non-market coordination of activities in the chain is achieved".* Gereffi's (Gereffi 1994) definition of governance focuses more in terms of inter-relationships between role players and resources within the chain: "*authority and power relationships that determine how financial, material and human resources are allocated and flow within a chain*". The analysis of governance in a value chain allows the researcher to determine how the chain is controlled and coordinated when specific role players have more power than others. Figure 5-12 is an example of how the various role players are integrated within a value chain and illustrates the numerous relationships that exist between them.

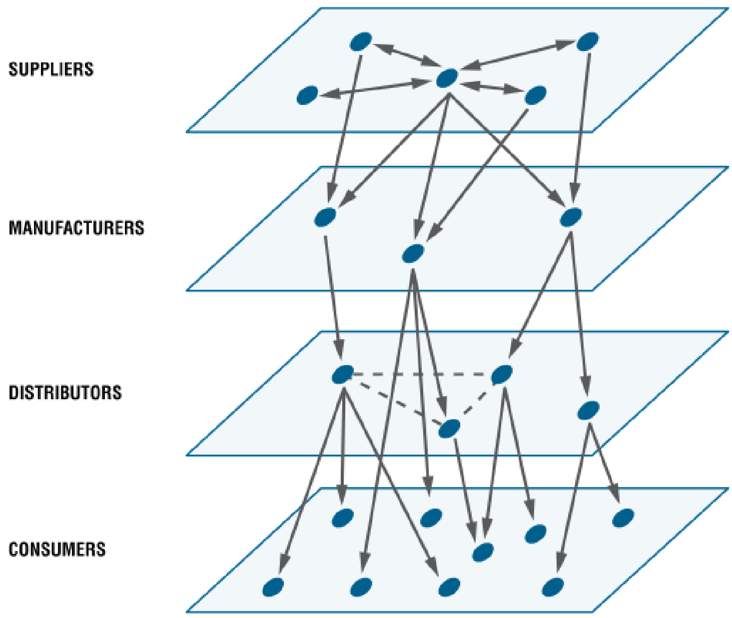


Figure 5-12: An example of a generic value chain network

Source: (Gereffi 1994)

Since GVCs are spatially extensive, organizationally fragmented, and highly dynamic, it is difficult to ascertain role player's position and prospects within the chain (Globalvaluechains.org 2016). Analysing the governance structures of value chains in a global context, provides insight into how GVCs function in specific cases and is a tool that helps predicts how they might change over time.

Initially governance of global value chains were describe simply as "producer-driven" or "buyer-driven" (Gereffi 1994). In buyer-driven chains large retailers and successful merchandisers are in the position of power and dictates how the chain is operated despite having limited or no production capabilities and leaving suppliers requiring to meet certain standards and protocols (Gereffi 1994). The basic producer-driven value chain structure is shown in Figure 5-13.

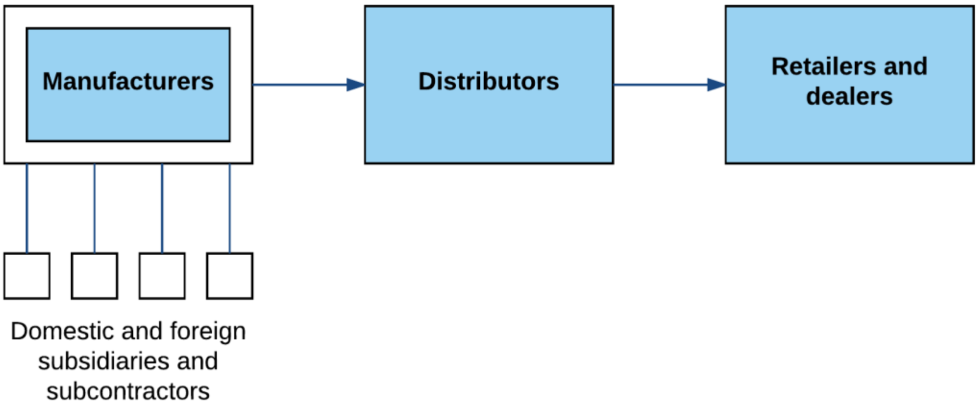


Figure 5-13: Producer-driven commodity chains

Source: (Gereffi 1994)

In contrast, producer-driven chains leverage advantages of integrated suppliers and these chains are more vertically integrated along all sectors of the value chain (Gereffi 1994). An example of a buyer-driven value chain is presented in Figure 5-14. Governance typologies has since then become more elaborate with five more sophisticated structures identified in GVC literature, namely market, modular, relational, captive and hierarchy (Gereffi et al. 2005).

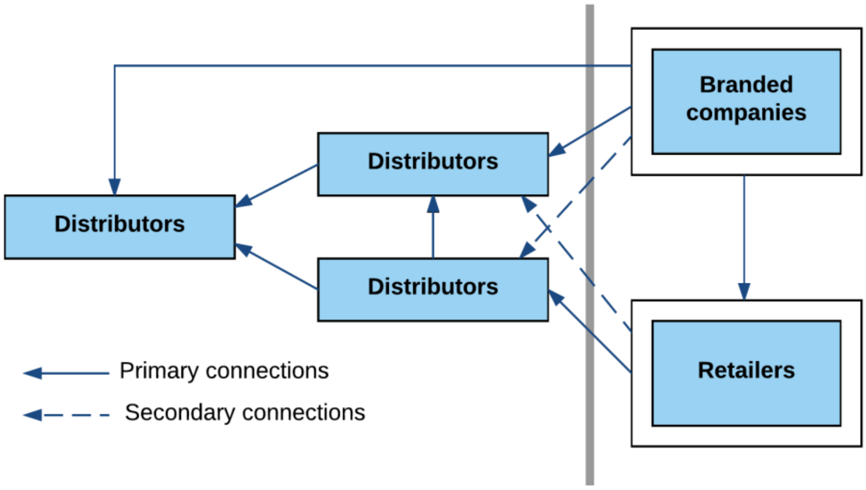


Figure 5-14: Buyer-driven commodity chains

Source: (Gereffi 1994)

The more sophisticated governance structures are analysed in-depth and used in the proposed framework to determine the power relationships between the various role players in a value chain. These five governance typologies, as shown in Figure 5-15, are determined by three variables (Gereffi et al. 2005; Suss et al. 2012; Gereffi & Fernandez-Stark 2011):

- The complexity of the information between actors / role players in the chain;
- How the information for production can be codified (the extent to which this knowledge and information can be transmitted efficiently);
- And the level of supplier competence.

5.3.1 Market

Market governance involves transactions which are easily codified, product specifications that are relatively simple and suppliers have the capability to make products with little input from buyers (Gereffi et al. 2005). The transactions can be governed with little or no formal mutual assistance between role players, since the complexity of information exchange is relatively low. In market exchange buyers respond to the specifications and prices set by sellers and the switching cost to new partners is low for both producer and buyer (Gereffi et al. 2005).

Features (Gereffi & Fernandez-Stark 2011; Suss et al. 2012)*:*

- Switching cost to new partners are low for both sides;
- Transactions are relatively simple;
- Product specification information is easily transmitted;
- Suppliers can make products with minimal input from buyers.

5.3.2 Modular

Modular governance takes place where complex transactions are relatively easy to codify. Suppliers in these structures manufacture products according to the customer's specifications and use general machinery that spreads investments across a wide base of customers (Gereffi & Fernandez-Stark 2011; Gereffi et al. 2005). This keeps the switching costs low between partners.

Features (Gereffi et al. 2005; Suss et al. 2012)*:*

- Switching costs between partners are low;
- Buyer-supplier interactions can be very complex;
- Both suppliers and buyers work with multiple partners.

5.3.3 Relational

Relational governance can be expected when product specifications cannot be codified, complex transactions take place, and supplier capabilities are high. In other words, when producers and consumers rely on complex information that is not easily transmitted or learned (Gereffi et al. 2005; Gereffi & Fernandez-Stark 2011). This leads to continual communication and knowledge sharing between them and in turn leads to these transactions or linkages requiring trust and generate mutual reliance. This mutual dependence is often controlled by reputation, social and spatial proximity, family ties, etc. (Gereffi et al. 2005; Gereffi & Fernandez-Stark 2011).

Lead firms, however, can still wield control over suppliers, since they specify what is needed. In relational chains, producers are likely to have a differentiation advantage for their products, which are based on unique characteristics, such as quality or geographic origin. Switching to new partners are costly and difficult due to the time that is necessary in building relational linkages (Gereffi & Fernandez-Stark 2011; Gereffi et al. 2005).

Features (Gereffi et al. 2005; Suss et al. 2012)*:*

- Switching costs to new partners are high;
- Complex interactions exist between suppliers and buyers;

- Transactions are very difficult to codify;
- Transactions are very complex;

5.3.4 Captive

Captive chains are characterised by small suppliers that are dependent on one or a few buyers which are in the position of power. In these networks suppliers link to their buyer under conditions which are set and often specific to that particular buyer, which in turn leads to high switching costs for both parties (Gereffi et al. 2005; Gereffi & Fernandez-Stark 2011).

Features (Gereffi et al. 2005; Suss et al. 2012)*:*

- The ability to codify is high;
- Complex product specifications;
- Supplier capabilities are low;
- Suppliers face very high switching costs (and are thus "captive");
- Suppliers are confined to a narrow range of tasks;
- Power is exerted directly by lead firms on suppliers

5.3.5 Hierarchy

Managerial control and vertical integration within companies that develop and manufacture products in-house, characterises hierarchical governance. This typically takes places when products are complex and specifications cannot be codified, or competent suppliers are almost impossible to find (Gereffi et al. 2005). Even though this sort of vertical integration is less common than in the past, it is still an important feature of the global economy (Gereffi & Fernandez-Stark 2011).

Features:

- Ability to codify product specifications are very low;
- Products complexity is high;
- Supplier capabilities are low.

5.3.6 Summary of governance structures

A representation of each of the five value chain government types are represented in Figure 5-15. The left end of the typology shows a market-based relationship among firms and the other end is the vertically integrated firm in the form of hierarchies. The other intermediate value chain governance structures, namely modular, relational and captive typologies, are composed of network relationships.

The type of governance that arises are determine by three conditions as mentioned earlier, namely (Gereffi et al. 2005):

a) The complexity of information and knowledge transfer required to sustain a particular transaction with respect to product and process specifications;
b) The extent to which this information and knowledge can be codified and;
c) The capabilities of suppliers in relation to the requirements of the transaction.

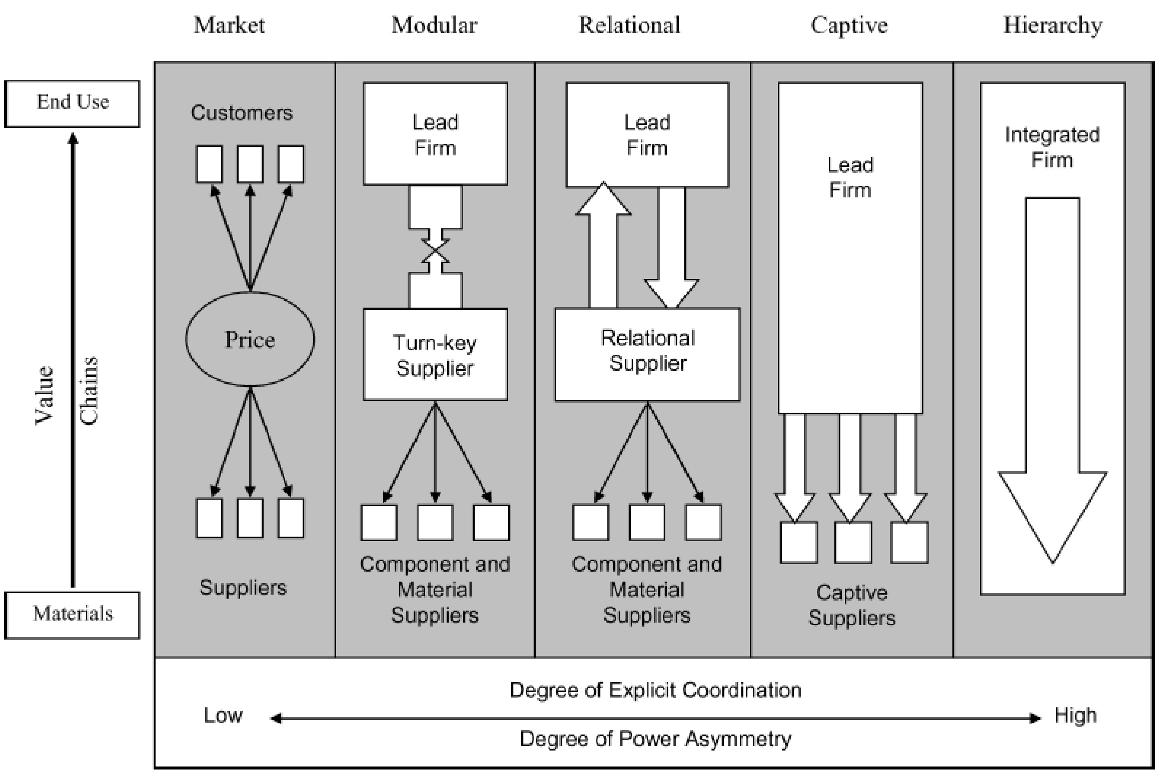


Figure 5-15: The five global value chain governance types.
Source: (Gereffi et al. 2005)

Figure 5-15 summarises the above description in a visual representation. The small line arrows in the figure represent the exchange based on price while the larger block arrows are an indication of thicker flows of information and control. This includes instructions from a more powerful buyer to a less power supplier, as in captive global value chains or within the confines of a hierarchy (Gereffi et al. 2005).

The five types of value chains are characterised according to the three governance conditions in Table 5-15. The table conveys the different trade-offs between the benefits and risks of outsourcing associated with each governance type. The last column in the table indicates the amount of explicit coordination that is required. The governance types comprise a spectrum from low levels of explicit coordination and power asymmetry between buyers and suppliers, in the case of markets, to high level of explicit coordination and power asymmetry between buyers and suppliers in the case of hierarchy (Gereffi et al. 2005).

Table 5-15: Key determinants of global value chain governance.
Source: (Gereffi et al. 2005)

Value chain governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply base	Degree of explicit coordination and power asymmetry
Market	Low	High	High	Low
Modular	High	High	High	Medium-low
Relational	High	Low	High	Medium

Value chain governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply base	Degree of explicit coordination and power asymmetry
Captive	High	High	Low	Medium-high
Hierarchy	High	Low	Low	High

5.3.7 Determining the governance structure of the value chain

The governance structure of a specific value chain can be determined by characterising the value chain according to the complexity of its transaction, the ability to codify its transactions and the capability of the supply base. By determining the level of each of these three conditions, it is possible to distinguish between the five governance typologies. A flow diagram is provided in Figure 5-16 which enables a quick classification of governance structure by determining the characteristics of the specific value chain.

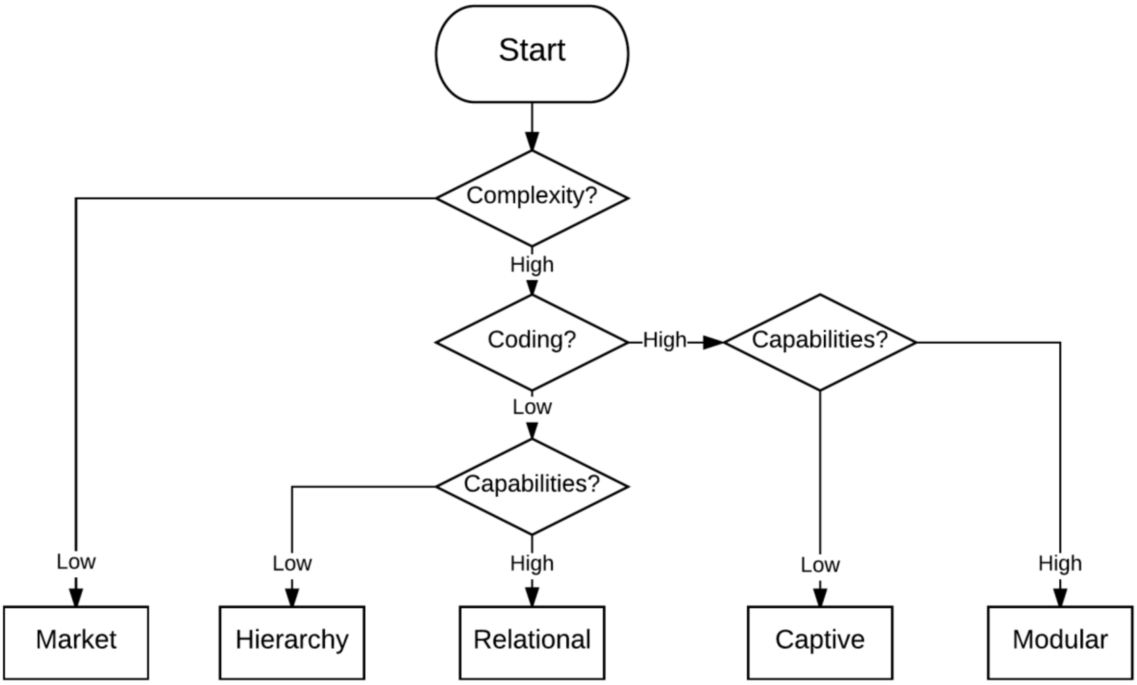


Figure 5-16: Flow diagram depicting the process of determining the value chain governance structure

5.3.8 Government structure of the South African manganese industry

Through the use of the above descriptions and Figure 5-16, it is possible to determine the governance structure of the manganese value chain, as illustrated in Figure 5-17. The structure might vary in a single value chain as an industry evolves and matures, resulting in one chain having multiple governance types throughout. Recent research indicates that many global value chains are characterised by multiple interacting governance structures, which affect opportunities and challenges for economic upgrading (Dolan & Humphrey 2004).

This multiple structures are present in the manganese value chain as well. Since the chain involves transactions that are easily codified, product specifications are relatively simple and suppliers have the capability to make products with little input from buyers, the upstream typology is mainly in the market form. This is especially the case for the activities between mineral production and alloy manufacturing, where switching costs are low and the products have low complexity.

According to Porter's Value Chain approach (Porter 1985; IMA 1996), firms must meet two criteria in order to survive and prosper in an industry. A firm's competitive advantage derives from the difference between the value it offers to customers and its cost of creating that customer value. Competitive advantage can take on two possible forms (IMA 1996):

1. *Differentiation advantage* – If customers perceive a product or service as superior, they become more willing to pay a premium price relative to the price they will pay for competing offerings.
2. *Low-cost advantage* – Which customers gain when a company's total costs undercut those of its average competitor.

Since alloy producers does not have a differentiation advantage over competitors, since alloys are commonly used in steel and widely produced around the world, they must primarily focus on gaining a low-cost advantage in order to improve their competitive advantage. They are thus under pressure to constantly adjust their business strategy to cut costs and one way of doing this is by ensuring they have the best trade agreement with ore providers, which places mining companies in a stronger trade position. This is highlighted by the fact that alloy producers also have to contend with rising electricity tariffs, labour issues and other operational costs which are currently a number of South Africa's largest barriers to growth.

The further down the chain, however, the chain takes on a modular structure since complex transactions occur that are relatively easy to codify. This translates to downstream products, such as ferroalloys, EMD and EMM, are made to the customer's specifications and the suppliers spread investments across a wide customer base. Switching costs are still low even though buyer-supplier interactions can be very complex. Unlike in simple markets, the linkages or relationships between partners are more substantial due to the higher volume of information flowing between them.

Companies within the modular structure of the chain, such as EMD and EMM producers, rely very strongly on their trade relationships as they fall under a very niche market. Since there is a very limited local market for these products in Africa, foreign consumer relations need to be secured. This, however, leads to directly competing with similar producers abroad and due to the low switching costs involved in modular structures, the primary consumer switches to their local supplier in order to improve costs. This ultimately leads to many South African based companies to battle to secure buyers.

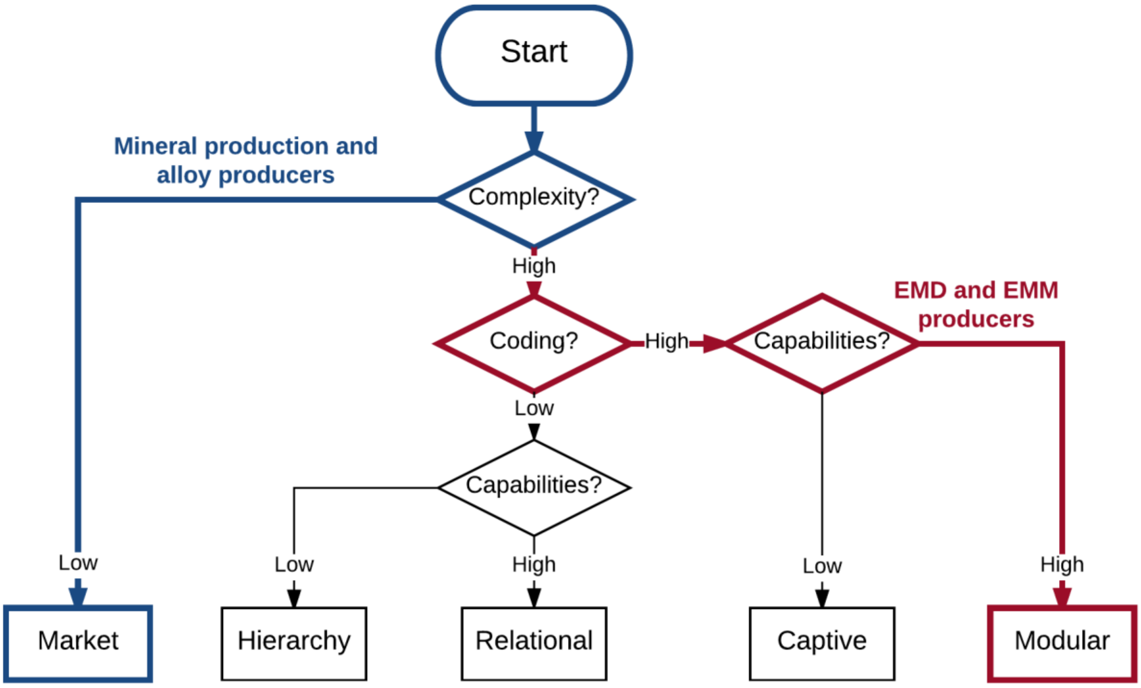


Figure 5-17: Determining the value chain governance structure of the South African manganese industry

5.4 Institutional context

By inspecting mineral value chains with the analysis tools mentioned in previous steps, it has become evident that there are numerous attributes which influences the various role players involved in the value chain and emphasises the importance of the context of the chain. Since global value chains interact with many different parts across the world, it is important to include a systematic comparative analysis to identify the impact of different features on relevant economic, social and regulatory conditions.

An institutional framework component would identify how local, national and international conditions and policies shape the globalisation in each stage of the value chain (Gereffi 1995). All global value chains are embedded within their own local economic, social and institutional dynamics which has a significant impact on local conditions, processes and role players, while simultaneously affecting interlinking stakeholders from abroad. The three main conditions affecting a wide range of factors, are the following (Gereffi & Fernandez-Stark 2011):

- Economic conditions – the availability of key inputs, labour costs, available infrastructure, access to other resources such as finance;
- Social conditions – availability of labour and its skill level, participation of previously disadvantaged workers in the labour force, access to education;
- Regulatory conditions – includes tax and labour regulation, subsidies, education and innovation policy that can promote or hinder growth and development.

These conditions and their underlying institutional context factors are explored in Table 5-16, Table 5-17 and Table 5-18 respectively. The tables provide a short description of each condition, the outcome it has on the industry and the parties that are affected by the specific conditions.

Table 5-16: Economic factors of South African minerals industry

Condition	Description	Outcome	Parties affected
Restricted transport infrastructure	Limited rail and port capacity for the transport of goods. Many projects aimed to expand and develop the infrastructure is consistently pushed back.	The demand rail and port capacity far outstrips the supply.	All
Unreliable electricity supply	Mismanagement from Eskom, South African electricity provider, has led to repeated instances of load shedding.	Repeated instances of load shedding which interrupts efficient operations.	All, especially further downstream (Alloy and intermediate product manufacturers)
Rising operational costs	Companies face continuous hikes in electricity tariffs, labour costs.	Uncontrolled and unpredictable cost increases.	All
Saturated market	Fragmentation in mineral companies in South Africa has led to the local industry structure to become dense with many smaller companies also vying for infrastructure usage and resources.	Increased competition leading to a shortage of available infrastructure. These restrictions cause companies to close.	Mainly mineral production
Abundant natural resources	South Africa is well endowed with vast mineral resources. It is one of the largest producers of many minerals, including manganese.	Large reserves of resources centred in certain areas with very high availability compared to other countries.	Mineral production
Mineral production knowledge	South Africa is a key player in the minerals industry and has gained immense knowledge and experience in the field of mining and mineral production.	South Africa has the necessary expertise, experience and technology for successful operation.	Mineral production

Source: (Edinger 2014; Baxter 2014; Bonga 2008; Elliot 2015a; Basson et al. 2007)

Table 5-17: Social factors of South African minerals industry

Condition	Description	Outcome	Parties affected
Shortage of skilled labour	Many of workers in South Africa have very limited qualifications. The workforce is generally inadequately trained and do not possess the necessary technical skills.	Extensive training programs are implemented takes longer and is expensive, strikes etc. lose knowledge	More parties affected further downstream
BEEE	Parliament has passed several pieces of legislation since 1994 to promote black economic empowerment ("BEE"). BEE is incorporated in the Minerals and Petroleum Development Act. The Act recognizes the states' control over the country's mineral resources and aims to provide equitable access to mineral resources and opportunities for historically disadvantaged South Africans.	Companies needs to ensure that BEE protocols have been met. This has to be taken into account with the composition of the workforce of the company.	All
Safety of working environment	Mineral production is notorious for its hazardous working conditions, especially in mining.	Proper medical schemes are provided by companies to their workers. The working conditions constantly need to be re-evaluated to ensure the safety of the workers.	All, but larger downstream

Source: (Edinger 2014; Baxter 2014; Bonga 2008)

Table 5-18: Regulatory factors of South African minerals industry

Condition	Description	Outcome	Parties affected
Beneficiation strategy	The beneficiation strategy is aimed at providing a strategic focus for South Africa's minerals industry in terms of developing mineral value chains and facilitating the expansion of beneficiation initiatives in the country, up to the last stages of the value chain.	The long term fallout of this policy is still unclear. Many investors rate mandated beneficiation as high risk. There is also a need for both low-cost power and infrastructure for beneficiation plants, which is currently not the case.	All, but greater further upstream
Mining Charter	The Mining Charter was unveiled in October 2002 and is a proactive strategy to foster and encourage transformation of the mining industry through promoting indigenous participation in mining ventures, employment equity, mine communities & rural development, and beneficiation to name a few.	The South African Mining Charter presents legislative uncertainty for many stakeholders in mining companies. There are uncertainties pertaining to its context, especially regarding the Mining and Petroleum Resource Development Bill and the BEE ownership requirements. These uncertainties cause difficulty in mitigating risks.	Mineral production
Slag discarded on waste dumps	In South Africa the slag that is created as a by-product during manganese alloy production, is discarded on slag dumps and classified as a hazardous material. In many European countries the slag can be used as a construction material.	Slag cannot be sold in South Africa. Thus it can be used as a measure to recover costs and large expenses has to be made to ensure that the slag is properly disposed according to environmental policies.	Alloy manufacturers
Government mismanagement	Many processes and projects need to be approved through government before it can commence, but it is often unnecessary difficult,	Required revisions for certain acts and policies, delays in state projects and inefficient management of license issuing are some examples.	All

Condition	Description	Outcome	Parties affected
	delayed and/or costly to the stakeholders involved.		
Anti-Dumping	This protectionist tariff is imposed by domestic governments on foreign imports that is believed to be priced below fair market value. This is to protect local companies from being pushed out of the market by foreign companies selling their products at uncompetitive prices.	In some countries the duty is so high, that it is no longer economically viable for South Africa to enter these markets. This poses a problem since there is often not a very large domestic demand for these products, especially products with little value-added.	All, especially further upstream

Source: (Ratshomo 2013; Department of Mineral Resources RSA 2011; Steenkamp & Basson 2013; Basson et al. 2007; Elliot 2015a)

5.4.1 Discussion of South African manganese industry's institutional context

It is clear from the three tables above that there are many attributes specific to South African manganese industry that influences local operations. South Africa is well-known for its abundance in mineral reserves and once inexpensive cost for labour and electricity. Since the latter has changed, many investors are searching for alternative options to continue operations elsewhere and using some of the costs saved from cheaper labour and electricity, among others, to pay more for the logistical costs of importing the ore from South Africa.

Unrest in the workforce and unskilled labourers are also a growing concern, consequently often leading to delays in operations and low productivity. According to an interview with an anonymous representative of a local alloy manufacturing company, many alloy production plants abroad often produce the same volume of output, but using a fraction of the manpower required domestically. He stated that this is the result of these two factors.

Furthermore, growing concerns in regulatory aspect of this field, has also made a significant impact on the industry. The outcome of new policies in the mineral processing field and the effects thereof, such as the Beneficiation Strategy and Mining Charter, has caused uncertainty for many stakeholders involved in the industry. In order to minimise risk, many companies and investors avert to long term commitments due to these uncertainties.

Anti-dumping laws also restricts South Africa from growing in the market, since it restricts the amount of locally-produced intermediate products from being exported abroad. This is a cause for concern, especially when exploring downstream production, since South Africa often does not have a local market for such products. Local producers of intermediate outputs for the manufacturing of finished goods, receives stiff competition from abroad and consumers often rely on local producers of these products to cater for their needs before considering imports. The attributes listed in the tables serve as an indication of areas where potential barriers in the value chain might occur.

5.5 Analysis of the value chain characteristics

The final step of Phase 3 investigates the key attributes specific to mineral value chain. The manganese industry has specific features that differs from other minerals. Such factors include, technology usage, capital requirements, workforce characteristics, operational technology used, etc. The investigation of these attributes often leads to the discovery of where the bottlenecks, process inefficiencies and general opportunities for improvement lie in the value chain. The tools for this analysis entails a summary of the key aspects in the value chain, which is elaborated upon through a PESTLE factor analysis. This provides the necessary insight required to perform a SWOT analysis of the manganese industry. Lastly, an influence diagram can then be constructed to determine who influences specific conditions that affect the industry.

5.5.1 Summary of key aspects in the value chain

The list of key aspects that will be investigated are as follows:

- *Primary input requirements* – The main inputs that are required for the manufacturing of a product;
- *Type of product outputs* – The different types of product outputs delivered in each sector;
- *Capital requirements* – The total financing needs of a company for its current and future plans, which includes long-term and working capital;
- *Return to scale effects* – The affect that changes in the size of inputs will have on the size of the outputs;
- *Nature of technologic requirements* – The type of technology that is needed for efficient operations in the specific sector;
- *Labour requirements* – The typical labour specifications in each sector of the industry;
- *Transport costs of inputs* – The level of costs required for the transport of input products;
- *Transport cost of outputs* – The level of costs required for the transport of output products;
- *Role of local transport infrastructure* – The impact of the local transport infrastructure (roads, freight systems, port facilities, etc.) on the industry;
- *Size of local supply* – The amount of the sector-related products available for purchase;
- *Primary competitors* – Countries apart from South Africa that are major producers of similar products and possible alternative options for consumers;
- *Destinations of exports* – Countries to which South Africa is selling their products to abroad;
- *Largest operational expenditures* – The largest ongoing costs of running the business.

Table 5-19: Summary of key aspects in the manganese value chain

	Mineral Production	Alloy Production	EMD Production	EMM Production
Primary input required	Capital, labour, equipment	Electricity, labour, ore, reductants, fluxes	Electricity, labour, ore, process chemicals	Electricity, labour, ore, process chemicals
Type of product outputs	Low (< 30% Mn), medium (≥ 30% and < 44%) and high grade ore (≥44%)	HCFeMn, Ref. FeMn, SiMn	EMD	EMM
Capital requirements	High since these are large mining operations	Medium to high. Capital requirements are similar to other mineral processing facilities	High	High
Return to scale effects	Must be big mining operation to be profitable	Since it is directly linked with the mining sector, the scaling effects are similar	Scaling effects are important since high volumes of Mn ore is required for production	Scaling effects are important since high volumes of Mn ore is required for production
Nature of technologic requirements	Widely available	Widely available	Sophisticated, production is restricted to a few countries. The only Africa-based producer's processes were discontinued in 2015	Very sophisticated (only producer outside of China and only producer globally which produces it selenium-free, which is a superior product)
Labour requirements	High labour intensity consisting of low-skilled workers and a few highly skilled employees in planning and managerial positions	Workforce consisting of a large group semi-skilled workers and few very skilled workers	Small to medium sized workforce, typically consisting of larger group semi-skilled workers and smaller group of very skilled workers	Small to medium sized workforce, typically consisting of larger group semi-skilled workers and smaller group of very skilled workers
Transport cost of inputs	Very little	Very high	Very high	Very high
Transport cost of outputs	Very high (seen as highest operational cost)	Very high	High	High

	Mineral Production	Alloy Production	EMD Production	EMM Production
Role of local transport infrastructure	Very high, it is controlled by state-owned Transnet. Rail capacity is allocated between different companies that want to make use of the railways. Transnet controls the allocation that each company receives.	Very high, it is controlled by state-owned Transnet. Rail capacity is allocated between different companies that want to make use of the railways. Transnet controls the allocation that each company receives.	High	High
Size of local supply	SA is the largest global producer of manganese (China is a close second)	SA is one of the largest global producers of HCFeMn and ref. FeMn alloys, but is much smaller compared to China. SA is however in the top 2 largest exporters of these alloys	Local production discontinued in 2015	SA only producer outside of China
Primary competitors	Primarily China, Australia, Gabon, Brazil, India	China, India, Japan, South Korea, Ukraine (SiMn)	China, USA, Australia, Greece, Ireland, Japan, Belgium	China
Destinations of exports	Primarily China and India, but also includes Russia and other countries in Asia	Primarily the USA, but also includes India, countries in Europe, South America, and Asia	Europe, USA, Africa, Japan, Asia	Primarily the USA, Japan and countries in Europe, but also includes Taiwan, South America, Canada and Africa
Largest operational expenditures	Logistics, equipment, labour	Ore / raw materials, electricity, labour	Ore, labour, electricity	Electricity, labour

5.5.2 PESTLE factors analysis

PESTLE analysis is a framework or tool used by marketers to analyse and monitor the macro-environmental (external marketing environment) factors that have an impact on an organisation (Professional Academy 2016a). PESTLE is an acronym which stands for (Professional Academy 2016a; PESTLE Analysis.com 2016):

- **Political:** These factors determine the extent to which a government may influence the economy or a certain industry. These factors are significant since companies need to be able to respond to current and anticipated legislation to adjust their marketing and policy accordingly. Political factors include: tax policies, fiscal policy, trade tariffs, political stability, foreign trade policy, trade restrictions, etc.

- **Economic:** These factors are determinants of an economy's performance that directly impacts a company, determine how a company conducts its business and also how profitable they are. Furthermore, these factors affect the purchasing power of consumers and can change the demand/supply models within the value chain. Economic factors include: interest rates, foreign exchange rates, economic growth, inflation, etc.

- **Social:** These factors investigate the social environment of the market and focuses on determinants such as demographics and population analytics. Social factors include: health and safety, fair representation in the workforce, training and development of workers, etc.

- **Technological:** These factors pertain to innovations in technology that may affect the operations of the industry and the market, both positively and negatively. Technological factors include: automation, research and development, technological awareness in a market, etc.

- **Legal:** These factors pertain to laws and policies that affect the business environment. Legal factors include: consumer laws, labour laws, safety standards, advertising standards, etc.

- **Environmental:** It involves all factors that influence or are determine by the surrounding environment. Environmental factors include: scarcity of raw materials, pollution targets, conducting business as an ethical and sustainable company, etc.

All of these aspects are crucial for analysing any industry, even though the importance of each of the factors may differ between various mineral industries. This strategy does, however, remains imperative for the identification of possible problem areas within the industry. The PESTLE analysis provides a comprehensive view of the SWOT analysis, which is performed in the next section. PESTLE analysis, together with SWOT analysis, will provide a platform for the topics to be discussed with industry experts in order to determine where possible barriers occur within the value chain. The PESTLE factor analysis of the South African manganese industry is displayed in Table 5-20.

Table 5-20: PESTLE factors impacting the South African manganese mining and mineral industry

Source: (TIA 2012)

Political	Economic	Social	Technological	Legal	Environmental
• Acts / Policies • MPRDA • Mining Charter • Research & Technology competitive edge • Partnerships with R&D institutions • Integrated sustainable development approach • Comparative advantage to competitive advantage	• Commodity needs in fast growing economies • Uncompetitive labour productivity • Exchange rate • Infrastructure • Electricity tariff increase • Commodity market volatility	• Skills shortage • High average age of mining professional • Literacy • HIV/AIDS • Respiratory diseases • Social license to operate • Unrest in workforce	• Innovation constraints • Productivity improvement • Safety • Emerging technologies • R&D contracted to overseas agencies	• Resource taxes and royalties • Licensing • Safety performance • Anti-dumping fees	• Industrial water usage • Acid Mine Drainage • Air pollution • Noise pollution • Land rehabilitation • Waste management / Slag disposal

5.5.3 SWOT analysis

Implementing a SWOT analysis is a useful technique for understanding the strength and weaknesses in a specific mineral value chain, as well as identifying both opportunities and threats in the industry. Figure 5-18 illustrates the basic structure of a SWOT analysis. One of the most significant features of this technique which makes it particularly useful, is that it can help uncover constraining factors in the industry with relatively little thought, which can be exploited further later on by conducting interviews with role players within the industry.

The four categories provide a prioritization of barriers. All the factors identified as a strength, indicate that they contributing to value production and not a concern. Opportunities are similar to strengths and can be perceived as factors that are likely to become strengths. Weaknesses are the major barriers in the industry and threats are factors that can potentially evolve to weaknesses if it is not properly managed. The SWOT analysis of the South African minerals industry is provided in Table 5-21.

Figure 5-18: Basic structure of a SWOT analysis

Source: (Professional Academy 2016b)

Table 5-21: SWOT analysis of the South African manganese mineral industry

Source: (TIA 2012)

Strengths	Weaknesses
• Resource abundance • Foreign direct investment • High level expertise in limited areas • Primary processing facilities • Global leader in some technologies	• State of research institutions • Limited R&D funding • Skills shortage • Low minerals value addition • Low international R&D collaboration • Slow sector transformation • Few new entrants • Adoption of innovation
Opportunities	**Threats**
• Iron and steel beneficiation • Supply side/upstream industry expansion • Health and safety and hazards management environment development • Local manufacturing • Downstream beneficiation • Employment creation • Wealth creation • Development of sustainable livelihoods • Lateral migration of technology	• Declining R&D funding • Electricity supply shortages • Skills affected productivity and safety • Non-generation of new skills • Lack of local R&D collaboration by industry • Transport infrastructure deficiencies • Imports of products and services

The Technology Innovation Agency (TIA) has conducted a South African mineral sector SWOT analysis as shown in Table 5-21 and described as follows (TIA 2012):

Strengths:

- South Africa has abundant natural resources and a substantial percentage of the world's reserves in platinum group metals, gold, ferrochrome and manganese.
- There are pockets of good research programs in some of the local institutions.
- The industry attracts large amounts of foreign direct investment and generates over 50% of foreign exchange for the country through exports.
- As a major mining country, South Africa's strengths include a high level of technical and production expertise as well as comprehensive research and development activities.
- The country has world-scale primary processing facilities for carbon steel, stainless steel and aluminium, gold and platinum.
- It is also a world leader on new technologies, such as a ground breaking process that converts low-grade superfine iron ore into high-quality iron units.

Weaknesses:

- A shortage of highly skilled and trained workers in high-technology areas and industry.
- The state of research institutions.
- The industry exports more minerals in primary, un-beneficiated form with minimal value addition.
- Insignificant mining and minerals R&D collaboration with international counterparts.
- Slow pace in transforming the sector and entry of new players.

Opportunities:

- The industry already has well-established companies in both mining and mining equipment that the government could leverage to develop local manufacturing capabilities and technology adoption.
- Increased focus on developing downstream beneficiation activities will create employment, increased revenue generation for the local mining industry and balance of payment in the broader economy.
- Technologies developed to support the mining sector can be used to create new economic sectors through lateral migration.

Threats:

- Decreased funding from mining companies and government for R&D in the mining industry.
- Government investment in electricity generation capacity not staying abreast of supply demands.
- Decreased productivity and safety standards as inexperienced staff fill the skills gaps.
- The need for new and deeper skills and capacity across the industry is universally recognised.
- The lack of local R&D collaboration amongst industry role players could lead to high tariff duties on imported capital equipment, which decreases the ability of the industry to purchase large amounts of required machinery and equipment, and improve productivity.
- Transport and logistics are challenging with insufficient road and inefficient and insufficient rail infrastructure to handle current and increased demand.

5.5.4 Influence diagram of the local manganese value chain

After the value chain has been deconstructed and each segment has been properly analysed in order to determine their main characteristics, it is important to identify who has control over specific aspects that affects the value chain. The final step of the phase is thus to determine what forces are in play that influence the industry and who has control over these forces. An influence diagram is constructed in Figure 5-19. It displays the three bodies that has control over specific aspects in the value chain.

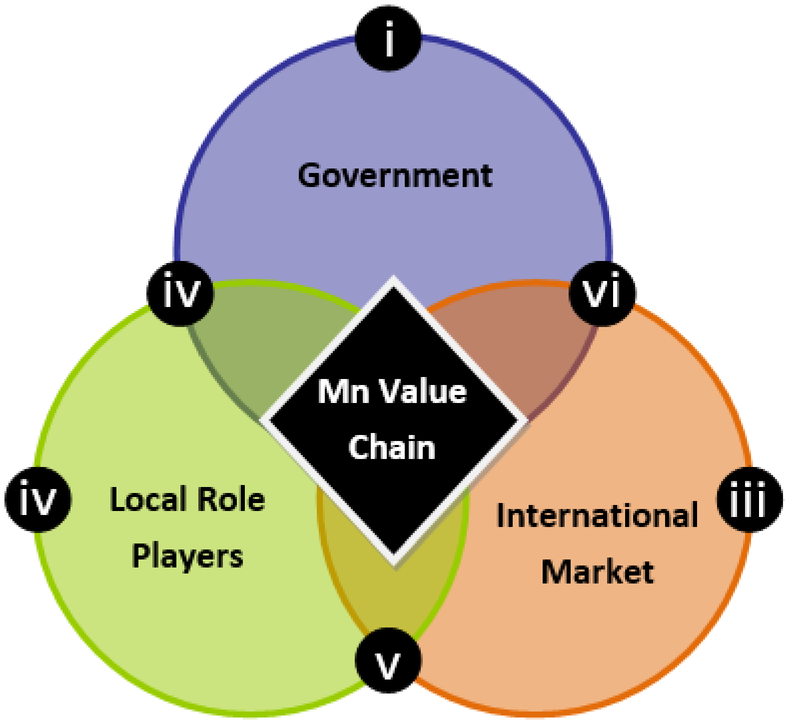


Figure 5-19: Influencers of the South African manganese industry

Each sphere represents an influencer of the in industry. Certain factors are often controlled by more than one influencer. The overlapping areas in the diagram indicate the aspects that have combined control by more than one influencer. Each influencer and the overlap of influencers, have control of specific forces which have a significant impact on the manganese industry. The forces could have a variety of outcomes for the role players involved in the value chain. These forces are shown in the blocks in Figure 5-20.

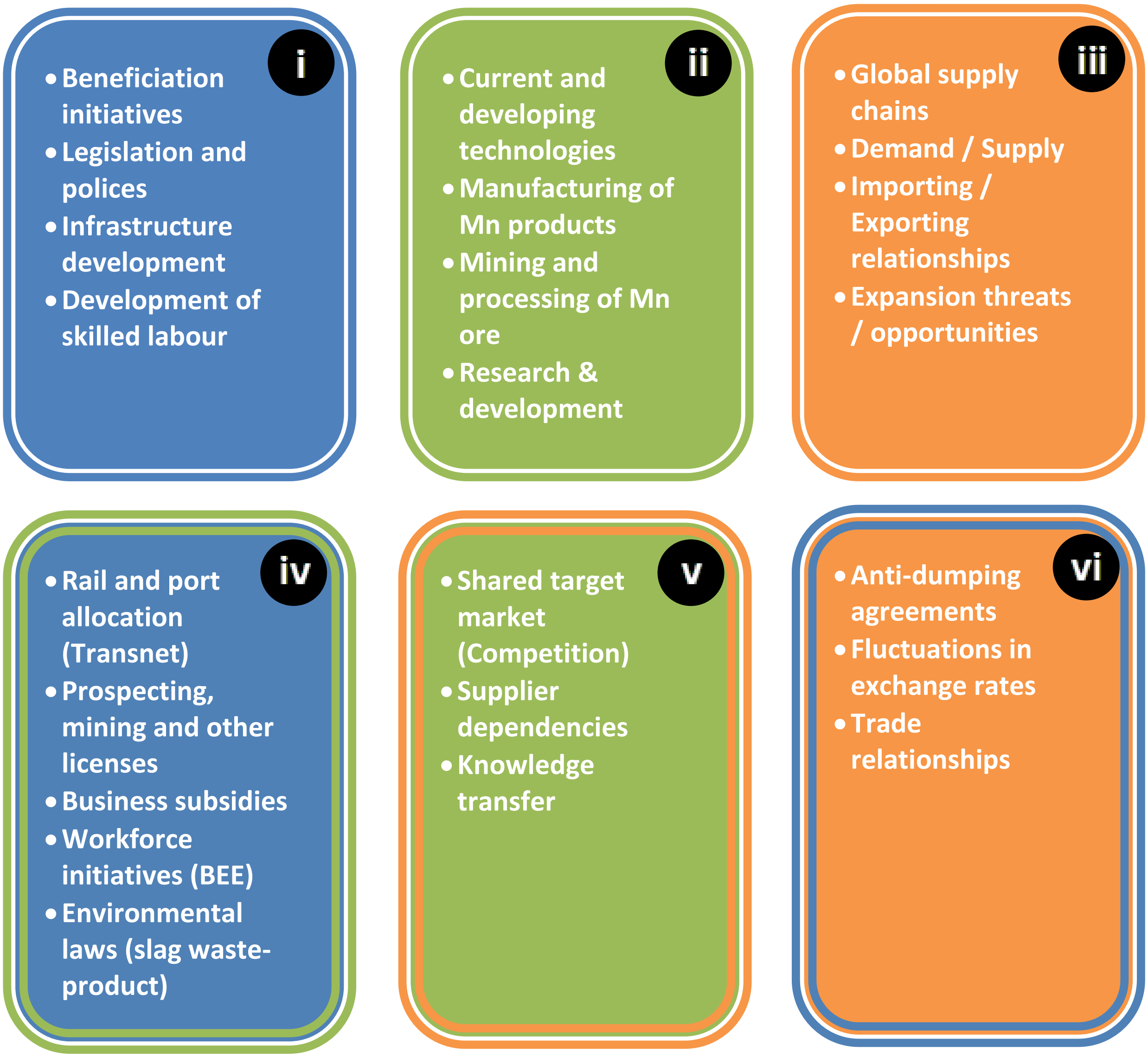


Figure 5-20: Influencer-controlled forces in the South African manganese industry

5.6 Chapter 5 summary

During this chapter South Africa's position in the global market was established. The supply and demand figures for manganese ore, ferromanganese and silicomanganese, as well as steel were provided in the form of information pertaining to the major producers, consumers and exporters of each product. A summary of the key findings in each of these sectors were provided. Furthermore, South Africa's global rank as a producer and consumer for each product was also conveyed. A list of the local role players revealed that there are five major manganese mining companies (South32, formerly BHP Billiton/Samancor Manganese, Assmang, Kalagadi Manganese, Tshipi Manganese and UMK) and four manganese alloy producers (Metalloys/South32, Assmang, Transalloys and Mogale Alloys) in the country.

The chapter also discussed the five different governance structures in Gereffi's GVC analysis and provided a summary and flow-diagram to determine which structure applies to a specific MVC. In the case study, it was determined that the manganese industry functions in a market structure, with modular typology further downstream.

The institutional context of the MVC was explained in terms of how economic, social and regulatory conditions and policies shape the globalisation in each stage of the value chain. This lead to a summary of key attributes of the manganese GVC, which defines how the industry is currently structured. This in turn lead to development of a PESTLE factor and SWOT analysis which served as tools to summarise the industry's current state, fundamental characteristics and initial barrier identification. The chapter concludes with an influence diagram of the local manganese value chain that represents the forces that are in play that influence the industry and who has control over these forces.

Chapter 6

6 Phase 4: Identifying and defining barriers in the value chain

This chapter describes the process of conducting interviews and surveys to identify barriers from experts within the specific mineral industry. This will be done through an iterative process and represent individuals from different sectors of the chain in order to account for the entire chain. The barriers will clearly be defined, ensuring that there is no ambiguity and that each is distinct. The process of setting up a survey to aid in determining the impact that each barrier has on each sector, as well as the sampling strategy for the interviews and survey, are also described in this chapter. It will conclude with a comprehensive list of all the identified barriers, clearly defined, faced by the various sectors comprising the South African manganese industry.

Research Question 4 – What are the barriers within the specific mineral industry?

- *Research Question 4.1*
  How will the barriers be identified?
- *Research Question 4.2*
  How will the identified barriers be defined?
- *Research Question 4.3*
  How will the final barrier list be determined?
- *Research Question 4.3*
  What is the sample strategy for the barrier identification sources?
- *Research Question 4.4*
  What measurements will be put in place to analyse the barriers?

6.1 Chapter overview

An overview of this framework phase is provided in Table 6-1 and a step-by step representation of the phase is shown in Figure 6-1.

Table 6-1: Overview of Phase 4

Phase 4: Identifying and defining barriers in the value chain		
Description: During this phase interviews are conducted with industry experts which represents specific sectors of the value chain. A survey will be provided afterwards that allows the experts to score the major barriers they face in terms of severity. After the feedback from the industry experts have been reviewed, all the identified barriers will be listed and defined.		
Key objectives		
• Identify representatives of major sectors in the industry • Investigate operation details which could aid in identifying barriers • Identify barriers from gathered responses	• Define identified barriers • Group similar barriers in clusters • Determine if consensus is reached by respondents	• Gather respective barrier score with regards to severity • Analyse feedback from respondents
Tools used in phase / Outputs:		
• Delphi process • Interviews • Questionnaires • Survey	• Identification of barriers in industry • Ranking of barriers per sector	• Identification of barrier clusters

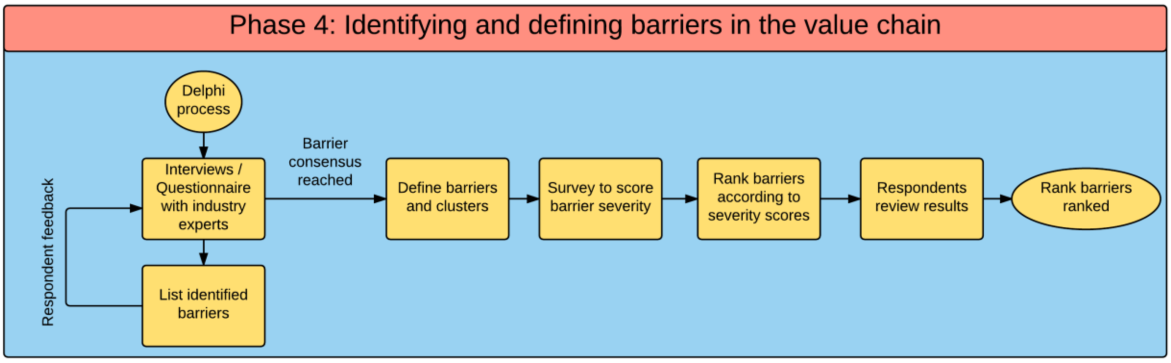


Figure 6-1: Methodology for Phase 4 of the proposed framework

6.2 Overview of the Delphi process

Identifying and defining the barriers faced in the manganese industry will have an iterative approach, with each iteration providing a broader and clearer understanding of the different constraints present in the value chain. The Delphi method is implemented during the data collection phase from industry experts to reach a consensus of the major barriers in each sector comprising the value chain. The process of collecting the data for identifying and ranking the barriers follows the standard Delphi method with four iterations. Each of these rounds has a specific objective and if each is achieved, the end results would enable the research coordinator to rank the major barriers faced by role players in different sectors of the industry. Each round of the Delphi process implemented in this study, as described in section 2.4.4, is summarised in Table 6-2.

Table 6-2: Summary of the Delphi process used

Round	Step	Description
Round 1: Generation of initial barriers	Step 1	Determine questions for interview guide.
	Step 2: Interview	Conduct interview with respondents.
	Step 3: Interview (continued)	Respondents discuss different aspect of the company's operations that might encounter constraining factors.
	Step 4	Researcher distils all the responses and creates initial list of barriers.
Round 2: Review and finalise barriers	Step 5: List of Barriers #1	Researcher mails first list of barriers to respondents. Questionnaire items are obtained from the generative round.
	Step 6: Feedback #1	Respondents review initial list of the barriers.
	Step 7	Respondents are encouraged to add to the list of barriers as well.
	Step 8	Respondents rank the barriers according to severity.
	Step 9	Finalise barrier list from respondents input.
	Step 10	Complete list by adding barriers identified prior to interviews to the list.
	Step 11	Define each barrier to avoid definition overlap.
	Step 12: List of barriers #2	Group similar barriers in clusters.
Round 3: Barrier severity survey	Step 13	Set up the survey with all of the barriers and a corresponding scale to score the severity for each.
	Step 14: Survey	Respondents score each barrier with a score between 1 and 10 (or n/a) regarding severity.
	Step 15	Researcher accumulates all the scores per sector.
	Step 16: Ranking of barriers	Researcher ranks the top 10 barriers per sector from the respondents' input.
Round 4: Finalise survey results	Step 17: List of barriers #3	The rankings of the barriers are sent to the respondents.
	Step 18	The respondents review the final results.
	Step 19	Analyse feedback.
	Step 20	Determine if consensus is reached.
	Step 21	Finalise rankings.
Process complete		

6.3 Sampling method for the Delphi process

Semi-structured interviews were conducted with the aim of gaining comparable views of the most pressing issues in the industry faced by various role players in different sectors of the manganese value chain. It was thus necessary that potential respondents from the different sectors in the value chain were approached for the study. The input from these various industry experts have allowed for the constraints to be ranked according to severity which in turn makes it possible to assign a level of priority to each constraint. All interview responses were used to identify major operational barriers and the scope of their impact.

The list provided by the DMR (Department of Mineral Resources RSA 2015a) of manganese mining companies and manganese-related product manufacturers, as well as relevant companies listed in literature (Callaghan 2014; Gajigo et al. 2011; Steenkamp & Basson 2013), identified 23 companies in the South African manganese value chain. Seven of these companies were disregarded, since their operational focus on manganese were negligible or they could not be reached for comments nor were any of their company documentation available. The remaining role players varied in business size, operation field, time in market and size of their market share. From the relevant candidates, three types of role players could be identified, namely those in mining, alloy production and lastly manganese related product manufacturers such as EMM and EMD producers. In order to cover the majority of the local value chain, it was important to have representatives from each sector participating in the study. Smaller sectors such as the specialized usage of manganese in chemical applications, which only accounts for approximately 1% of manganese usage, is not as crucial for this research purposes and were therefore excluded from the study.

Interviews were conducted with representatives of two of the largest manganese mining companies in the world, two of the four South African manganese alloy producers, gaining perspectives in both ferromanganese and silicomanganese alloys operations, and the world's only non-China based producer of electrolytic manganese metal and Africa's only producer of premium-quality electrolytic manganese dioxide.

Table 6-3: Sampling and sourcing of data

Role player Type	Interview	Questionnaire	Public records	Survey	Could not reach	Identified role players in sector
Mining	2	2	6	3	9	**16**
Alloy production	2	2	4	3	0	**4**
EMD production	1	1	1	1	0	**1**
EMM production	1	1	1	1	0	**1**
External (R&D)	0	0	0	9	-	**-**
Total sources	**6**	**6**	**12**	**17**	**10**	

A large scope of the South African manganese industry was covered when representatives were selected to take part in the study. Information on all four of South Africa's manganese alloy producers were gathered, with 3 out of the 4 responding directly via interview or the survey. The representatives of the EMD and EMM sectors respectively partook in all forms of the data gathering process which ensured consistency throughout the process. Only three of the companies in the manganese mining sector partook in the survey and two could be reached for interviews beforehand. This is deemed sufficient for the study however, since these mining companies were a good representation of the manganese mining sector in South Africa and the results gathered from this sector was corroborated with the findings from public records and literature.

To add an extra dimension to the study, representatives from the research and development field were also approached to partake in the survey. This is simply to gather additional insight in the field and to determine the coherence between this field and the role players directly involved in the industry. By comparing the results between these two group, it is possible to determine if there are any disparity between them. Nine respondents from R&D partook in the survey. Table 6-4 is a summary of the type of respondents that took part in the study and the method that was implemented for data gathering.

Table 6-4: Respondents partaking in the Delphi process (excluding R&D representatives)

Respondent	Role / Sector	Operation phase	Interaction type
1	Mine	Running	Interview / Questionnaire / Publications / Survey
2	Mine	Running	Interview / Questionnaire / Publications / Survey
3	Mine	Running	Publications / Survey
4	Mine	Running	Publications
5	Mine	Running	Publications
6	Mine	Running	Publications
7	Alloy	Production decreased	Interview / Questionnaire / Publications / Survey
8	Alloy	Production decreased	Interview / Questionnaire / Publications / Survey
9	Alloy	Production decreased	Publications / Survey
10	Alloy	Production decreased	Publications
11	EMM	Running	Interview / Questionnaire / Publications / Survey
12	EMD	Process of closing	Interview / Questionnaire / Publications / Survey

6.4 Process of building the barrier list

Barriers were initially identified through interviews with the respondents, which was supplemented by observations in company reports and other literature. The barriers were elaborated upon through primary sourcing in the form of questionnaires. Afterwards the respondents were asked to identify and rank the top three barriers to economic growth that they face. These barriers were grouped according to the sector it occurred in the value chain. A score was assigned to each ranking as follows:

- Ranked 1st = 5 points
- Ranked 2nd = 3 points
- Ranked 3rd = 2 points
- Mentioned = 1 point

The final rankings were determined according to the highest accumulative score between the respondents in the same sector. This provided an initial insight into the major barriers faced by role players in the manganese mining, alloy manufacturing, EMD and EMM production.

Examining the results can help determine how the barriers influence each business and where bottlenecks occur which hinders progression. This analysis thus reveals which barriers cause the greatest restriction on economic growth. The results from the respondents were compared to secondary data from published company reports to determine if there is a degree of consensus. The literature corroborated the findings.

Through primary and secondary sourcing, numerous barriers in the manganese industry were identified, stretching from lack of proper infrastructure and energy supply to labour issues and the implementation of new policies by the government. It is also clear that the barriers provided by role players in the same sector had a strong correlation, but sometimes differed from role players in other sectors, as can be seen in Table 6-5. An example is the unreliable energy supply identified in the energy-intensive alloy, EMD and EMM production sector, but does not have as a significant impact in the mining sector. In some instances, some barriers were ranked together by the respondents (such as both the unreliable supply and rising cost of electricity), in which case these barriers shared the respective ranking.

Table 6-5: Scoring of barriers

MINING SECTOR					
Ranked barriers	**1st**	**2nd**	**3rd**	**Other**	**SCORE**
1) Low market price	1	1			8
2) Industry fragmentation	1				5
3) Lack of rail capacity			2		4
4) Electricity (unreliable supply)		1			3
4) Electricity (rising cost)		1			3
MANGANESE ALLOY SECTOR					
Ranked barriers	**1st**	**2nd**	**3rd**	**Other**	**SCORE**
1) Low market price	2				10
2) Electricity (unreliable supply)		2			6
2) Electricity (rising cost)		2			6
3) Low productivity of workforce			1	1	3
4) Volatility of workforce			1		2
5) Cost of labour				1	1
EMD SECTOR					
Ranked barriers	**1st**	**2nd**	**3rd**	**Other**	**SCORE**
1) Oversupply of product	1				5
2) Anti-dumping duty		1			3
3) Electricity (unreliable supply)			1		2
3) Electricity (rising cost)			1		2

EMM SECTOR					
Ranked barriers	**1st**	**2nd**	**3rd**	**Other**	**SCORE**
1) Electricity (unreliable supply)	1				5
1) Electricity (rising cost)	1				5
2) Lack of rail capacity		1			3
3) Lack of government support			1		2

It was still evident however, that there were underlying barriers mentioned during the interviews that were not identified as one of the top three barriers by the respondents. Numerous barriers from literature were also identified during the literature review which was not addressed. These barriers were added to the list of barriers which were identified directly by the respondents. All of these barriers were properly defined in order to prevent any ambiguity and to provide a proper grasp of what each entails. Afterwards, barriers with similar characteristics or origins were grouped together in clusters. Ultimately, total of 31 barriers and 9 clusters were identified, as indicated in Table 6-6.

Table 6-6: Final list of identified barriers and clusters

Barrier	Description
SUSTAINED DEVELOPMENT	
Restricted access to capital	Capital scarcity for long-term capital-intensive investments is a major constraining factor of an expanded mineral industry in South Africa. Relatively high levels of investor expectations and corporate tax rates cause the cost of capital in South Africa to be very high in comparison to many other major mineral producing countries. Many players in the industry, especially juniors, struggle to access capital. Many foreign businesses have reservations towards supporting major planned investments in new production facilities in South Africa. These perceptions have caused many attractive potential projects to be implemented in other countries.
Technology	The mining and metals sector is constantly forced to look for innovative ways to cut costs and increase efficiencies. Many companies are turning to new technologies to advance exploration, increase productivity, improve recovery rates, decrease energy usage, etc. Many new technologies can potentially disrupt the status quo of the market, leaving companies that are unable or unwilling to adapt to these technologies in a disadvantaged economic position.
Lack of research & development and innovation	South Africa's investment in R&D has been in steady decline for the past few years. This indicator is regarded as fundamental contributor to innovation led economic growth and competitiveness and South Africa pales in comparison to most of its BRICS counterparts and the international average. Increase in R&D and innovation could lead to more efficient product processing, delivery of new products which provides businesses with a unique selling point, and ultimately provide a competitive advantage to increase economic growth.
INSUFFICIENT PHYSICAL INFRASTRUCTURE	

Under-developed infrastructure and facilities	The continued growth in mineral demand challenges mining and metals companies to look for new sources of supply which are often situated in remote locations that lack access to infrastructure. Developing mines, plants or other mineral processing facilities is often very complex when taking factors, such as difficult terrain, less stable political or regulatory management and the need to build social infrastructure at these regions, into account. These economic and social costs could add considerably to the total cost of an operation. These factors can also cause delays in delivery or places a limiting factor on the amount of products that can be transported via roads, railways and ports.
Lack of railway capacity	The freight system in South Africa is currently suffering from inefficiencies rendering most of the manganese products incapable of being optimally distributed to domestic and international markets. Since the country's transport infrastructure has been found inadequate of supporting higher export volumes to the international market, greater efforts are to be made to improve the efficiency of South Africa's rail utilities. Accelerated economic growth and lack of adequate maintenance and upgrading, however, have rendered the transport system in urgent need of corrective measures. The demand for rail capacity far outstrips the supply from government owned Transnet. Companies receive a limited tonnage entitlement to use the railway in order to transport products across the country, which forces other more expensive forms of transport to be used. The railway capacity is insufficient for a large number of companies.
Lack of port facilities	Port Elizabeth is the only dedicated port for manganese export. The development of the Port of Ngqura, also to be used as a manganese terminal, is continually pushed back due to various reasons. The port capacity does not comply with the demand and mines have to compete with a variety of other commodities and products to be delivered abroad.
High transport costs	High costs for transporting goods via rail, road and ports are becoming ever present. These escalating transport costs cuts into company profits and disables companies distributing their products at a profitable rate if the right deal cannot be made.
LABOUR	
Rising cost of labour	South Africa's weak economic growth, rising costs, high unemployment and numerous socio-economic challenges have resulted in many problems and unrest in labour cost and efficiency. The cost of labour is one of the largest expenditures in a mining company. With the raise in strikes and workforce unrest, the increase in worker wages are regularly increasing.
Unrest / Volatility in workforce	Unrest in workers has led to decreased labour productivity which undermines companies' profitability and threaten the sustainability of the business. The current perception that the workforce unrest is a high risk is discouraging potential investors in the industry. This extreme financial pressure has been evident in extended strikes in the platinum and metal industries.

Low productivity of workforce	Low productivity of the workforce cause delays in operations and leads to project schedules not being met. Low productivity often leads to the occurrence of financial losses.
Skills shortage	Increase interest in mining and mineral product manufacturing has led to the development of many new projects to ramp up production in mining and alloy manufacturing. This increased investment is in turn driving demand for skilled workers. As supply increases, the number of skilled workers also needs to increase in order to maintain the higher levels of production. The risk is that a skills shortage could slow growth and increase cost.
REGULATIONS / POLICIES	
Resource nationalism	Resource nationalism can be described as a balancing act between promoting investment and maximizing local benefits. Many governments, including South Africa's, have begun to promote initiatives to attract mining investments into their jurisdictions. Despite a decline in commodity prices, there is still a growth in resource nationalism to gain a greater share of shrinking returns from the mining and metals sector. Mandated beneficiation and state ownership is becoming a very popular political tool as governments seek to capture more value from their resources by implementing regulations that forces minerals to be processed locally prior to export. In order to ensure national beneficiation, governments are ensuring export levies or export bans on unrefined ore.
Mining Charter concerns	The South African Mining Charter presents legislative uncertainty for many stakeholders in mining companies. There are uncertainties pertaining to its context, especially regarding the Mining and Petroleum Resource Development Bill and the BEE ownership requirements. These uncertainties cause difficulty in mitigating risks.
Obtaining mining license	Obtaining the necessary legal documents for mining is often an onerous process. It is strictly controlled by government and administrative mismanagement from their side can lead to delays in production. They ultimately decide when and to whom mining licenses can be issued.
Disposal of slag	In South Africa the slag that is created as a by-product during manganese alloy production, is discarded on slag dumps and classified as a hazardous material. It is estimated that approximately 20 Mt of HCFeMn and SiMn slag is discarded on dumps in South Africa(Kazadi et al. 2013). Commercially viable options to reduce the size of these slag dumps are continuously investigated by various interested and affected parties, despite it being utilised by many countries for construction materials. This product cannot be sold in South Africa and large expenses is made to properly ensure that the slag is properly disposed according to environmental policies.
MARKET CONDITIONS	
Market volatility	Commodity prices are often affected by external factors which many times cannot be controlled by producers. All commodities are subject to wide fluctuation, especially minerals used for alloy and steel manufacturing.

	Manganese supply and demand are closely dependent to the iron and steel market with all manganese products following a similar trend to these resources. This causes price volatility which can have adverse effects on a company's operating results, asset values and cash flows. If commodity prices remain weak for sustained periods, growth projects could not be longer perceived as viable options. China's dominance in the steel market also determines many trends in the industry.
Fluctuations in exchange rate	Volatile exchange rates create an element of uncertainty in projecting future income and expenditure scenarios, which in turn casts doubt on project feasibility. By stabilizing the rand exchange rates, the South African authorities could create an environment more conducive to future expanded ferroalloy production.
Competition / Oversaturated market	An upsurge in local commodity companies has resulted in the oversaturation of the market. This increase in competition has limited the number of available resources and fragmented the power of product pricing from a handful of companies to an expanding number.
Sizeable domestic market / Proximity to market	South African alloy producers have not always found it economic to exploit rising demand for manganese products due to its distance from the markets, despite the existing excess production capacity to do so. Competitors that are located closer to the markets have traditionally had a competitive advantage over producers from abroad.
Anti-dumping duty	This protectionist tariff is imposed by domestic governments on foreign imports that is believed to be priced below fair market value. This is to protect local companies from being pushed out of the market by foreign companies selling their products at uncompetitive prices. In some countries the duty is so high, that it is no longer economically viable for South Africa to enter these markets.
Geopolitical uncertainty	Geopolitics is about the competition over the control of territory and the extraction of resources. Geopolitical uncertainty is a risk that lies outside the control of a company, but can have a major effect on its growth plans. It can also threaten disrupt operations and destroy shareholder equity. The impact of geopolitical instability can extend further down the value chain and cause a collapse in consumer demand, an increase in currency volatility and disrupt critical infrastructure and transportation networks.
RESOURCE MANAGEMENT	
Access to water	The availability, accessibility, quality and active management of water is crucial for the operational success of mining and metals companies, especially where they expand into remote and arid areas of the country.
Competing demands for land use	Land access remains a significant risk to the mining sector especially, that often faces community opposition over environmental concerns and land usage, with the resulting national and local governing laws becoming more stringent about

	land use. This opposition can increase start-up costs and cause significant delays to operationalizing a project.
Scarce resources	South Africa has been self-sufficient for many years with respect to rich mineral resources and raw materials for the production of mineral products. In recent years, however, many resources required for operation have become scarce, such as high-grade ore, reductants and other raw materials. This could lead to increases in material costs and delays in production.
Environmental concerns	Mining and metals companies are constantly under scrutiny by regulators, external stakeholders, local communities and activist NGOs to adopt a more sustainable approach to operations. Climate change concerns have increased the sensitivity of all the stakeholders, resulting in legal or punitive action on the companies. The impact is not only on the performance and brand image of the specific company, but also on the industry and employees.
ELECTRICITY CONCERNS	
Unreliable supply	Since 2008, the mining sector has faced electricity rationing that limited production due to electricity shortage in South Africa. The establishment of any new plant is dependent on the availability of electricity. Electricity limitations are a major constraint in the manganese industry and are effecting all the major role players on a large scale. Unscheduled electricity supply interruptions affect many businesses' ability to achieve their production targets.
Rising tariffs	South Africa is no longer an international competitive low cost electricity supplier. Excessive energy costs affect the profitability of all businesses and the annual increase in tariffs are eating away at profits.
SOCIAL ISSUES	
Social license to operate	To ensure that specific social factors are properly addressed and maintaining a social license to operate (SLTO), is becoming an increasingly multifaceted and multi-stakeholder risk. Poor working conditions, dangerous practices and environmentally hazardous activities which could potentially threaten the health and safety of employees and local communities, could lead to business closure. Losing a social license is a very real and potentially very expensive risk to a business.
MANAGEMENT RELATED	
Poor governmental execution	Lack of support in policy and capital investment from government has a constraining effect on local role players in the manganese industry. Incentives are promised when certain beneficiation objectives are met, but it is often not delivered upon.
Poor corporate project execution & Mismanagement	Poor project execution and mismanagement of operations in an industry that is filled with risks, can have extremely detrimental consequences on the company and lead to huge losses.
Low efficiency	Efficiency is defined as the comparison of what is actually produced or performed with what can be achieved with the same consumption of resources (money, time, labour, etc.). Efficiency has been declining significantly in the

	mining industry over the past decade, with more money and labour being utilized to extract ore as quickly as possible, instead of making provision and implementing sustainable structures for efficient systematic mining which could produce the same yield with the use of less resources. It is an important factor in determination of productivity. It was a conscious choice by industry participants to pursue volume at any cost during an unprecedented boom in commodity prices, leading to low efficiency. Mines were developed to get product out as quickly as possible, not as efficiently as possible.

6.5 Chapter 6 summary

Chapter 6 describe the four rounds of the Delphi process which is implemented to gather information on the barriers faced by role players in different sectors of the South African manganese industry. The first round entails the initial barrier identification process through interviews with experts on the extent of the barriers impact. During the second round, the list of barriers is reviewed and finalised. The list contains 31 distinct barriers which are grouped together in 9 clusters, with each cluster representing a general constraining factor. The third round consists of conducting a survey with the industry experts. The survey allows them to score the impact of each barrier on their companies growth, which can later be used to determine each barriers severity. During the last round, the results are reviewed and finalised. The Delphi process included three respondents representing the mining sector and alloy production sector respectively, and one representative from both the EMD and EMM sector for the survey. Nine representatives from the R&D sector were also included in the study to gain additional insight on the perceived barriers faced in the industry.

Chapter 7

7 Phase 5: Ranking and classification of the identified barriers

During this chapter all of the data gathered from industry experts are analysed to determine the impact that each barrier has on specific sectors within the value chain. The top ten most severe barriers in each sector of the value chain are then identified. This is followed by a simple variance analysis to determine if there are disparities between different sectors and between different respondents within the same sector. Afterwards, the prevalence of the barriers is determined to establish the scope of the impact of each barrier on the industry. The chapter is concluded with the severity and prevalence scores used to classify of each barrier in one of four groups, which determines the level of priority for each barrier. The outcome can be used as a guide to determine which barriers are the most pressing within the industry.

Research Question 5 – What are the primary barriers to growth faced by the different role players within the specific mineral industry?

- *Research Question 5.1*
  How severe is each of the identified barriers on the respective sectors in the value chain?
- *Research Question 5.2*
  What are the top ten barriers per sector in the value chain?
- *Research Question 5.3*
  How prevalent is each barrier across the value chain?
- *Research Question 5.4*
  How do the barriers vary between the sectors in the value chain?
- *Research Question 5.5*
  What barriers have the biggest impact on the industry?
- *Research Question 5.6*
  How are the impact of the barriers categorised?

7.1 Chapter overview

An overview of this framework phase is provided in Table 7-1 and a step-by step representation of the phase is shown in Figure 7-1.

Table 7-1: Overview of Phase 5

Phase 5: Ranking and classification of the identified barriers		
Description: After the barriers are identified, they are ranked according to their severity and prevalence in the industry. The barriers are categorised in groups that have a specific priority assigned to each which relates to the size of its impact on the industry. The extent of the barrier impact on specific role players, and the industry as a whole, are determined.		
Key objectives		
• Identify top 10 barriers per sector according to severity scores • Determine the prevalence of the barriers across the VC	• Determine and analyse the inter-sector variance of barrier scores • Determine and analyse the cross-sector variance of barrier scores	• Classify barriers in severity vs. prevalence quadrants • Interpret the final results
Tools used in phase / Outputs:		
• Top 10 barriers per sector • Ranking of prevalence of barriers across the VC	• Determine and analyse the inter-sector variance of barrier scores • Determine and analyse the cross-sector variance of barrier scores	• Classify barriers in severity vs. prevalence quadrants

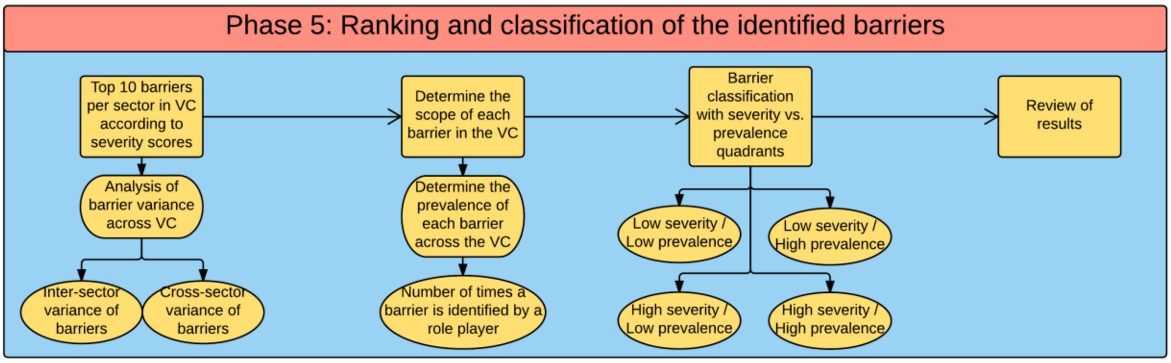


Figure 7-1: Methodology for Phase 5 of the proposed framework

7.2 Severity of identified barriers

The survey sent out during one of the Delphi process iterations, asked respondents from all four sectors of the manganese industry (mining, alloy manufacturing, EMM and EMD production) to score all of the identified barriers with a score between 1 and 10 (or not applicable) in terms of severity. Representatives working in manganese industry related R&D were also approached to gain additional insight on what they believe are the biggest constraining factors in the manganese value chain. This allows us to determine how well the R&D sector's understanding of the industry relates to the key role players involved in the field.

The average severity scores of the respective sectors where calculated and sorted to determine the biggest barriers faced in each sector. These results are shown in Figure 7-2, Figure 7-3, Figure 7-4, Figure 7-5 and Figure 7-6.

7.2.1 Interpretations of severity scores

It is evident that the distributions of the scores between the different sectors differ quite significantly. The scores from the mining sector represents a s-curve distribution with a few high-scoring barriers and smooths out with a large group of barriers receiving similar scores. The distribution takes a dip with a few barriers being scored quite low in terms of severity.

The score distributions of the alloy manufacturing and R&D sectors are a bit more evenly distributed with small differences in scores between barriers. These sectors' scores represent a more linear-like distribution. Lastly the EMD and EMM sectors has similar distributions which are more step-like with many barriers receiving the same score. This is due to a single respondent from each of these sectors partaking in the survey. There are no other representatives in these sectors since there is only one company respectively in the whole of Africa involved in the manufacturing of these products. It is also important to note that there are three barriers in the EMD sector and four barriers in the EMM sector that received a score of 0. This is an indication that *Mining Charter concerns and Obtaining mining licenses* are barriers that are not specific to these two sectors. The other four barriers, *Disposal of slag, Sizeable domestic market/Proximity to market* and *Anti-dumping duty*, cannot be disregarded as barriers for these sectors since only one representative of each sector responded. It is possible that these could be low-scoring barriers, but identified as barriers nonetheless, if more representatives in these sectors partake in the survey.

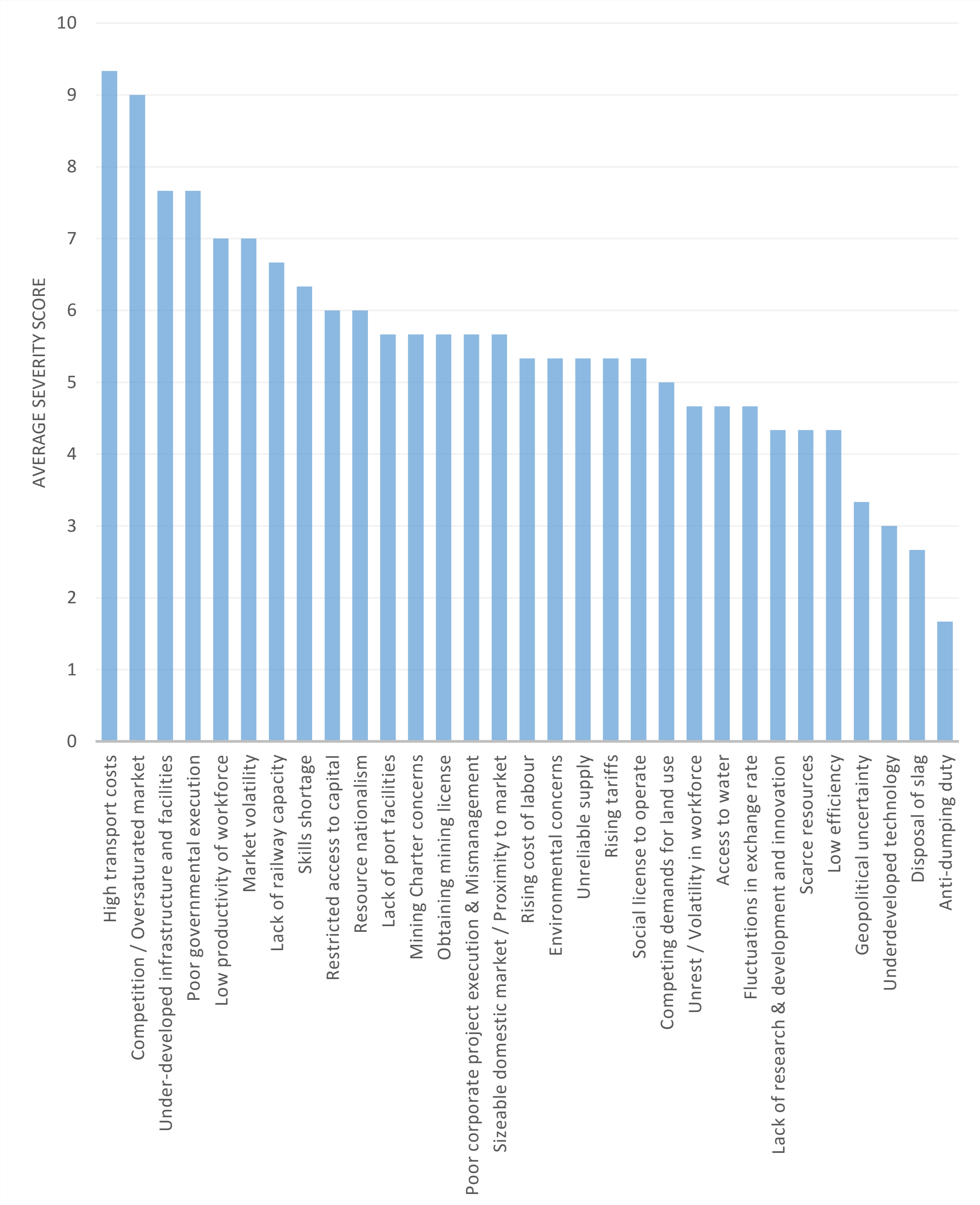


Figure 7-2: Average severity score per barrier in the mining sector

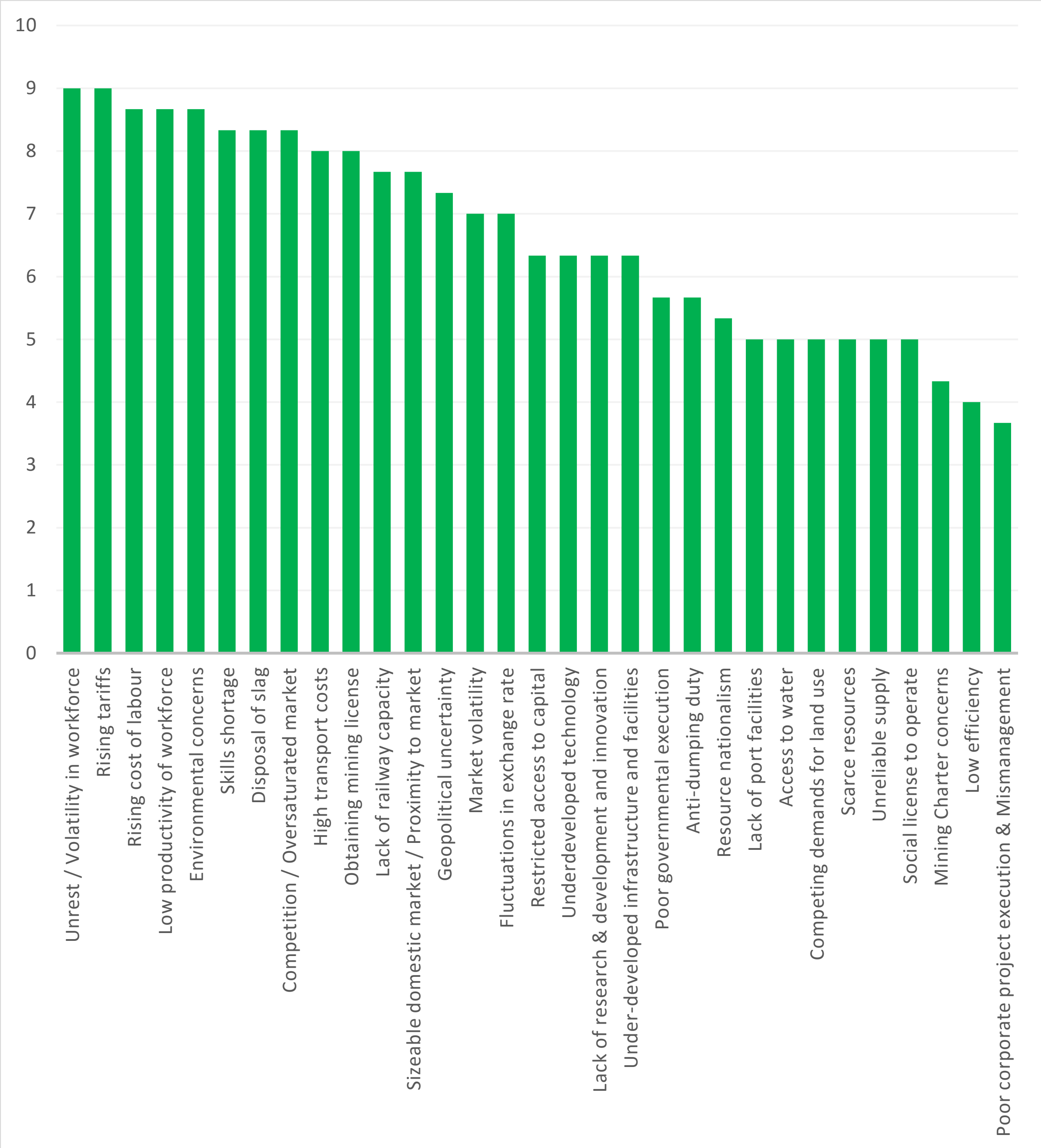


Figure 7-3: Average severity score per barrier in the alloy manufacturing sector

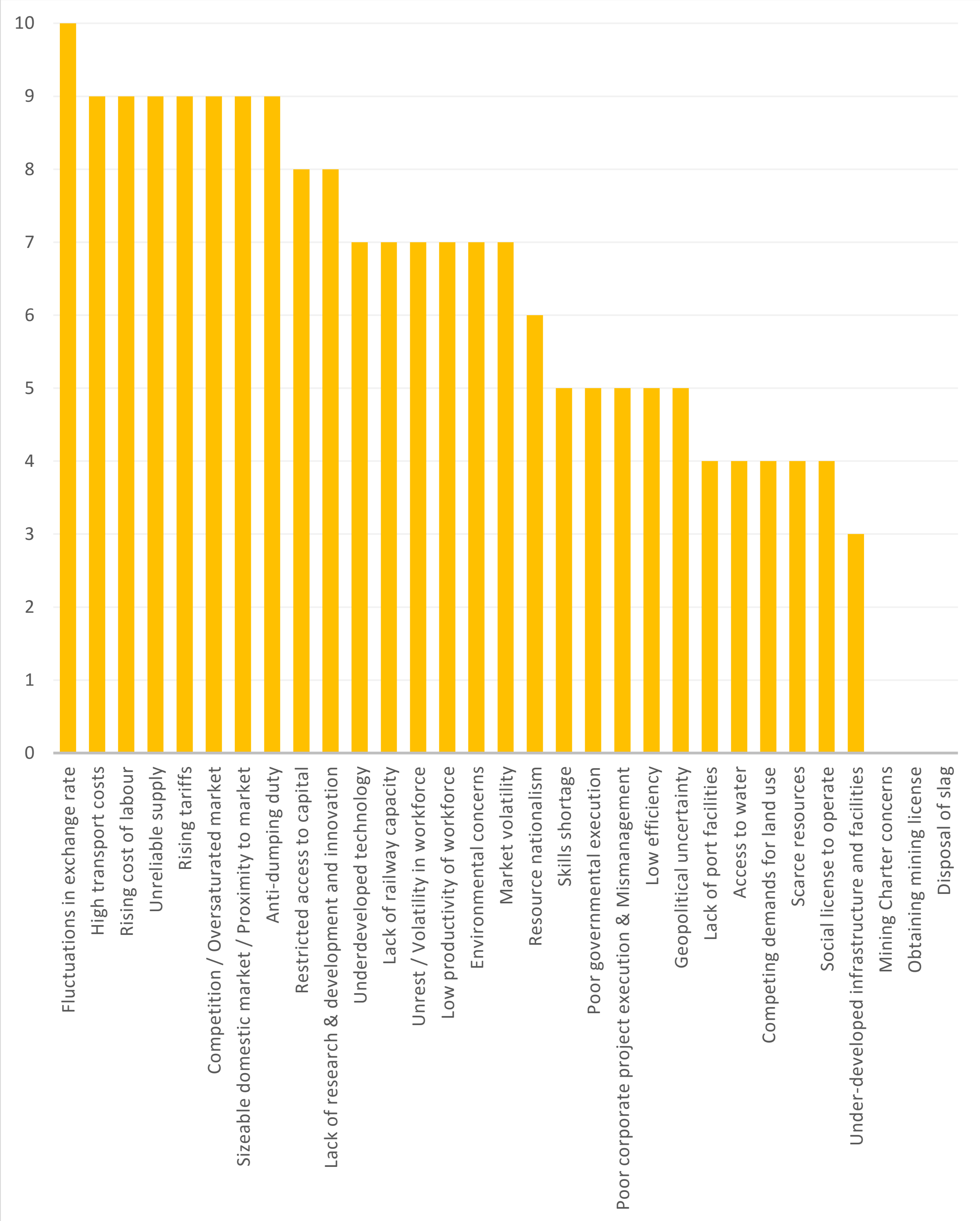


Figure 7-4: Average severity score per barrier in the EMD sector

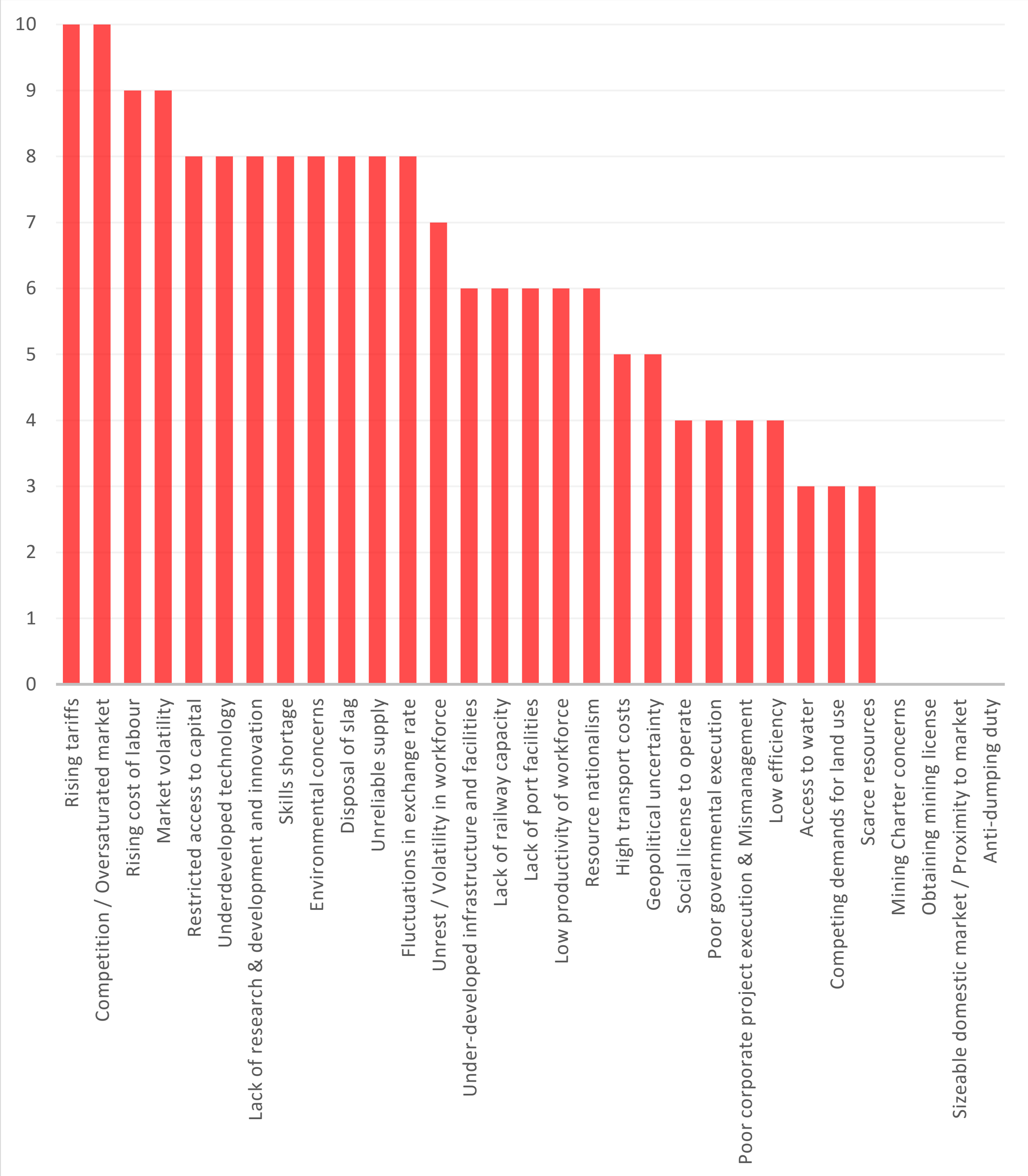


Figure 7-5: Average severity score per barrier in the EMM sector

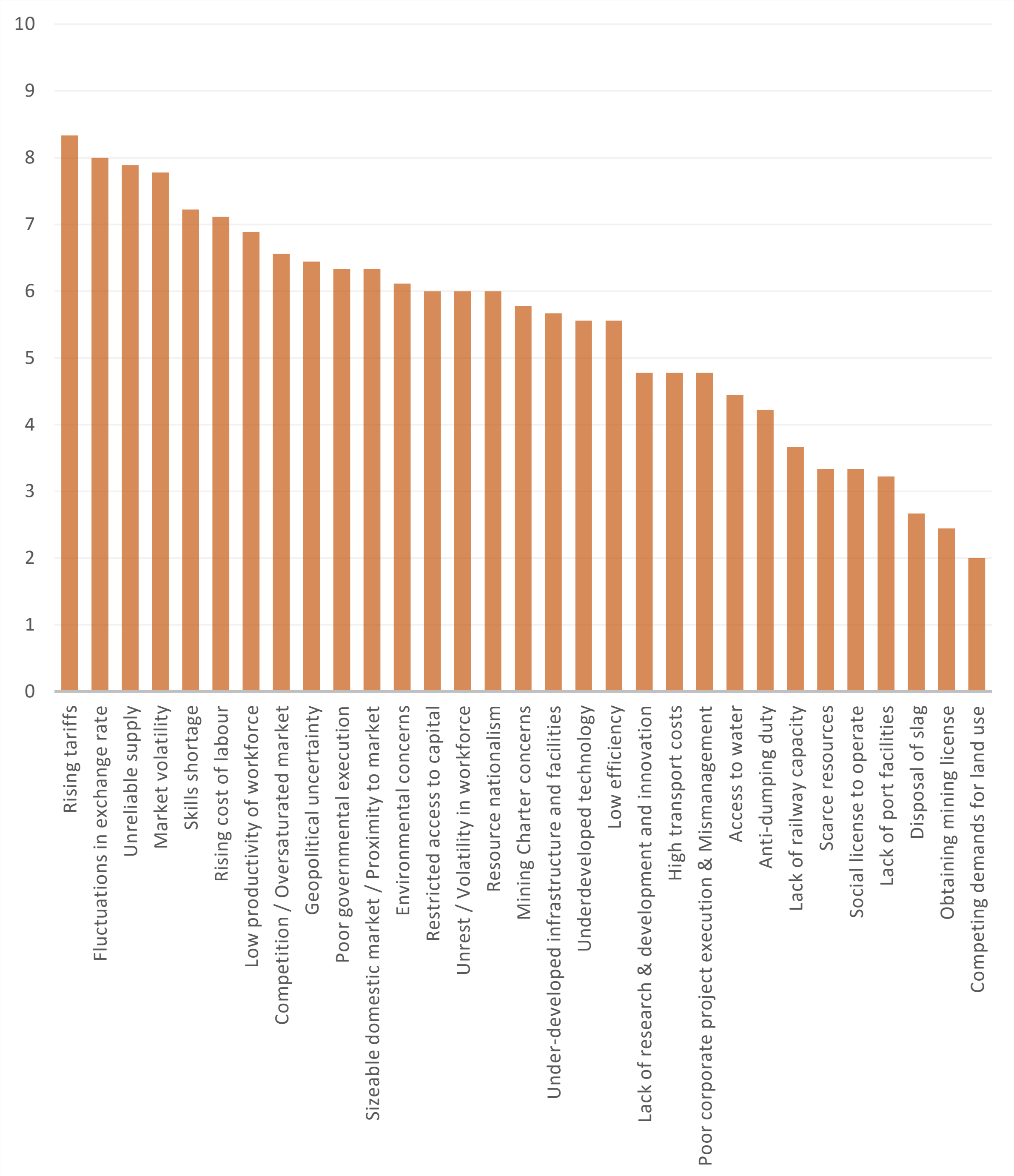


Figure 7-6: Average severity score per barrier according to R&D representatives

7.2.2 Top 10 barriers per sector

After the average severity scores per sector has been calculated, the scores can be used to identify the main barriers faced in the different sectors of the value chain. The top ten barriers per sector are identified in Table 7-2, Table 7-3, Table 7-4, Table 7-5 and the perspective of the R&D sector in Table 7-6. The ten barriers with the highest average score in each sector is listed in the tables. Barriers that received the same average score, share the ranking. This is indicated with a "=".

Each sector identified a different top barrier, with the exception of R&D matching with the EMM sector:

- Mining: High transport costs
- Alloy Manufacturing: Unrest/Volatility in workforce
- EMD: Fluctuation in exchange rate
- EMM: Rising electricity tariffs
- R&D: Rising electricity tariffs

It is evident that the major barriers are related to operational costs (such as logistics and especially electricity), labour issues (such as unrest in the workforce and increases in labour costs) and market conditions (such as fluctuations in the exchange rate and an oversaturated market). The top ten barriers in each sector scored quite high, with an average score of 8 being the lowest, apart from the mining sector that has a greater difference between higher and lower barriers.

Table 7-2: Top 10 barriers in the mining sector

MINING SECTOR		
Rank	**Barrier**	**Score**
1	High transport costs	9.33
2	Competition / Oversaturated market	9.00
3	Under-developed infrastructure and facilities	7.67
=	Poor governmental execution	7.67
5	Low productivity of workforce	7.00
=	Market volatility	7.00
7	Lack of railway capacity	6.67
8	Skills shortage	6.33
9	Restricted access to capital	6.00
=	Resource nationalism	6.00

Table 7-3: Top 10 barriers in the alloy manufacturing sector

ALLOY MANUFACTURING SECTOR		
Rank	Barrier	Score
1	Unrest / Volatility in workforce	9.00
=	Rising electricity tariffs	9.00
3	Rising cost of labour	8.67
=	Low productivity of workforce	8.67
=	Environmental concerns	8.67
6	Skills shortage	8.33
=	Disposal of slag	8.33
=	Competition / Oversaturated market	8.33
9	High transport costs	8.00
=	Obtaining mining license	8.00

Table 7-4: Top 10 barriers in the EMD sector

EMD SECTOR		
Rank	Barrier	Score
1	Fluctuations in exchange rate	10
2	High transport costs	9
=	Rising cost of labour	9
=	Unreliable electricity supply	9
=	Rising electricity tariffs	9
=	Competition / Oversaturated market	9
=	Sizeable domestic market / Proximity to market	9
=	Anti-dumping duty	9
9	Restricted access to capital	8
=	Lack of research & development and innovation	8

Table 7-5: Top 10 barriers in the EMM sector

EMM SECTOR		
Rank	**Barrier**	**Score**
1	Rising electricity tariffs	10
=	Competition / Oversaturated market	10
3	Rising cost of labour	9
=	Market volatility	9
5	Restricted access to capital	8
=	Underdeveloped technology	8
=	Lack of research & development and innovation	8
=	Skills shortage	8
=	Environmental concerns	8
=	Disposal of slag	8
=	Unreliable electricity supply	8
=	Fluctuations in exchange rate	8

Table 7-6: Top 10 barriers identified by R&D

RESEARCH & DEVELOPMENT		
Rank	**Barrier**	**Score**
1	Rising electricity tariffs	8.33
2	Fluctuations in exchange rate	8.00
3	Unreliable electricity supply	7.89
4	Market volatility	7.78
5	Skills shortage	7.22
6	Rising cost of labour	7.11
7	Low productivity of workforce	6.89
8	Competition / Oversaturated market	6.56
9	Geopolitical uncertainty	6.44
10	Poor governmental execution	6.33
=	Sizeable domestic market / Proximity to market	6.33

7.2.3 Severity in terms of barrier clusters

The nine barrier clusters are ranked according to their respective barrier's total severity scores in Table 7-7. The clusters are ranked according to their total scores, despite not all cluster containing the same number of barriers. This decision was made since it will also take the breadth of the cluster into account. This means that a cluster with few but highly scored barriers, are just as a big concern as a cluster with many but low scoring barriers. The average barrier score per cluster is, however, also included in the table.

Table 7-7: Ranking of barrier clusters in terms of severity scores

Rank	Cluster	Total score	No. of barriers	Avg. barrier score
1	Market conditions	304	6	6.33
2	Labour	232	4	7.25
3	Insufficient physical infrastructure	215	4	6.72
=	Regulations / Policies	215	4	6.72
5	Sustained development	144	3	6.00
6	Management	120	3	5.00
7	Electricity concerns	110	2	6.88
8	Resources management	108	4	3.38
9	Social issues	39	1	4.88

It is evident from the results in the table, that the *Market conditions* cluster is the most severe. Even though its average barrier score is not particularly high, it does contain the most barriers. The *Labour* cluster, that only contains four barriers, is second on the list and has the highest average barrier score by a significant margin. The *Electricity concerns* cluster is ranked quite low, since it only contains two barriers, but has the second highest average barrier score. This implies that both of these barriers are quite significant. *Insufficient physical infrastructure* and *Regulations / Policies* are both ranked third, with the same number of barriers and relatively high average barrier score.

7.3 Variance in survey responses

A simple variance analysis is performed on the survey data in order to determine if there are disparities between different sectors and between different respondents within the same sector. This would allow us to discover if there is conformity within the sectors as well as the difference in impact that each barrier would have across the various sectors. In other words, this would allow us to explore the difference in severity that each respondent experience. This will also serve as a validation tool to determine how well the barriers are defined as well as how they were interpreted.

Box and whiskers plots are used to investigate the variance of the survey results. Figure 7-7 provides a brief description of the key values used in the plot. The "whisker" or end points on either side of the plot, represent the maximum and minimum values respectively. The area from the maximum and minimum points to the box, are the upper and lower quartiles respectively. The median is represented as the horizontal line through the box and the mean is shown as a cross. All the data points (apart from the maxima and minima) are indicated as small circles. Outliers (values that are much smaller or larger than the other values in the set of data) are not attached to the plot line.

The box and whisker plots displaying the inter-variance of each sector is shown in Figure 7-8, **Figure 7-9** and Figure 7-10. This provides an indication of the difference in scores between the different representatives in each sector. Since there is only a single respondent for the EMD and EMM sector respectively, and thus no variance in the single sets of scores, there are no variance in the responses for these sectors. The cross-sector variance is provided in Figure 7-11 and Figure 7-12. These figures convey the difference in severity scores between the various sectors. The cross-sector variance takes the average score of each barrier per sector into account.

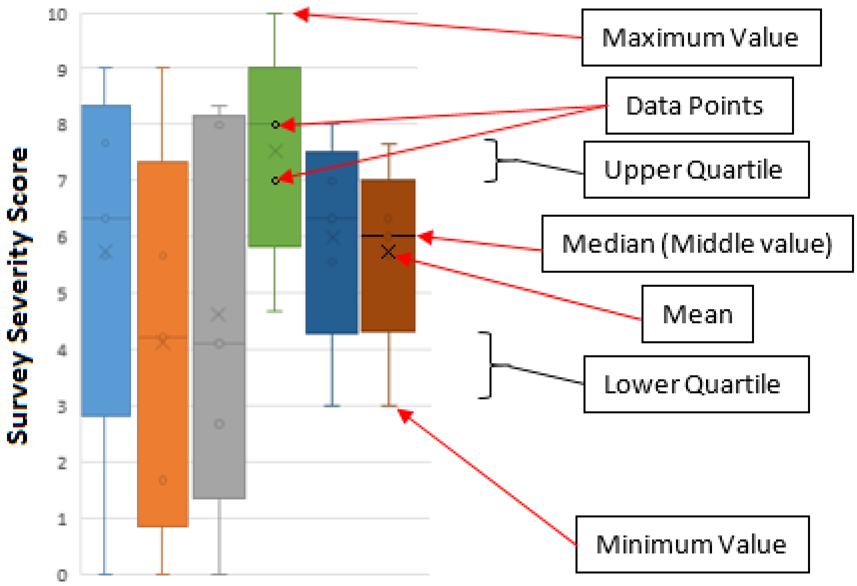


Figure 7-7: Description of the box and whiskers plot

7.3.1 Interpretation of variance (box and whiskers plots)

Figure 7-8 and Figure 7-9 conveys quite a change in inter-sector variance between die different barrier scores. In both instances there are some severity scores which vary immensely, such as the two electricity related barriers in the mining sector and *Resource nationalism* and *Social license to operate* in the alloy production sector. The could be an indication that these barriers vary in impact on the different companies within the sector, for example that the mining companies' electricity usage greatly vary from one another and thus the size of these barriers would not be the same on all of them. It is also important to note that none of the respondents in the mining sector scored a barrier with 0, which means that all of the identified barriers has an impact on the mining sector.

The latter half of the scores, however, reflect conformity in these sectors as many barriers received similar scores. This is evident in the mining sector where *High transport costs, Poor governmental execution, Anti-dumping duty* and *Geopolitical uncertainty* are scored relatively the same. The case is even stronger in the alloy manufacturing sector where *Rising cost of labour, Low productivity of workforce, environmental concerns* and *Geopolitical uncertainty* received similar scores and *Unrest/Volatility in the workforce* receiving the exact same score from all of the respondents in the sector. It is clear that labour related issues in this sector is a concern that is well understood in this sector that all of the representatives are well aware of.

Through inspection of Figure 7-10, the disparity in barrier scores from the R&D responses become clear. Ten of the barriers received scores between 0 and 10, thus spanning across the entire spectrum of possible scores. Almost half of the barriers received a score varying with 9 between the lowest and highest scorers, which clearly displays the disparity within these responses. Four of the barriers have an outlier in the data set, seen by points that are not attached to the plot line. This gives an indication that a few of these respondents had a different interpretation of the barrier than the rest of the group.

One of two conclusions can be made from this disparity. Firstly, there is a gap between the R&D sector and the rest of the manganese industry. Since there is little conformity in their responses, it is clear that they have alternative opinions as to what the major barriers are that the role players have to face in reality. The second possible conclusion is that the barriers were not properly defined in the survey or little was done to ensure that the respondents from this sector correctly interpreted the barrier definitions and did not simply answer the survey according to their understanding of what was meant by each barrier. The second conclusion is a bit less likely, however, since even though there were disparity in the other sectors as well, it was not to the same degree as found in the R&D responses.

The cross-sector variance in Figure 7-11 illustrates how the average score of each barrier vary per sector. Apart from *Sizeable domestic market / Proximity to market, Anti-dumping duty, disposal of slag* and *Obtaining mining license*, the barriers have relatively similar effects across the industry. The reason for the large disparity of these barriers, is due to the fact that they are more sector-specific, for example, that *Obtaining mining license* is much more likely to impact the mining sector than the others. Figure 7-12 displays the cross-sector variance of the role players that are in reality directly part of the industry, in other words, excluding the R&D responses. In this case it seems that the variance is much higher with this exclusion, but is important to note that since there are less data points per plot (4 instead of 5), each score has a greater influence on the distribution. Figure 7-13 displays the variance between each individual respondent and not according to sector as done previously. This provides insight as to how each respondent's score vary from one another.

Figure 7-8: Inter-sector variance of mining sector responses

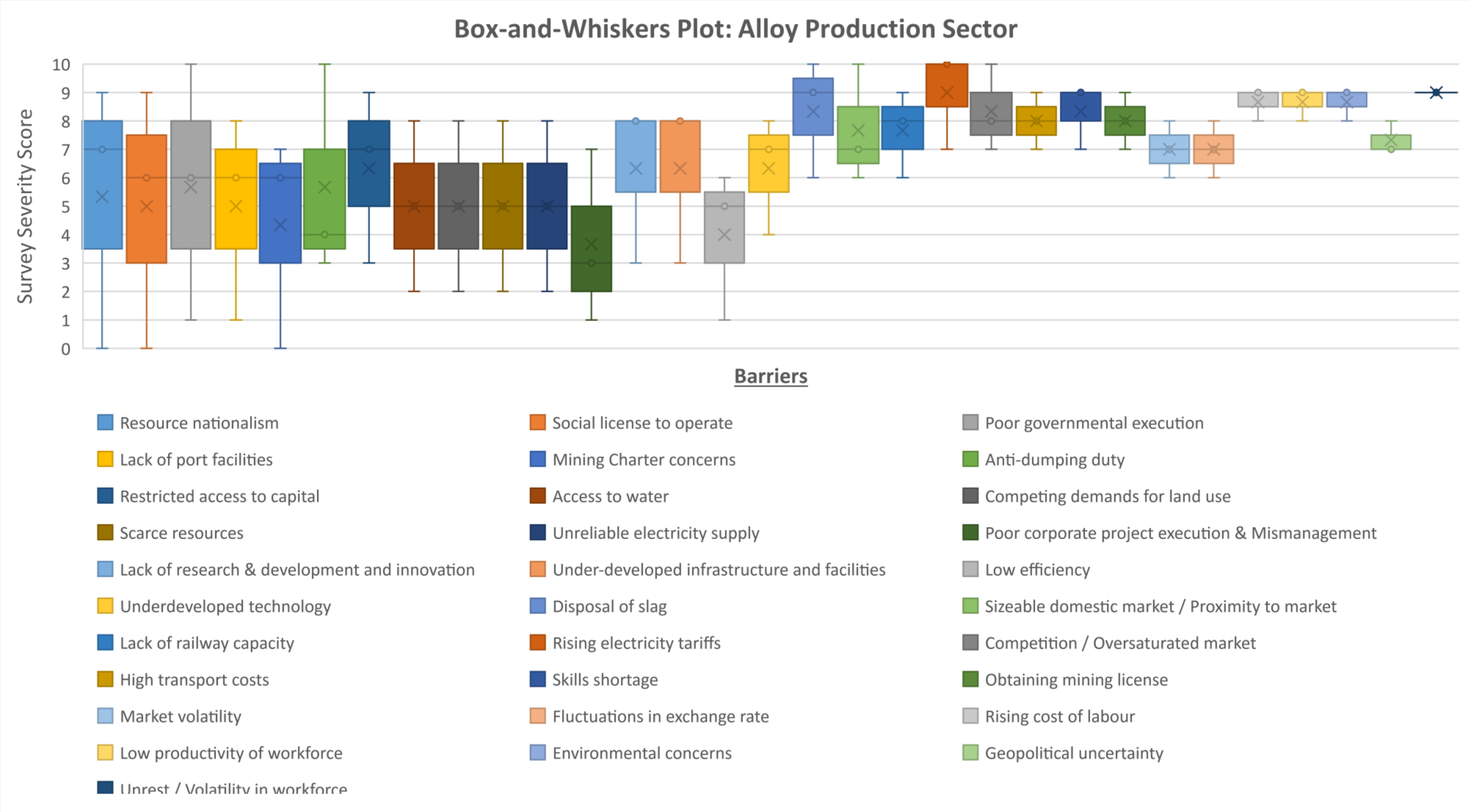


Figure 7-9: Inter-sector variance of alloy manufacturing sector responses

Figure 7-10: Inter-sector variance of R&D responses

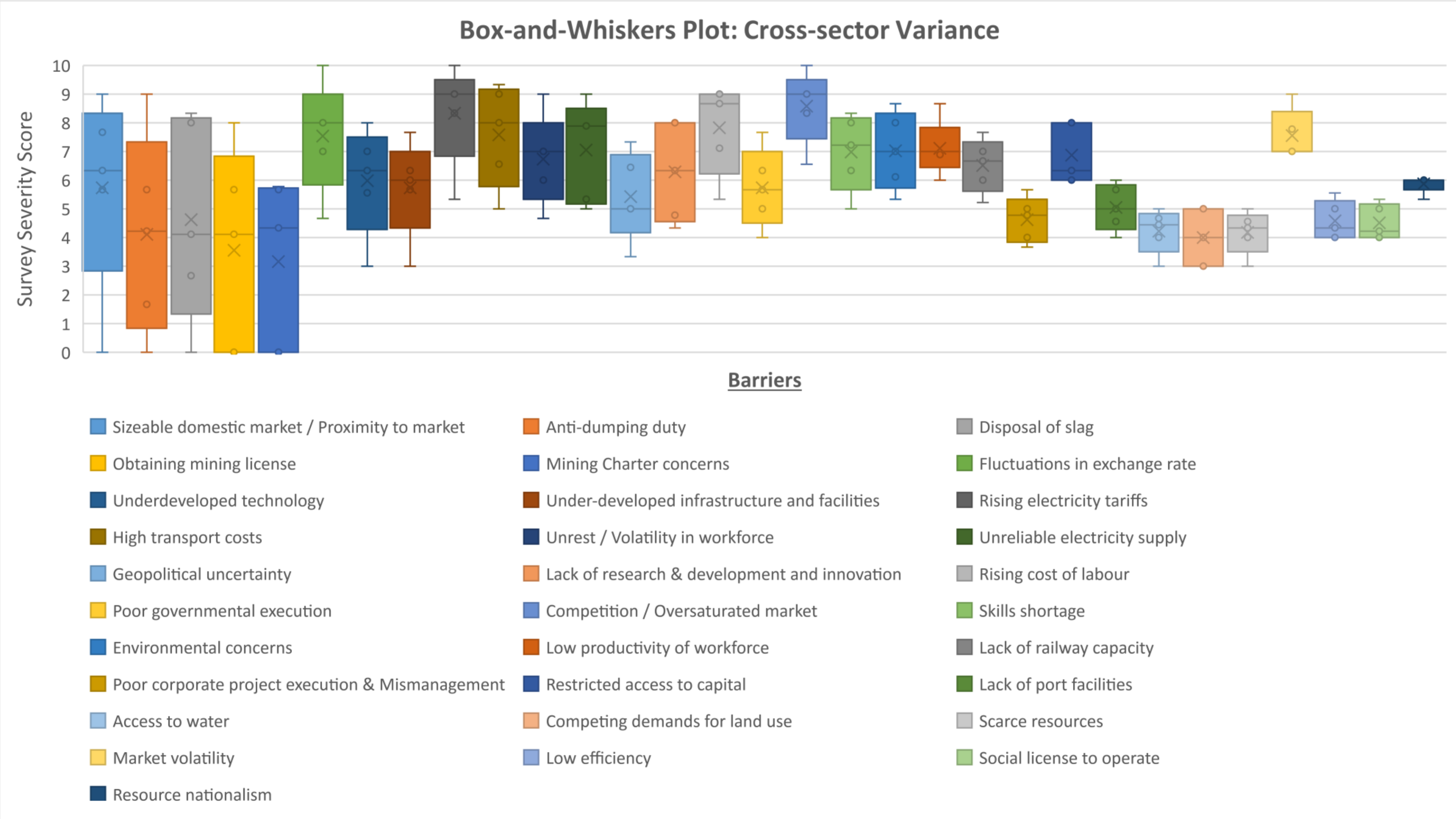


Figure 7-11: Cross-sector variance (difference in average scores between sectors)

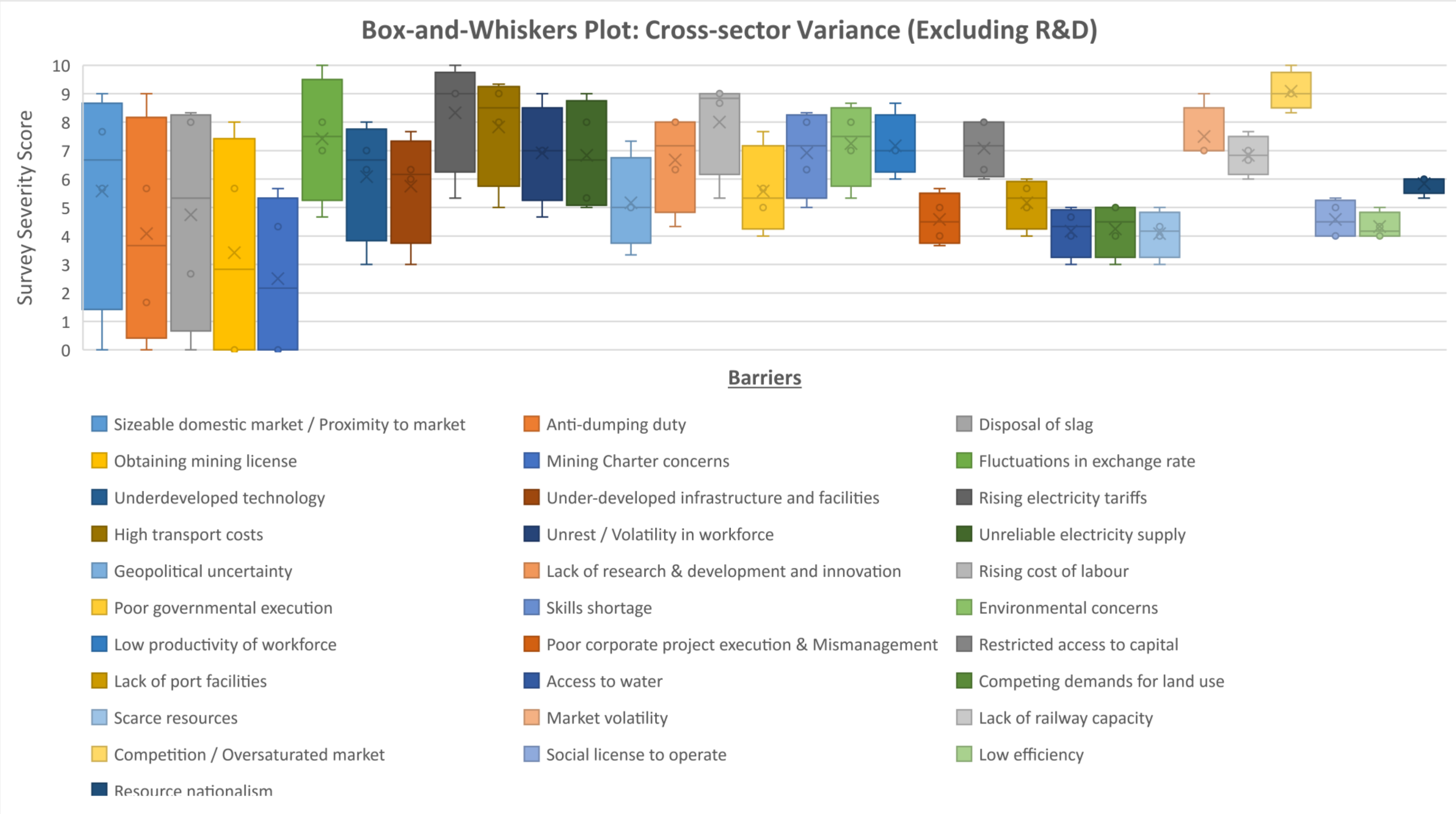


Figure 7-12: Cross-sector variance (difference in average scores between sectors, excluding R&D responses)

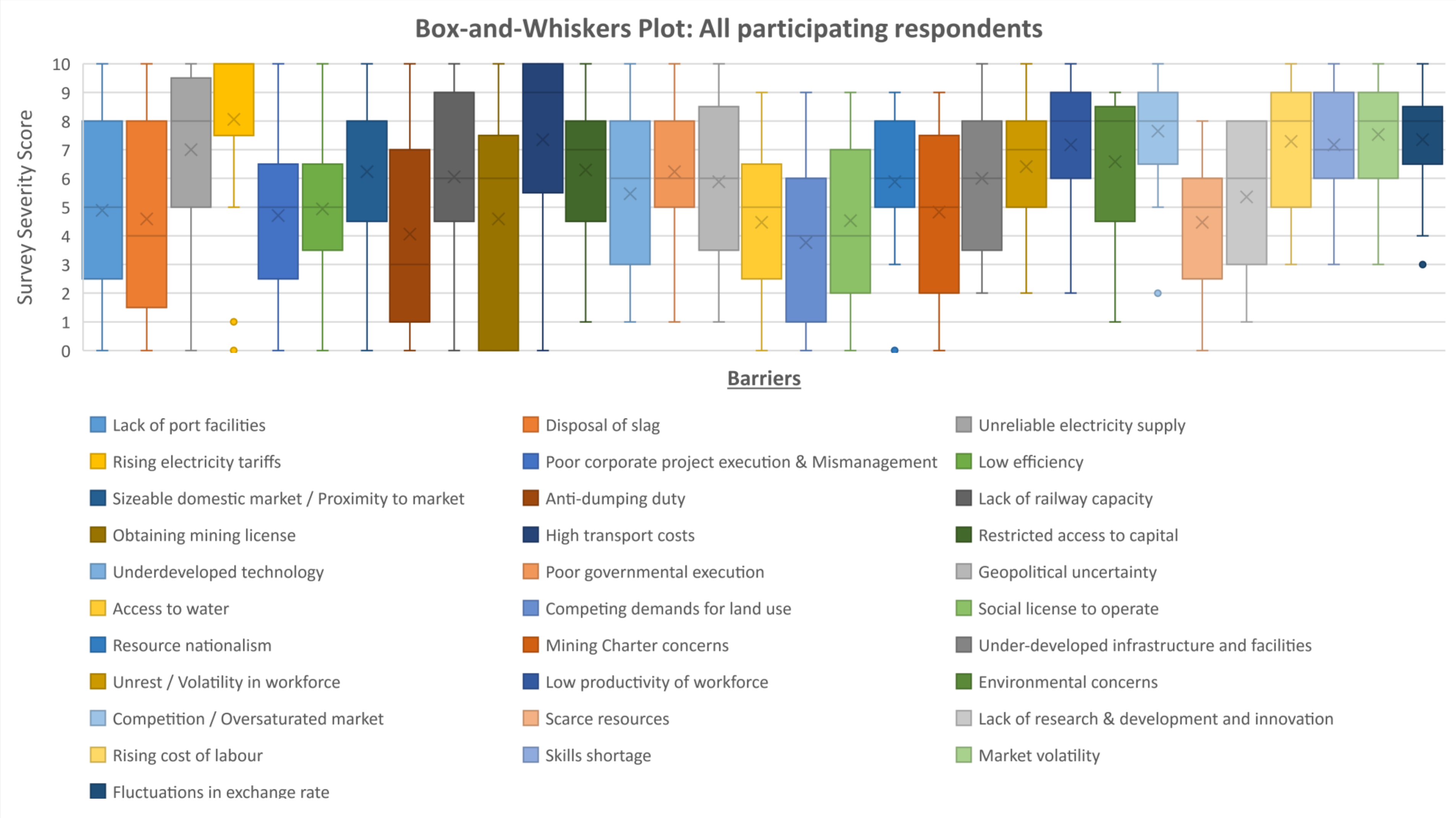


Figure 7-13: Variance between all of the responses

7.4 Prevalence of identified barriers across the industry

During the examination of the variance in severity scores, we discovered that certain barriers had a very small impact on specific sectors, while others had high severity scores across all of the sectors. In this section the prevalence of the barriers is determined in order to identify the scope of the impact of each barrier in the industry. Ultimately, this process will help to discover which barriers affect the most role players in the value chain.

Initially there were two different approaches of interpreting prevalence from the survey responses. The first approach was to define prevalence as the number of times a barrier received a score above a specific number, e.g. 7. This however, meant that prevalence would be strongly influenced by the severity scores and thus not an independent variable. The second approach was to define prevalence as the amount of times the barrier was listed in the top ten responses of a representative. This allows for less dependence on the severity scores, as it is possible that a low scoring barrier could be listed in the top ten.

Thus the prevalence of each barrier was calculated by determining the top ten barriers identified per respondent and counting the number of times the barrier was identified in the list. To ensure that all of the sectors were represented fairly, these numbers were normalized by using the sector's average prevalence, so that each sector was weighted the same. This prevented that the number of respondents per sector influenced the prevalence. In other words, sectors with few representatives, such as EMD and EMM, are represented equally with regards to the other sectors.

7.4.1 Interpretation of barrier prevalence scores

Barriers that are most prevalent in the industry are *Competition / Oversaturated market, Rising electricity tariffs, Unreliable electricity supply, Rising cost of labour* and *Fluctuations in exchange rate*, as shown in Figure 7-14. It is clear that these barriers are not sector specific and include barriers that not only constrain companies in the mineral industry, but other businesses as well. On the other side of the spectrum, *Mining Charter concerns, Competing demands for land use, Poor project execution, Access to water, Scarce resources* and *Low efficiency* are less prevalent and only relate to specific sectors. This might be due to the fact that the resource required for operation in the various sectors differ immensely and that certain barriers, such as *Mining Charter concerns*, has a smaller effect on role players further downstream in the value chain.

When the R&D responses are no longer taken into account, as shown in Figure 7-15, there is a drastic difference in prevalent barriers. *Competition / Oversaturated market* is identified as a very prevalent barrier spanning across all of the sectors. It is also important to note that *Low efficiency* has a prevalent score of 0, thus meaning that in retrospect that this is not a true barrier in the industry.

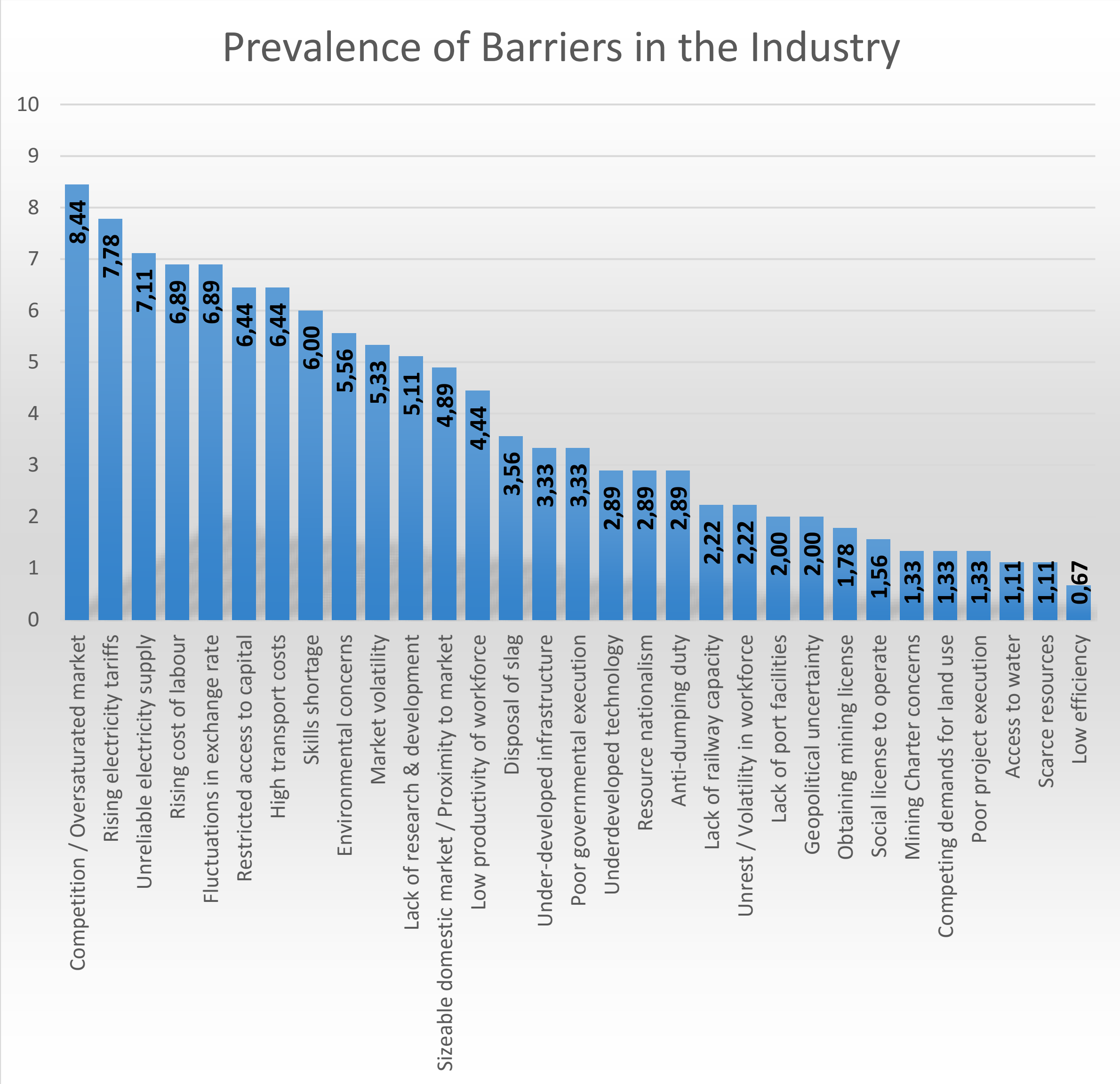


Figure 7-14: Prevalence of the barriers across the South African manganese industry (including R&D responses)

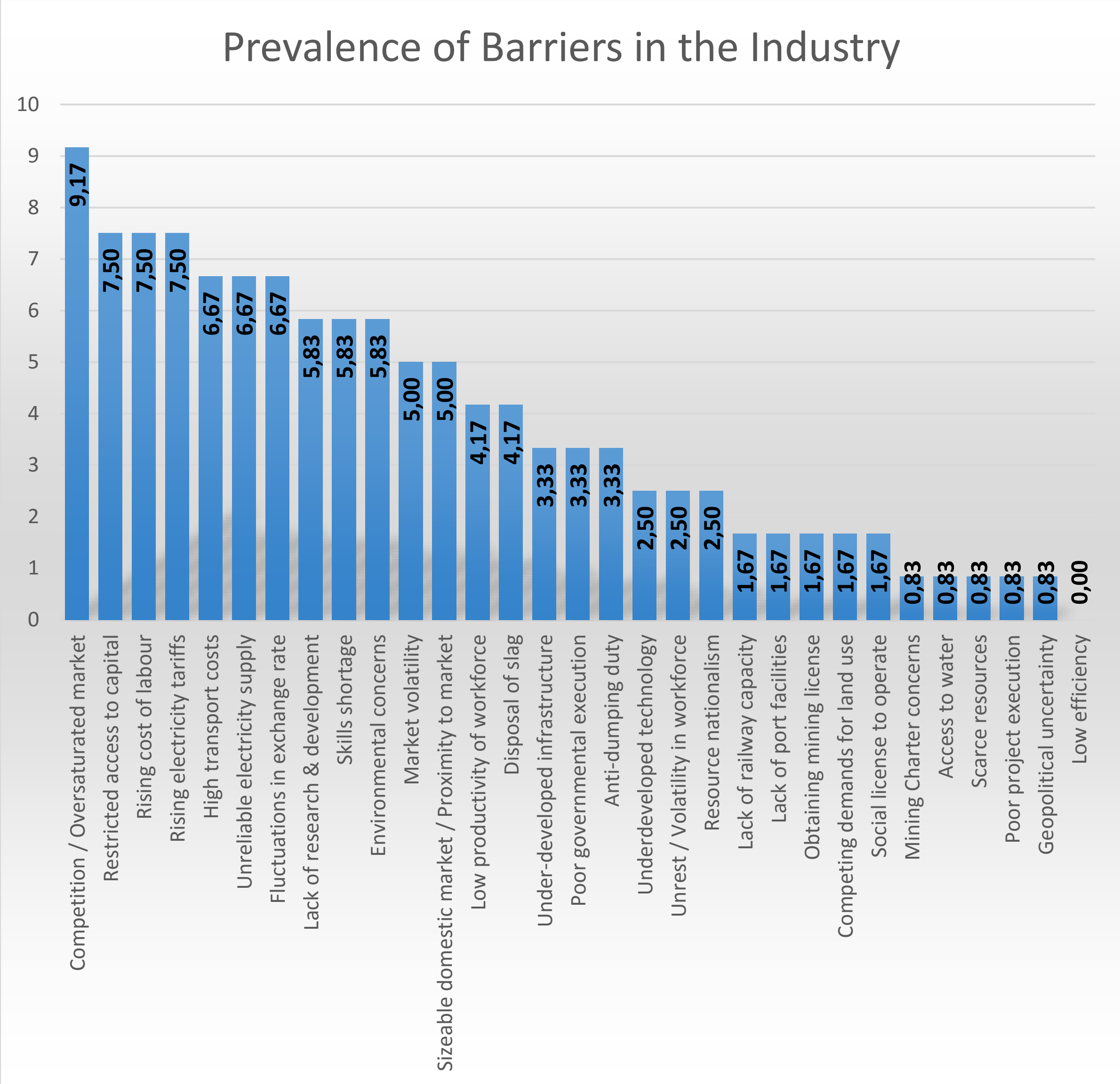


Figure 7-15: Prevalence of the barriers across the South African manganese industry (excluding R&D responses)

7.5 Classification of barriers per severity and prevalence in the industry

After the severity and prevalence of the identified barriers in the manganese industry has been investigated, the barriers can be classified in one of four groups. By grouping these barriers together, it is possible to provide a level of priority to each one, which in turn could provide policymakers, government or other industry significant bodies a guide as to which barriers to approach first when searching for possible solutions. The barriers are categorised, according to their respective severity (y-axis) and prevalence (x-axis) scores, into one of four quadrants as indicated in Figure 7-16. The severity and prevalence scores are reworked to a point out of 5. This provides a guide as to how to prioritize barriers that should be addressed.

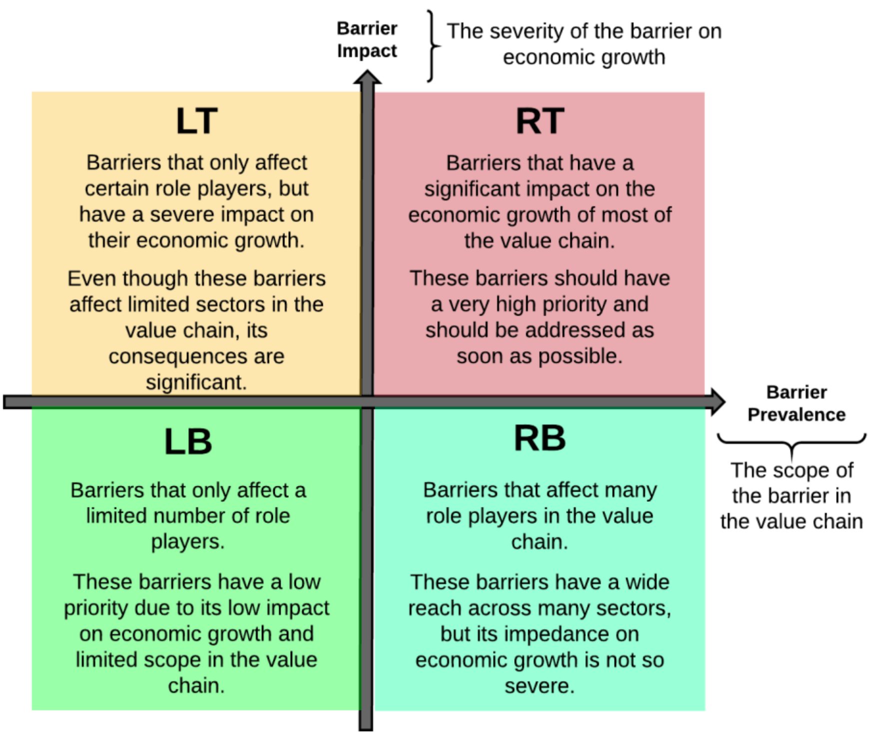


Figure 7-16: Severity versus prevalence quadrants

7.5.1 Analysis of barrier classification

The barriers are classified first by taking all of the responses into account, Figure 7-17, as well as only plotting the responses from role players directly involved in the industry, in other words with the exclusion of the R&D responses, Figure 7-18. When comparing the two distributions in these figures it is evident that the former is linear distributed, while the latter is more dispersed. The barriers in Figure 7-18 are classified as follows:

Table 7-8: Classification of barriers

TR (Top-Right)	TL (Top-Left)	BL (Bottom-Left)	BR (Bottom-Right)
• Competition / Oversaturated market • Rising electricity tariffs • Rising cost of labour • Restricted access to capital • High transport cost • Fluctuations in exchange rate • Unreliable electricity supply • Environmental concerns	• Low productivity of workforce • Unrest/volatility in workforce • Lack of railway capacity • Resource Nationalism • Underdeveloped infrastructure • Underdeveloped technology • Poor governmental execution • Social license to operate	• Disposal of slag • Poor project execution • Low efficiency • Competing demands for land use • Anti-dumping duty • Scare resources • Access to water • Obtaining mining license • Mining charter concerns	*None*

<table>
<tr><th>TR (Top-Right)</th><th>TL (Top-Left)</th><th>BL (Bottom-Left)</th><th>BR (Bottom-Right)</th></tr>
<tr><td>• Skills shortage
• Lack of R&D</td><td>• Lack of port facilities
• Geopolitical uncertainty</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td colspan="2">• Market volatility
• Sizeable domestic market / Proximity to market</td></tr>
<tr><td>TOTAL: 10 (12)</td><td>TOTAL: 10 (12)</td><td>TOTAL: 9</td><td>TOTAL: 0</td></tr>
</table>

Through inspection, it is evident that the *Oversaturated market* is the most severe and prevalent barrier to economic growth in the manganese industry of South Africa. *Rising electricity costs* also have a substantial impact on economic growth in the industry and is the second most severe barrier. This together with the unreliable supply of electricity, makes electricity issues particularly prevalent throughout the value chain. *Rising cost in labour* is also a large concern affecting many role players in the industry, together with *High transport costs*.

It seems that across the industry, problems in the market, such as the oversaturated market, are the cause of many concerns. This, together with the volatility of the market and fluctuations in the exchange rate, conveys that market related issues are a growing concern.

It is clear that the South African manganese industry is facing several headwinds and a tough economic climate. More than 70% of the identified barriers are listed in the top quadrants of the graph, which serves as an indication that there are a significant number of barriers with a constraining effect on economic growth in this industry. It is hoped that this research will enable the identification and prioritisation of actions to address these barriers.

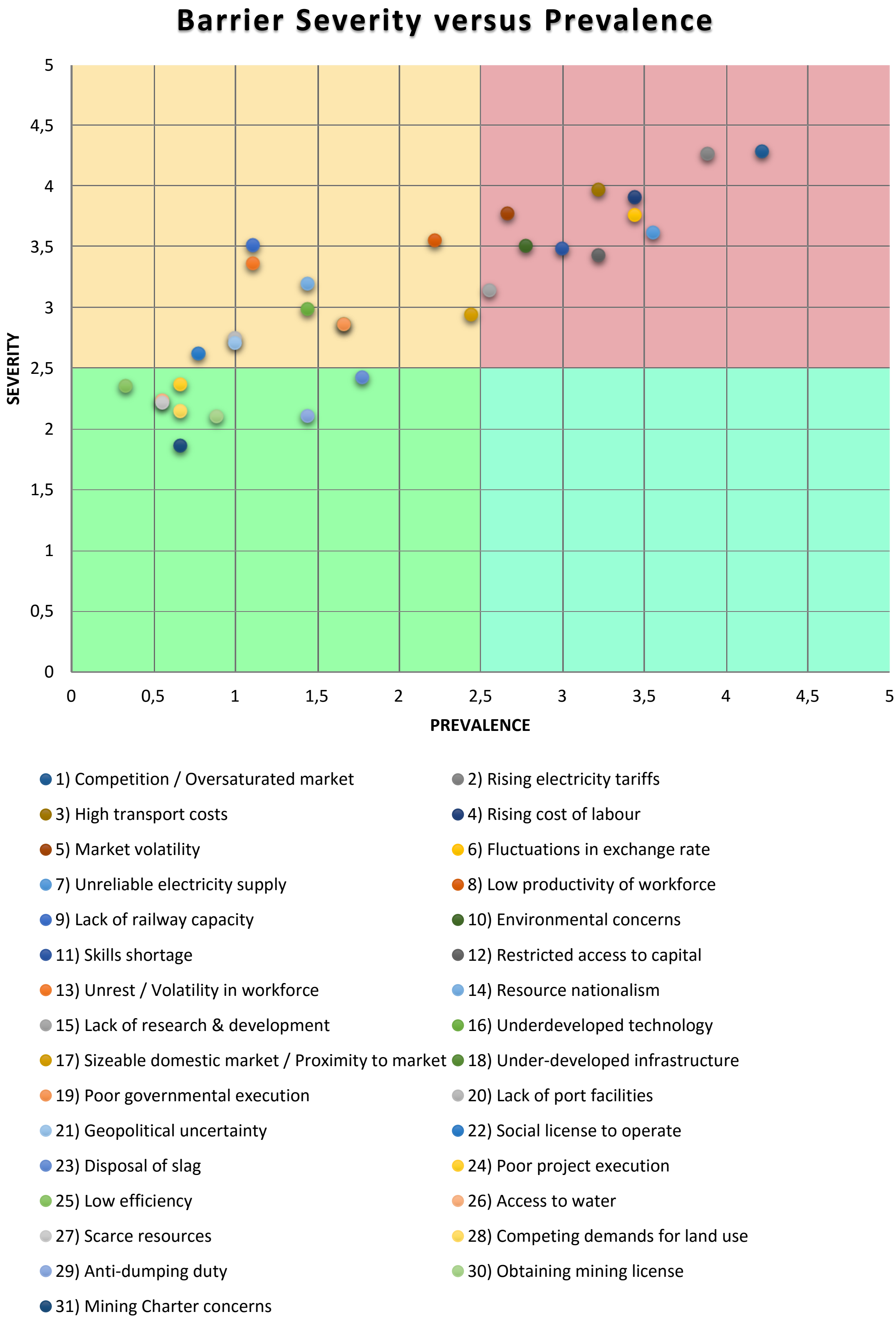


Figure 7-17: Barriers classified per their severity and prevalence in the manganese industry.

(Barriers are listed in order of severity in the legend).

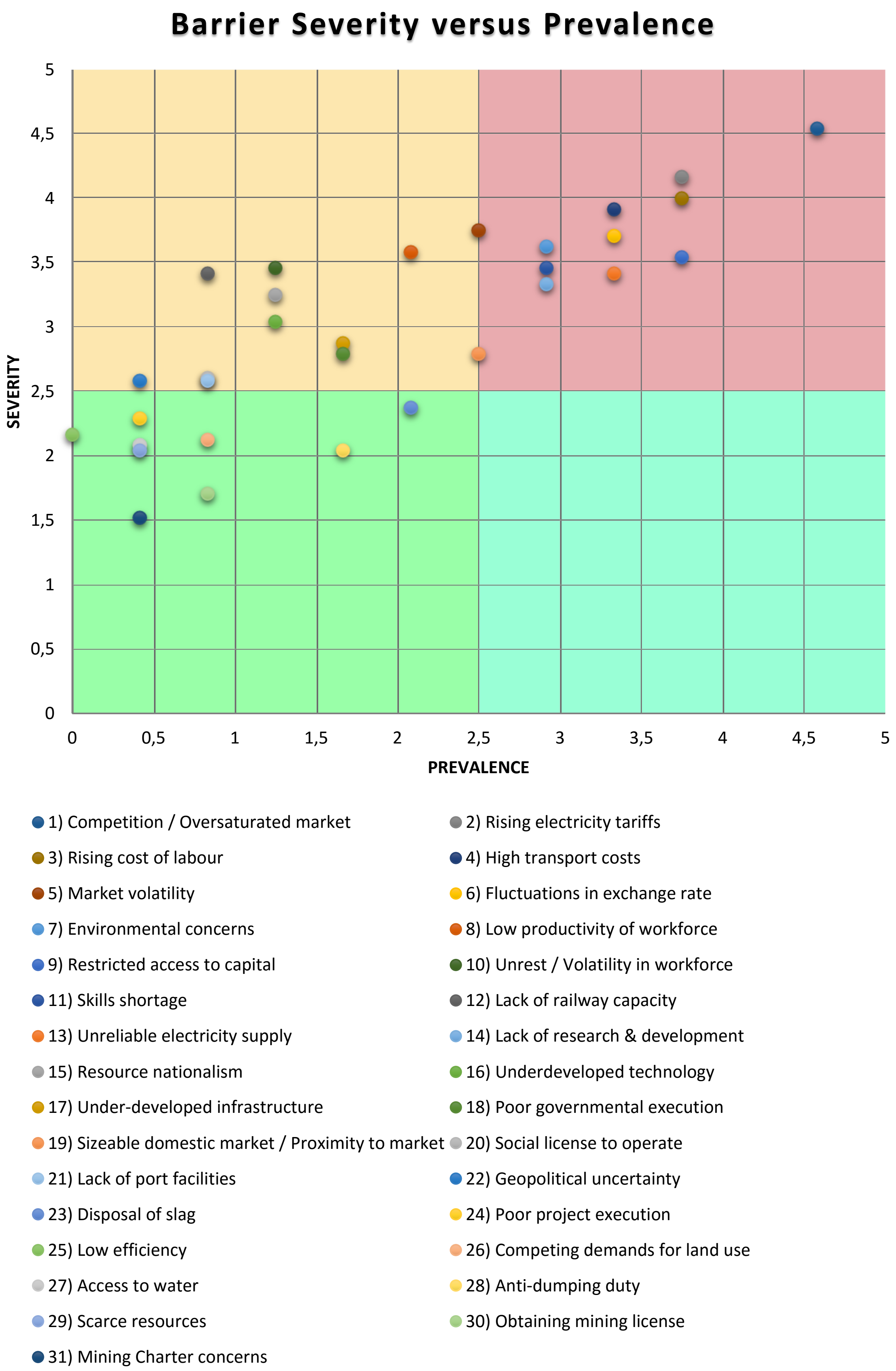


Figure 7-18: Barriers classified per their severity and prevalence in the manganese industry (excluding R&D responses).

7.6 Chapter 7 summary

The aim of phase 5 is to prioritize the identified barriers in terms of their impact on the industry. In this chapter the survey scores that were gathered in the previous framework phase, are tallied to identify the most severe barriers faced in each sector of the manganese value chain. The top ten barriers of each sector are identified, with the highest-ranking barrier of each being: *High transport costs* (mining sector), *Unrest / Volatility in workforce* and *Rising electricity tariffs* (joint first in the alloy production sector), *Fluctuations in exchange rate* (EMD sector) and *Rising electricity tariffs* (EMM sector). The survey was also conducted with representatives in the mineral R&D sector to broaden the scope of the research and allows us to determine how well R&D's understanding of the industry relates to the key role players actively involved in the value chain. R&D also ranked *Rising electricity tariffs* as the most severe barrier.

The nine barrier-clusters were ranked according to their respective barrier's total severity scores as well. *Market conditions* was the highest ranked cluster, while the *Labour* cluster was ranked second and contained the barriers with the highest average barrier score. The variance in of the results were also investigated. The inter-sector variance determined the difference in barrier responses of role players in the same sector, while the cross-sector analysis investigated the variance between the four sectors of the chain. The inter-sector variance revealed that the severity scores for the two electricity related barriers in the mining sector and *Resource nationalism* and *Social license to operate* in the alloy production sector vary immensely between the respondents. The could be an indication that these barriers differ in impact on the different companies within the sector, for example that the mining companies' electricity usage greatly vary from one another and thus the impact of these barriers would not be the same on all of them.

The latter half of the scores, however, reflect conformity in these sectors as many barriers received similar scores. This is evident in the mining sector where *High transport costs, Poor governmental execution, Anti-dumping duty* and *Geopolitical uncertainty* are scored relatively the same. The case is even stronger in the alloy manufacturing sector where *Rising cost of labour, Low productivity of workforce, environmental concerns* and *Geopolitical uncertainty* received similar scores and *Unrest/Volatility in the workforce* receiving the exact same score from all of the respondents in the sector. Through inspection, the disparity in barrier scores from the R&D responses become very evident, which serve as an indication that there is a gap in understanding between them and the active role players within the chain.

In this chapter, it was also revealed that the barriers that are most prevalent and thus affect the most role players within the industry are: *Competition / Oversaturated market, Rising electricity tariffs, Unreliable electricity supply, Rising cost of labour* and *Fluctuations in exchange rate*. It is also important to note that *Low efficiency* has a prevalent score of 0. This could mean that it might not be a true barrier in the industry.

The chapter concludes with the classification of the barriers, according to their respective severity and prevalence scores, into one of four groups. Each group is assigned a level of priority which serves as a guide to which barriers carry the largest concerns. Twelve barriers where assigned the highest level of priority, which have a large impact on the industry and also affects many role players across the chain. Through inspection, it was evident that the *Oversaturated market* is the most severe and prevalent barrier to economic growth in the manganese industry of South Africa. *Rising electricity costs* also have a substantial impact on economic growth and is the second most severe barrier.

Chapter 8

8 Phase 6: Barrier root cause analysis

The final step required to understanding the barriers in a MVC, is to review the barriers and identify their origins, the influencers responsible for each and possible alleviation strategies to address them. In this chapter the root cause analysis (RCA) process is developed and implemented on the manganese value chain to determine the causal factors for these barriers, as well as quantitively determining the impact that it has on role players and the industry as a whole. These results will be represented in a causal factor summary table and sunburst diagram.

Research Question 6 – What are the causes of the barriers?

- *Research Question 6.1*
  How are the barrier's causal factors determined?
- *Research Question 6.2*
  What are the major concerns for the barriers?
- *Research Question 6.3*
  How do the barriers effect the role players in the chain?
- *Research Question 6.4*
  Who are the main influencers responsible for the barriers?
- *Research Question 6.5*
  How can die barriers be addressed?

8.1 Chapter overview

An overview of this framework phase is provided in Table 8-1 and a step-by step representation of the phase is shown in Figure 8-1.

Table 8-1: Overview of Phase 6

Phase 6: Barrier root cause analysis		
Description: The main barriers in each sector are comprehensively reviewed and discussed. Afterwards a root cause analysis is performed on each major barrier to determine its origin. Furthermore, each barrier will be traced to the specific influencer or multiple parties responsible for each barrier. Lastly, a possible alleviation strategy will be provided for each barrier.		
Key objectives		
• Analysis and review of main barriers • Link influencers to respective barriers	• Identify root causes of respective barriers	• Final review and conclusions
Tools used in phase / Outputs:		
• Analysis and discussion of main barriers faced across the value chain	• Sunburst diagram: Barrier cluster conveying influencers and causes of barriers	• Final review and conclusions

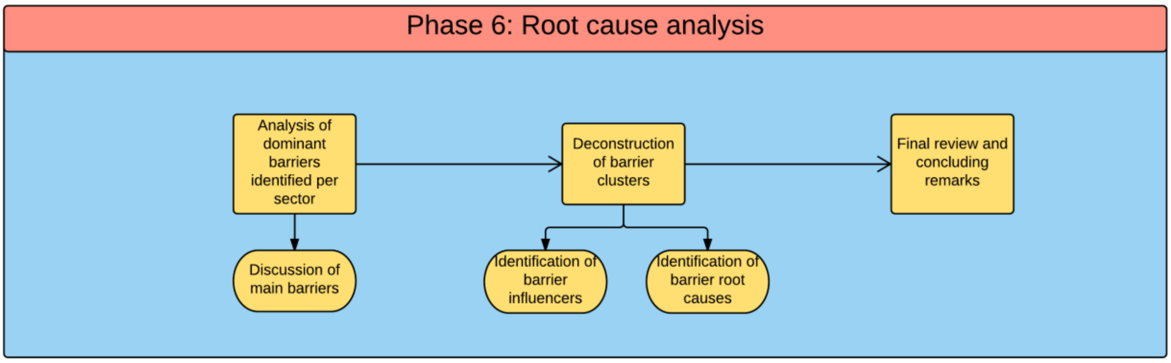


Figure 8-1: Methodology for Phase 6 of the proposed framework

8.2 Root cause analysis overview

Root cause analysis (RCA) is the process designed, in this instance, for use in investigating and categorizing the root causes of barriers to growth in a mineral value chain. It is a tool designed to identify not only how a barrier occurred, but also why it happened. When sufficient information is gathered and the reasons why a barrier occurred, is identified, only then will it be possible to specify the necessary corrective measures that will prevent barriers of the same type from reoccurring. Understanding why barriers occur, is key to develop effective recommendations.

Identifying the major barriers in mineral value chains does not add any practical value, unless these issues are addressed. In order to respond to these concerns, the causes must first be identified to know which areas in the value chain must be targeted. RCA is incorporated into the framework for the following reasons (Rooney & Heuvel 2004):

- RCA helps identify what, how and why a barrier occurred, thus preventing recurrence;
- Root causes are a significant part of barrier identification since they are underlying, reasonably identifiable, can be controlled by management and allow for generation of recommendations;
- The groundwork of data collection for this process has already been laid in the previous phases;
- The process outputs are cause charting, root cause identification and recommendation generation.

8.2.1 Definition of root causes

The definition of a root cause may vary from different sources, but Rooney and Heuvel's definition will be used in the context of this study, which is as follows (Rooney & Heuvel 2004):

1. Root causes are specific underlying causes;
2. Root causes are those that can reasonably be identified;
3. Root causes are those management has control to fix;
4. Root causes are those for which effective recommendations for preventing recurrences can be generated.

These characteristics can further be contextualised as follows:

Root causes are underlying causes:
The goal of the RCA is to identify specific underlying causes. The reason for the occurrence of the barrier should be as specific as possible, since it will be easier then to arrive at recommendations that will prevent recurrence.

Root causes are those that can reasonably be identified:
Investigation of root cause occurrences must be resource beneficial, since it is not practical for an investigator to indefinitely search for root causes. A structured RCA will ensure that the best outcome is achieved from the time that is invested in the investigation.

Root causes are those over which management has control:
The identified causes should be specific enough to allow management to make effective changes. It is necessary to know exactly why a failure occurred before measures can be put in place to prevent recurrence.

Root causes are those for which effective recommendations can be generated:
Recommendations should directly address the root causes identified during the investigation. Vague recommendations could be an indication that the basic cause has not been identified and more effort should thus be expended in the analysis process.

8.3 The RCA process

There are several approaches in conducting a RCA, such as the cause mapping method and the 5 why approach. These methods are often very time-consuming, requires a small team to conduct the analysis and can be become quite technical (ASQ 2016). A slightly different approach is used in the framework which addresses the beforementioned issues, as well as present the results in a clear and more user-friendly manner, also adding a new dimension to the analysis in the form of associating main influencers responsible for each barrier. The RCA implemented in the framework is a five-step process involving the following:

1) Data collection;
2) Barrier review and discussion;
3) Causal factors and alleviation strategy identification;
4) Influencer identification, and;
5) Presentation of results.

8.3.1 Data collection

The first step in the RCA process is to gather data on the identified barriers. Without a comprehensive understanding of the barriers through reviewing relevant information, the causal factors and root causes associated with the barrier cannot be identified. Data gathering comprises the majority of the time spent in analysing a barrier. Much of the groundwork has already been covered in the previous framework phases, but it is still necessary to scrutinize the barriers to determine their specific causes.

8.3.2 Barrier review and discussion

After all relevant information is gathered on the specific barriers, it is analysed and reviewed. The barriers are placed in context while their effects on different role players and its impact on the industry are discussed. To gain a better understanding of the barrier severity, the extent of their impact should also be described in monetary terms, or similar information, which can quantitative convey exactly how and to what degree the barriers are affecting economic growth.

8.3.3 Causal factors and alleviation strategy identification

This step provides a structure to organize and analyse the information gathered during the investigation of the origins of the respective barriers. The results will be summarised in the form of a table which will convey the barrier with its corresponding causal factors and/or an alleviation strategy to address the situation. In some cases, the causal factors will be described in terms of the events leading up to the occurrence and the conditions surrounding these events.

As much causal factors for each barrier as possible should be identified. Afterwards, achievable recommendations to alleviate these barriers are generated. This provides suitable solutions which could be applied by government, policymakers or relevant businesses to address the identified issues.

8.3.4 Influencer identification

When all the causal factors have been identified, the major contributors or influencers who are either responsible for the barriers or who are in the best position to address them, should also be identified. This addition is not typically included in a RCA. It is a valuable contribution since not only are the causes for each barrier identified, but the primary influencer as well, which enables the user of the proposed framework to distinguish what parties are affecting which barriers. The influencer is also listed in the beforementioned table next to the corresponding barriers for which it is responsible. A number of different influencers are often responsible for contributing to the same barriers from different perspectives. It is important to identified as many influencers as possible to address the barrier in its entirety.

8.3.5 Presentation of results

The results of the RCA need to be presented in a clear and straightforward manner, only highlighting the key aspects. The results are displayed in two parts, namely a sunburst diagram, illustrating the barriers that each influencer is responsible for, and a causal factor summary table. The diagrams are drawn up according to each specific barrier cluster. Each diagram consists of 3 layers (Figure 8-2):

1. The inside layer represents the specific barriers within the cluster;
2. The second layer is the influencer responsible for addressing the barrier, and;
3. The outside layer is a representation of the causal factor and/or alleviation strategy recommendation.

The table elaborates on the detail captured in the diagram by describing the barrier causal factors and alleviation strategies.

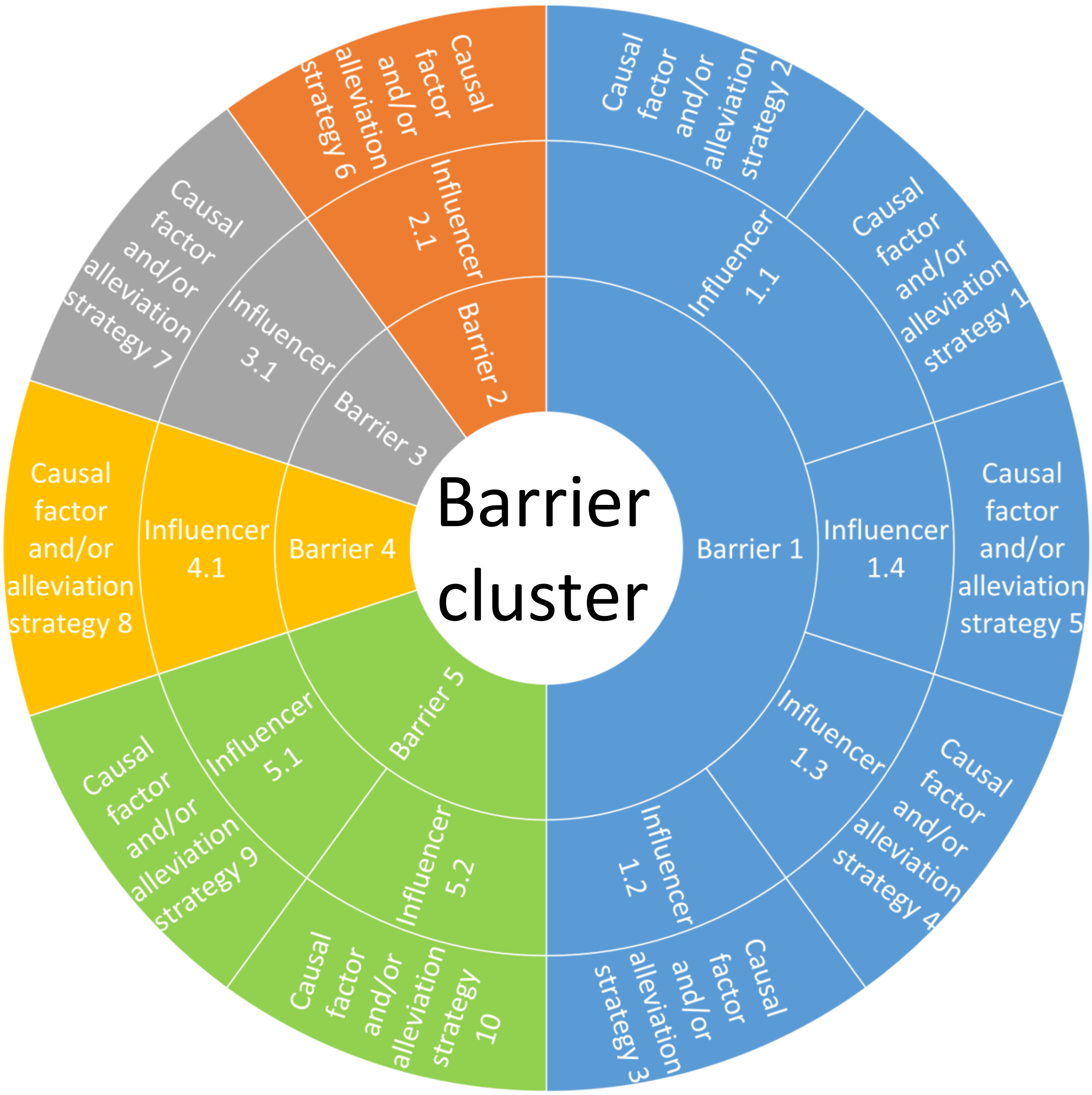


Figure 8-2: An example of a RCA sunburst diagram

8.4 Review of key barriers

It is important to note that the RCA results from the case study in this chapter are for illustrative purposes only and are by no means complete. In order to determine all the causal factors for the respective barriers, the influencers involved for each and the alleviation strategies to possibly addressed them, a more detailed analysis needs to be conducted. It is only applied to the case study, to convey the value that this tool can contribute and its importance in the framework to better understand the barriers and the MVC environment. To analysed each barrier in-depth, falls outside the scope of research, so only on barrier-cluster will be analysed in this chapter, namely *Electricity concerns*.

8.4.1 Review of electricity concerns

South Africa could increase its production and exports of beneficiated manganese products if the power supply to processing plants is improved. Since 2008, the mining sector has faced electricity rationing that limited production due to electricity shortage in South Africa (Booyens 2012; Ratshomo 2013). The establishment of any new manganese alloys smelter plants is dependent on the availability of electricity. The power limitations have been one of the largest constraints of manganese industry in South Africa and are effecting all the major role players on a large scale.

The processing of alloys is particularly energy intensive. The smelters in ARM's (part owner of Assmang) Ferrous Division consume nearly half of the business group's total electricity. According to ARM, excessive energy costs will affect the profitability of all businesses and ultimately undermine job creation, social development and the flow of revenue to the government (African Rainbow Minerals 2014). Furthermore, unscheduled electricity supply interruptions affect many businesses' ability to achieve their production targets.

South Africa's electricity demand has at present more than caught up with the state energy supplier's, Eskom, electricity-generating capacity. An increasing number of global commodity businesses have reservations about supporting major planned investments in new production facilities and believe that South Africa will no longer remain a low cost electricity supplier (Ratshomo 2013). These perceptions have caused many attractive potential ferroalloy production projects to be implemented at alternative areas. These reservations can be summarised in the following power and electricity access concerns (Edinger 2014):

- *Lack of infrastructure:*
  South Africa's power needs are expected to double by the year 2030. The construction of the Medupi and Kusile power stations are still underway and with constant delays, the completion of these projects is expected over next 10 to 15 years.
- *Cost of power:*
  Electricity tariffs are expected to increase by 8% for next five years, rising to 89.13c/kWh in 2017. This projection is, however, already surpassed when the National Energy Regulator (Nersa) approved a 9.4% electricity hike for 2016/2017 on 1 March 2016 (Pretorius & Le Cordeur 2016).
- Unreliable supply: Repeated instances of load shedding, notably 2008 and beginning of 2014, highlights the need for better demand management.

8.4.2 Economic effects on the industry

With the manufacture of mineral products currently much lower due to the weak mineral economy, the electricity supply is sufficient for operation. If the commodity cycle recovers and operations increase to the standard production rate, however, the intermittent supply will cause many operational setbacks and the rising tariffs will cut into profits. Where South Africa used to have very inexpensive electricity in the past, the country has now lost its international competitive advantage in this regard. Furthermore, it seems that these prices may still be on the rise in the coming years, as seen in the forecasts shown in Figure 8-3 and Figure 8-4,while other country's prices remain relatively consistent (Fripp 2015). In recent years, power has seen a massive jump in price which had a significant impact on operation costs of all alloy producers.

Energy-intensive alloy producers also regularly experience power containments where energy consumption in the company must be lowered for a duration of time in order to lighten the burden on the national electricity grid as per agreement with Eskom. Consistency is key for these producers and their furnaces need to remain continuously running for as long as possible to attain ideal operating conditions. Power containment and interrupted supply, drastically decreases efficiency and increases the operating costs of the furnaces.

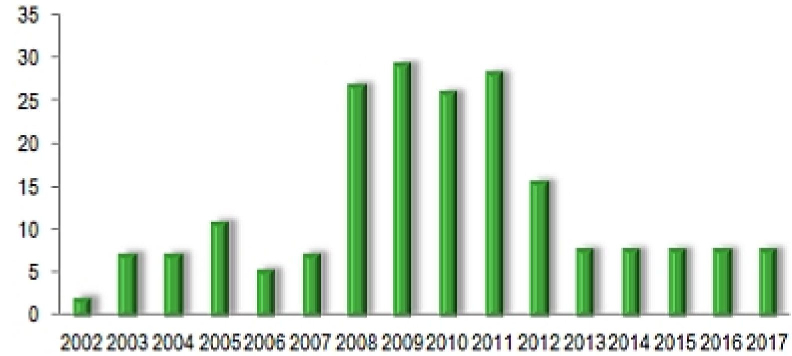


Figure 8-3: Estimated South African electricity price increases (%) between 2002-2017

Source: (Ramyia 2013)

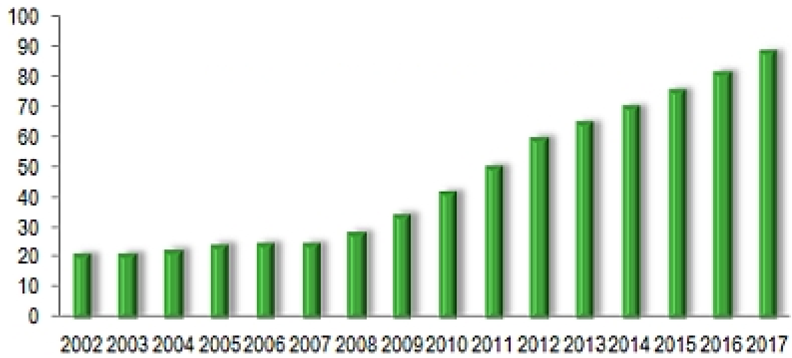


Figure 8-4: Estimated South African average electricity price (cents per kWh) between 2002-2017

Source: (Ramyia 2013)

An Energy Market Survey conducted by NUS Consulting, conveys how South Africa's energy prices compare to other countries. According to the report, South Africa is positioned near the middle of the list of 18 countries surveyed for electricity prices. Between 2014 and 2015, the country's power prices increased by 8.2% to 8.46 US cents per kilo-Watt hour (kWh), which was the second largest hike in price after Belgium's 9.9% increase (BusinessTech 2015). According to this report from NUS, South Africa has the 10th most expensive power prices out of 18 countries in 2015, which is 5 positions higher than in previous year, as indicated in Table 8-2. The increases indicated in the table, as measured by NUS, does not include other increases often implemented by resellers, such as municipalities.

Table 8-2: Highest global electricity prices in 2015

Sources: (BusinessTech 2015)

Ranking	Country	Electricity price (USD c/kWh)	Electricity price (ZAR c/kWh)	Change from 2014 (%)
1	Italy	15.70	219.12	-6.8%
2	Germany	15.22	212.42	-1.2%
3	United Kingdom	14.16	197.63	+1.3%
4	Belgium	11.17	155.90	+9.9%
5	Portugal	11.05	154.22	-0.4%
6	Spain	11.04	154.08	+1.0%
7	Slovakia	9.90	138.17	-1.6%
8	United States	9.43	131.61	-5.7%
9	France	8.97	125.19	+4.2%
10	South Africa	8.46	118.07	+8.2%
11	Austria	8.38	116.95	+0.2%
12	Poland	8.33	116.25	-1.6%
13	Netherlands	8.23	114.86	+1.9%
14	Australia	8.17	114.02	+2.2%
15	Czech Republic	8.03	112.07	-4.8%
16	Canada	7.23	100.90	+2.39%
17	Finland	6.42	89.60	-6.7%
18	Sweden	5.34	74.52	-13.2%

By late 2014, Eskom's system reserve capacity stood at approximately 8%, compared to the international norm for power companies with a 15% margin in excess capacity (BusinessTech 2015). This lead to Eskom reinitiating its load shedding program which caused widespread disruptions throughout 2015. The energy consulting firm reflected its outlook on South Africa's electricity concerns by stating the following (BusinessTech 2015):

"This trend is not good news for South Africa's mining, manufacturing and commercial industries. Rising power prices could present a slippery slope for South Africa. Further price increases coupled with unemployment and economic hardship could dampen the country's ability to stay competitive globally."

The electricity use and billing management company, PowerOptimal, has created a graph explaining the proposed increases in electricity price correlates with South Africa's Consumer Price Index (CPI) or inflation rate. The graph in Figure 8-5 shows the Eskom tariffs from 1988 to 2015, plotted against the inflation rate over the same period. The graph includes projections up to 2017, which is based on the additional increases requested by Eskom and based on SARB's inflation projections.

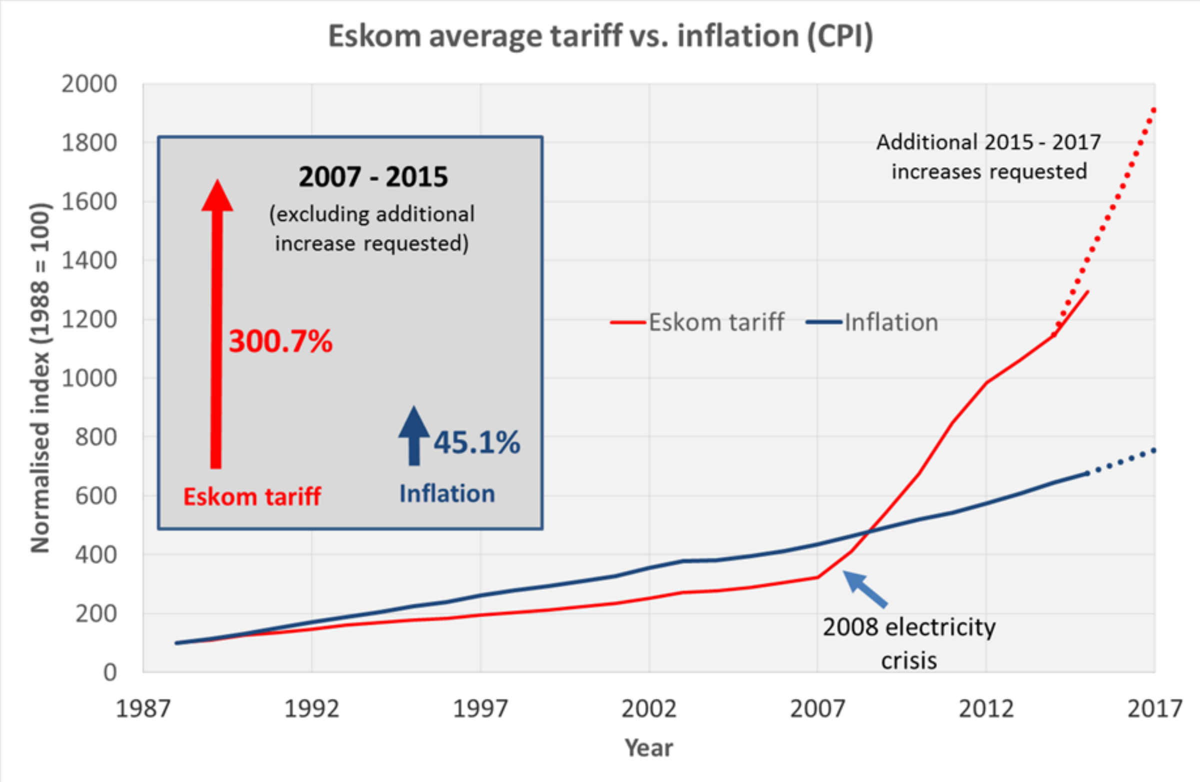


Figure 8-5: Eskom's average electricity tariffs versus the inflation rate since 1988 (with projections to 2017)
Source: (Moolman 2015)

The following significant conclusions can be derived from the graph (Moolman 2015):

- In the period from 1988 up to the electricity crisis in 2008, the electricity tariff did not keep tread with inflation and increased at a much slower rate. This can be ascribed to the government's policy at the time to keep electricity tariffs as low as possible for poor communities, but also due to Eskom's large surplus of electricity supply in the 1990's. This was the major reason behind not investing in expanding capacity in the 2000's.
- Between 1988 and 2007, the electricity tariffs increased by 223%, in comparison to the 335% increase of inflation in this period.
- After the electricity crisis in 2008, there is a very clear and sharp inflection point for electricity tariffs in South Africa. The electricity tariffs increase by 300% between 2007 and 2015, whilst inflation over this period was 45%. Thus, the electricity tariffs tripled in 8 years.
- If the additional increases of another 9% on top of the yearly 8% is approved by Nersa for 2016/2017, the total increase in electricity tariffs from 2007 to 2017 would be 495%, compared to the 74% for inflation over the same period. Thus, electricity tariffs would have increased 5-fold in the span of 10 years.

It is very important to note, that South Africa's electricity is still not very expensive when compared to the rest of the world or even Africa as seen in Figure 8-6. In 2012, Ghana, Namibia and Ghana had tariffs more than double that of South Africa (Frost & Sullivan 2012). The problem, however, is that

South Africa's economy is structured around inexpensive electricity, which is changing very quickly. It will be very costly to change the operational behaviour of companies to more energy-efficient infrastructure.

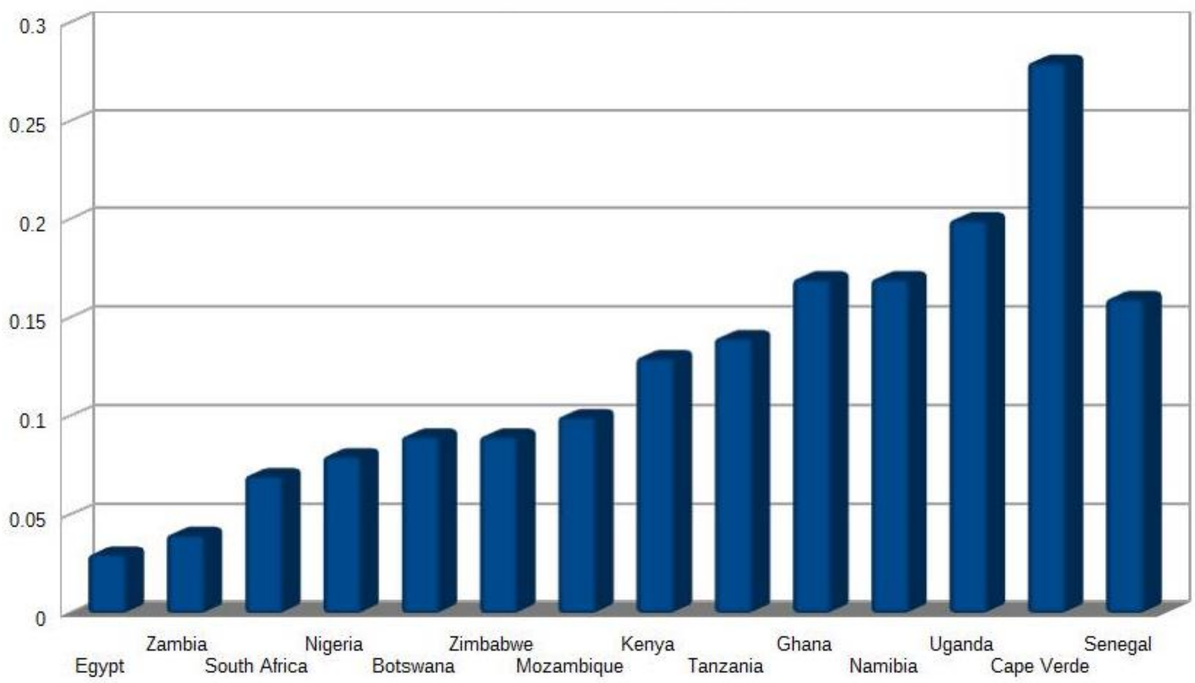


Figure 8-6: Average price of electricity in African countries in 2012
Source: (Frost & Sullivan 2012)

When all is considered, it is safe to assume that in the short to medium term, a continuation of the current electricity supply shortages and higher-than-inflation electricity price increases are to be expected (Moolman 2015).

8.4.3 Barrier implications placed in context

The following example illustrates how an alloy producer is effected by these electricity concerns. All of the information used in the example was gathered from literature and interviews with various alloy manufacturers.

- South African alloy manufacturers typically has a production capacity between 40 000 tpa and 170 000 tpa.
- The amount of electricity usage required per ton of alloy manufactured can vary due to a number of reason, such as the composition and grade of the ore and the efficiency of the smelter.
- South African alloy producers use approximately between 56 000 MWh to 72 000 MWh of electricity per year.
- Eskom's MegaFlex tariff rate (typically implemented by facilities that that use between 1 MVA and 5 MVA) was approximately 43 c/kWh in 2010/2011 (Eskom 2011), which more than double by 2016/2017 with a rate of 92 c/kWh.

- This means that the approximate annual cost for electricity usage was between R24-million and R31-million in 2010/2011 and approximately between R52-million and R66-million in 2016/2017.
- Electricity now very nearly makes up 30% of the total operational cost for the production of the alloys. This has become one of the largest monthly operational expenditures, which also includes the cost of labour, the ore itself and other raw materials required for production, such as fluxes.
- *"In the past, a couple of years back, the cost of power made up about 10% of our production costs, but since 2010/2011, it went up to nearly 30%. For the other costs, one can always try to get less expensive raw materials to work with for example, but with power, that's what you get. You have no other option. You have to pay, because you need it."* ~ (*Interviewee 2016*).

8.5 Causal factor summary table and sunburst diagram

A summary of the causal factor table of the two barriers within the Electricity Concerns barrier cluster, is shown in Table 8-3. It is important to note that the results are for illustrative purposes only and are by no means complete. In order to determine all the causal factors for the respective barriers, the influencers involved for each and the alleviation strategies to possibly addressed them, a more detailed analysis needs to be conducted.

Table 8-3: Causal factor summary of electricity barriers

Source: (CDE 2008; Booyens 2012; Ratshomo 2013; Edinger 2014; Fripp 2015; Moolman 2015; BusinessTech 2015)

Barrier	Influencer	Root cause	Causal Factor / Alleviation strategy
Unreliable supply	Government	RC1.1	Inadequate investment in distribution maintenance and refurbishment.
		RC1.2	Lack of preventative measures were put in place to make provision for any risks that may appear.
		RC1.4	Projects in power supply are often delayed and do not start on time with development. For instance, the delays in development of the Medupi and Kusile power stations.
		RC1.5	Government's failure to implement its own policies as contained in the 1998 Energy White Paper, due to not authorising investments on new power stations. The White Paper clearly stated that demand for electricity would very likely exceed supply in 2007 and it warned that the decision to build new power stations would need to be made by 1999 if a crisis was to be avoided.
Rising tariffs	Government	RC1.6	The prices are mostly determined by Eskom, a state-owned company, which produces almost the totality of electricity supplied in South Africa.

Barrier	Influencer	Root cause	Causal Factor / Alleviation strategy
			Eskom calculates its selling price based on numerous factors, including the government policy and its own company strategy.
		RC1.7	Municipalities act as resellers of electricity and decide their own electricity tariffs based on Eskom tariffs, adding their margin.
	Nersa	RC1.8	The state regulator, Nersa, has on numerous occasions approved Eskom's application for additional funding, often ranging in the billions of Rands, instead of encouraging alternative strategies.
	Economy	RC1.9	Energy prices rely on the national price inflation, which was 5.32 % on average in 2014.

The sunburst diagram in Figure 8-7, conveys the various causes that each influencer is involved in. The figure provides a representation of the degree that each influencer is responsible for the two barriers.

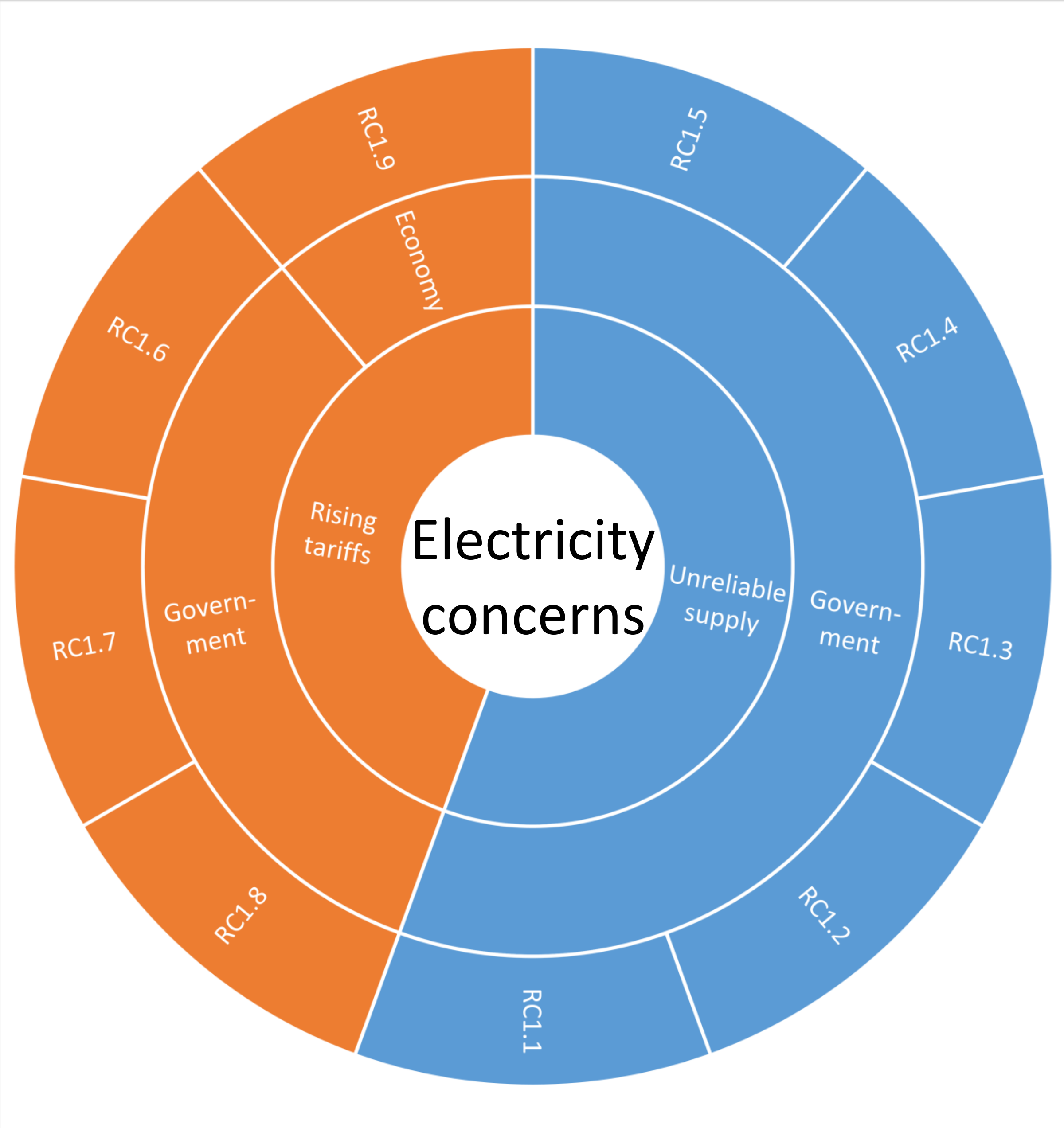


Figure 8-7: Sunburst diagram for electricity barriers

It is evident from the table and diagram, that government is mostly responsible for these barriers and have the most to contribute by addressing these issues. Many state bodies fall under the umbrella-term of government, such as Eskom and Nersa, which specifically should be targeted to help relieve the effects of these barriers. Five causes and/or solutions for the unreliable supply of electricity has been identified and four for the rising electricity tariffs. By addressing each of these factors through the alleviation approaches that are suggested, the constraining effect that these barriers have on the industry, can be lifted. For other and more comprehensive examples of the RCA process applied to major barriers, see Appendix E – Additional RCA Examples.

8.6 Chapter 8 summary

Chapter 8 discussed the RCA process implemented within the proposed framework. The process consists of five steps, starting with data collection on the identified barriers. This is followed by the review and discussion of the barriers, which described their impact in monetary terms or with similar information, to convey to what degree the barriers are affecting economic growth. The third step entails the barrier's causal factor and alleviation strategy identification. The last two steps of the RCA process involve the barrier's influencer identification, which determines the major contributors who are responsible for the barrier or in the best position to address them, and finally, the presentation of the results in a sunburst diagram and causal factor summary table.

The RCA process was applied to the *Electricity concerns* barrier-cluster, during which a comprehensive overview of the origins and impact of these barriers were provided. The economic effects of the two electricity barriers on the industry was discussed in quantitative terms and was concluded with a practical example of the implications of these barriers on an alloy producer (the sector affected the most by this barrier-cluster). The chapter concluded with the RCA findings summarised in the causal factor table and sunburst diagram. Five causes and/or solutions for the unreliable supply of electricity has been identified and four for the rising electricity tariffs. It was found that government is predominantly responsible for these barriers and have the most to contribute by addressing these issues.

Chapter 9

9 Validation of framework and results

The main purpose of chapter 9 is to validate the outcomes and the assumed value of the proposed framework. Expert opinion will be used to assess the validity of the results provided by the framework on the manganese case study, as well as the steps implemented within the framework to better understand the barriers within a mineral value chain. The validation strategy for both the framework and the results that it delivered, as well as the validation conclusions, are provided in this chapter.

Research Question 7 – How is the proposed framework validated?

- *Research Question 7.1*
  How is the validation process conducted?
- *Research Question 7.2*
  How are the framework's results validated?
- *Research Question 7.3*
  What is the outcome of the validation process?

9.1 Validation strategy

The term "validation" in this study, refers to the process of determining whether the proposed framework is effective in identifying, analysing and providing a better understanding of barriers in a mineral value chain. Due to the nature of the research, it is possible to practically implement the barrier identification framework, to some degree, which was done through applying it to the case study in the form of the South African manganese industry. This provided quantitative results which could be reviewed by industry experts. Apart from the results gathered from the case study, the framework itself can be validated through inspection by policymakers and experts in similar fields, to determine the usefulness and value of such a framework.

The validation of the of this research was done in two parts:

1. Using the South African manganese industry as a case study:
    - The full capacity of the barrier identification framework was used to analyse the industry and identifying the barriers to economic growth face by role players from the different sectors comprising the value chain. Every tool of the respective framework phases, discussed in chapters 3 to 8, made use of this case study to illustrate the usage of the framework and its capabilities.

2. Framework validation through expert analysis:
    - The analysis was performed through questionnaires and interviews, with six experts from diverse fields that are relevant to this study. Each of these experts added input from a different perspective and made distinctive contributions from their respective areas of knowledge and expertise. This allowed for the validity of the different aspects of the research to be evaluated.

Both processes provided immense insight into the practical implementation of this framework and the feedback was used in refining the framework, as well the framework assessment tool. The validation strategy that was followed for this study is shown in Figure 9-1.

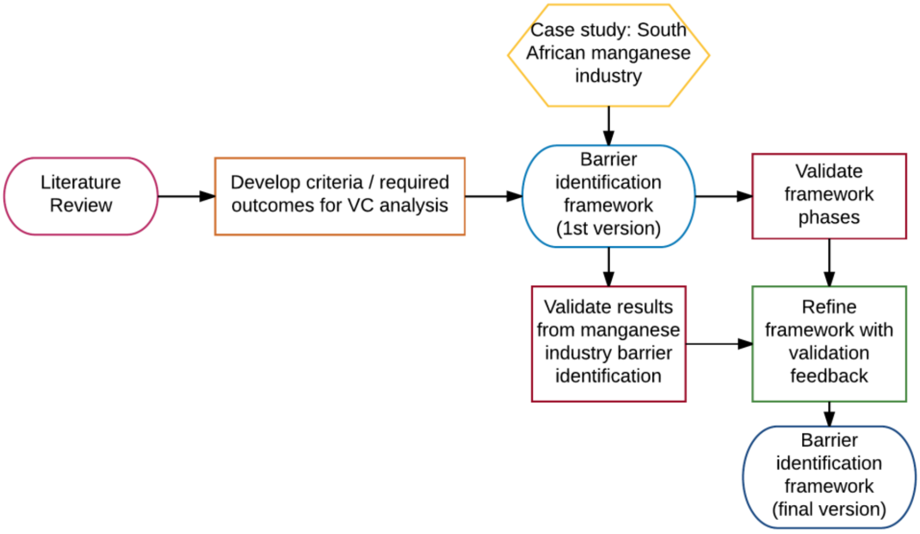


Figure 9-1: Research validation strategy

The phases and criteria that are required to develop a comprehensive framework model to identify barriers in a mineral value chain, was identified through literature and expanded upon by identifying specific needs from the case study. The model was used to identify the barriers in the South African manganese value chain and the results were validated at the 2nd SAIMM Manganese School to determine if the results are valid and thus if the framework did indeed achieve the research aim. The framework was then presented to experts in relevant fields, who gave feedback and made recommendations to make it more efficient, thus optimizing the framework. The feedback from both sets of validation was incorporated in refining the framework.

9.2 Validation of results through the case study

Throughout chapters 3 to 8, this thesis has made use of the case study to illustrate the application of the proposed framework. The aim of the first phase of validation is to apply the barrier identification framework to the South African manganese value chain and through the inspection of the results, validate the key attributes of the framework. If the results, usefulness and need for the framework are deemed to be valid, it will justify that the framework is able to conclusively identify the barriers in the value chain. It will also convey that the framework could be of significant value to role players in the industry. To be able to determine these aspects, the framework must be validated by experts spanning across various sectors of the manganese value chain in South Africa, who has the necessary knowledge and experience in this particular field.

The 2nd School on Manganese Ferroalloy Production presented at Mintek in Johannesburg on 27th and 28th June 2016, provided an ideal platform for validating these results. SAIMM hosted the first School on Manganese Ferroalloy Production in 2012 as an initiative to support the four domestic ferroalloy smelters in South Africa and foster collaboration between researchers in the field. The conference built on the collaboration between South Africa and Norway in the manganese ferroalloy research field, as well as role players within the South African manganese industry and included a large number of local participants. The focus of the event was the identification of techno-economic challenges faced by role players in the South African manganese industry and finding ways to address these challenges. Since this directly aligned with my research, the school was used as an ideal opportunity to validate the results from the case study.

The validation process was as follows:

1. A document containing a summary of my research, the results gathered from the case study and validation questions, was included in the event proceedings provided to each delegate (Appendix C – Validation Document 1 (SAIMM Manganese School)).
2. A short summary of my research was given during the opening of the event. The delegates were asked to complete the questions in the document and hand it in during the last session of the second day.
3. The documents were collected for review.

9.2.1 The validation document

Each of the delegates attending SAIMM's 2nd School on Manganese Ferroalloy Production received a 5-page document that provided the purpose of the study, as well as a description of how the results were determined. This was followed by the results that was gathering during the case study through the implementation of the framework, which included the top ten barriers that were identified in four sectors of the South African manganese industry, amongst other results. The document concluded with key findings that was discovered during the case study and the validation questions to the delegates on the results of the specific study. Appendix C – Validation Document 1 (SAIMM Manganese School) shows the validation document that was given to the attendees of the event.

9.2.2 Validation questions

The validation document included a questionnaire for the experts to complete. The questionnaire was drawn up to evaluate the four key aspects or criteria that make up the research scope, as stated in section 1.2.2. The criteria incorporated within the validation questions, is summarised in Figure 9-2. The validation questions provided in the document were as follows:

1. Is there a need to identify the barriers to economic growth for specific mineral value chains and to determine their severity and prevalence? Please explain briefly.

2. Do you believe that the proposed framework used to produce these results for a specific mineral value chain, would be useful as a barrier identification and analysis tool for the government, policymakers or companies in the specific value chain? Please explain briefly.

3. Are there other frameworks in place that produce similar results that you are aware of? Please explain briefly.

4. Are there any shortcomings or feedback on the listed results obtained or the methodology employed by the proposed framework? Please explain briefly.

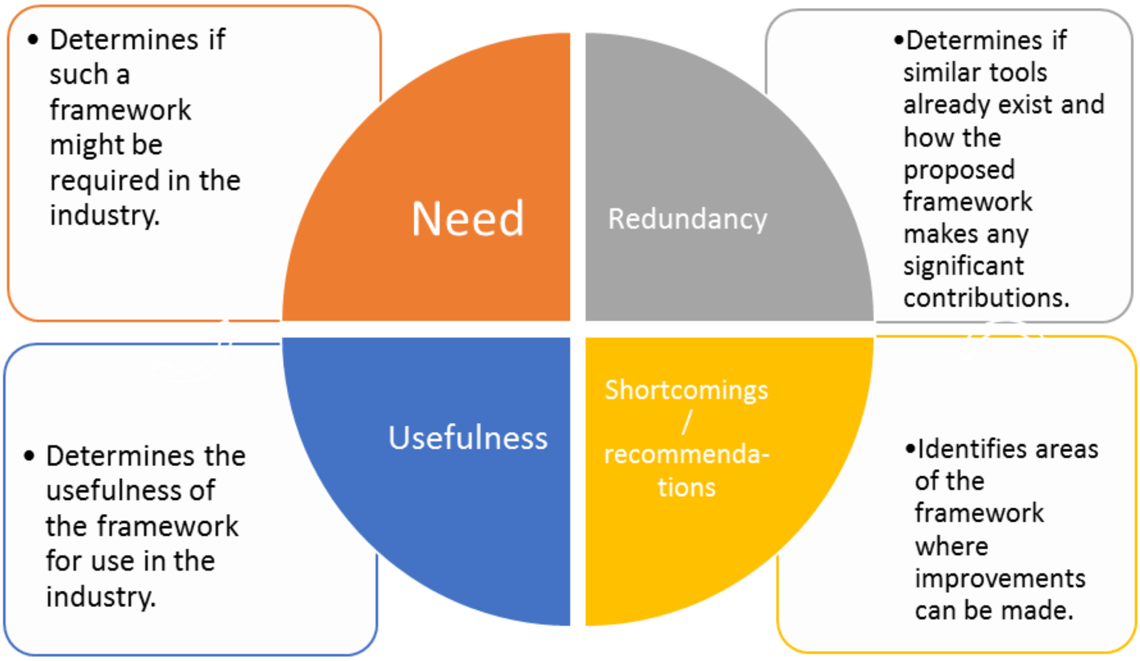


Figure 9-2: Key aspects of the research scope that were validated

9.2.3 Feedback from the conference delegates

1. **Is there a need to identify the barriers to economic growth for specific mineral value chains and to determine their severity and prevalence? Please explain briefly.**

The following feedback was given on the need to identify barriers in mineral value chains:

- All the responses affirmed that there is a need for such a framework to identify barriers in mineral value chains, with one response even stating that it is critical.
- The replies highlighted the importance of such a framework for research and development, policymakers and other relevant influencers of the MVC.
- The responses revealed that grouping the barriers according to particular sectors, is very beneficial. It would then be possible to compare the severity and prevalence of the major barriers across sectors, thus highlighting the specific need for particular role players and not generalising barriers for the entire industry. The respondents believed that this is necessary to prohibit key barriers in particular sectors from falling under the radar.

2. **Do you believe that the proposed framework used to produce these results for a specific mineral value chain, would be useful as a barrier identification and analysis tool for the government, policymakers or companies in the specific value chain? Please explain briefly.**

The following points were made on the usefulness of the framework for role players in the industry:

- All responses concurred that such a framework will be very useful in the minerals industry.
- The feedback provided various reasons for why it would be helpful, including: identifying current barriers from relevant role players, promoting cross-sector communication, and illustrating the varying degrees of impact of these barriers on the industry.

- It was also stated in one of the responses, that it would be preferred if the effect of the barriers would also be conveyed in monetary terms. It was suggested that the impact of each barrier on the downward trend of competitiveness for each role player be illustrated.

3. **Are there other frameworks in place that produce similar results that you are aware of? Please explain briefly.**

The following feedback was given on if similar frameworks exist that identify barriers in mineral value chains:

- None of the respondents were aware of any other frameworks or similar frameworks for identifying barriers in mineral value chains.

4. **Are there any shortcomings or feedback on the listed results obtained or the methodology employed by the proposed framework? Please explain briefly.**

The following feedback was given on any shortcomings or recommendations of the framework:

- There was only one recommendation made for inclusion in the framework, which was to provide more detail illustrating the effect of these barriers in monetary terms. It is suggested that the worsening trend of how each barrier impacts the competitiveness of companies in the value chain should be expressed in terms of cost.
- The respondent believes that when comparing the business cost of the barrier with the industry trend line for production cost, it should become more apparent how these barriers erode the financial viability of South African producers.
- The respondent believes that providing quantitative financial effects of these findings would produce a message that decision makers can better understand.

9.3 Validation of framework through expert analysis

The first part of the validation process, determined if the results provided through the use of the framework are accurate, useful and fulfils a specific need in the mineral community. This was achieved through applying the framework on a case study and providing the results to experts in the manganese field with a list of validation questions. This part of the validation procedure, focuses on a different approach. Experts from different backgrounds and expertise, but all associated with the minerals industry, are sampled and provided with a validation document containing questions regarding the specific method/steps outlining the structure of the framework.

The focus has shifted to not be engrossed by the specifics of the results, but rather be more attentive on the process of how the results were gathered. It is very important to include individuals with experience in different minerals, preferably not in the manganese to ensure that the framework is applicable to other mineral value chains as well. The rest of procedure is very similar to that used in the first step of the validation process.

The validation process was as follows:

1. A document containing an overview of each research phase, research objectives for each phase, the developed framework methodologies, and validation questions was provided to each expert.
2. All of the experts received a summary of the research before the document was sent to them. The summary explained the background of the study and any other further details of the research, either through a short presentation, verbal communication or via email.
3. The research was discussed and a questionnaire was completed by each of the experts and collected afterwards.

9.3.1 The expert analysis validation document

Each of the experts was given a 23-page validation document that summarised the outline of the framework structure, as well as the theories and methodologies used to develop the framework. The document provides a description of each phase with an explanation of how it should be applied and some of the key outputs of each phase to illustrate its usefulness. The document consisted of a short introduction providing information on the background of the study, followed by an outline of each of the six research phases and concluding with the validation questions. Appendix D – Validation Document 2 (Expert Analysis) shows the document that was given to the experts for validation.

9.3.2 Sampling of expert analysis

Expert analysis is required for the external validation of the proposed framework to determine its practical value. A strong test to determine the normative value of the research, is the degree to which relevant groups find the framework and the ideas behind it of value. Since the mineral industry is very broad and encompasses large number of different groups and individuals, it is important to ensure that the framework is applicable and of value to all. Since the framework was developed with the aid of applying it to the South African manganese industry as a case study, it was seen as important to include validators from different mineral fields to determine if the framework is applicable to the complexities of different mineral value chains as well. Table 9-1 provides a summary of the experts that were selected for the validation process, with information regarding their respective backgrounds and reasons for their inclusion.

Table 9-1: Experts approach for external validation of the framework

Name	Background / Occupation	Reason for inclusion
Dr Nic Barcza (NB)	Dr Nic Barcza has a PhD in Metallurgical Engineering and is a registered Professional Engineer. He is an Executive Consultant to Mintek in South Africa and was the Chairman of Mintek's subsidiary Mindev. He has served on a number of Boards such as Mogale Alloys and is a past-President and Honorary Life Fellow of the South	Dr Barcza has vast experience in policymaking and implementing strategies to improve mineral structures on a national level. He has significant insight in framework design and its practical implementation. He will be able to determine the practical value of the proposed framework and its feasibility.

Name	Background / Occupation	Reason for inclusion
	African Institute of Mining and Metallurgy (SAIMM), chairman of the International Committee of INFACON, a Fellow of the South African Academy of Engineering and has served on several academic advisory Boards and the Council of Wits University.	
Prof. Dee Bradshaw (DB)	Prof. Bradshaw is the UCT hosted South African Research Chair: Mineral Beneficiation at the University of Cape Town (UCT) and the Director of UCT's Minerals to Metals Signature Theme. She is also an Honorary Professor at the Sustainable Minerals Institute at the University of Queensland (UQ).	Prof. Bradshaw is very well established in the field of minerals and beneficiation. She heads a research group that is currently doing similar research and is well-versed in this particular line of work. She understands the key constraints in the industry, as well as the research side thereof.
Oliver Witt (OW)	Oliver is a Commercial & Economic Evaluation Analyst in exploration at Anglo American. He has a strong background in investment banking, corporate and business strategy. He is currently responsible for evaluating commercial agreements, assessing projects and lead strategic initiatives in Anglo American Exploration's corporate team in London.	Mr Witt will analyse the framework from a business perspective and evaluate the pratical side thereof to determine where the framework can add value. With his immense experience in business strategy, he will be able to identify the framework's strong points and weaknesses, as well as determine whether the framework can be implemented and is useful for individuals outside of the research community. He also provides perspective from minerals other than manganese.
Attie Rossouw (AR)	Mr Rossouw has over 25 years of experience working in the mining industry. He is currently project manager supervising a new mining project for Kudumane Manganese Resources. He has qualifications as both a mechanical and mining engineer. He has gathered a lot of experience in the diamond, iron and manganese industry as a mine manager and general manager over the years.	Mr Rossouw is unlike the other validators in the way that he has been involved on a practical level with many different mineral fields. He has many years of experience physically working on-site where he witnessed many of the identified barriers first-hand. He has worked on ground-level on various mines and mining projects around the country. He has also worked in the manganese industry which aligns with

Name	Background / Occupation	Reason for inclusion
		the case study used to illustrate the application of the framework.
Dr Dawie van Vuuren (DvV)	Dr van Vuuren is part of the Council for Scientific and Industrial Research (CSIR), where he is the leader of the Materials Science and Manufacturing research group. He has many years of experience in the field and currently heads up the CSIR's piloting of titanium metal production and titanium beneficiation.	Dr van Vuuren has focused his research in the field of titanium, especially on the beneficiation thereof. He is very specialised in this field and would be able to apply the proposed framework with great detail on this specific mineral industry to determine its flexibility on minerals other than manganese.

9.3.3 Validation questions

The validation document included a questionnaire for the experts to complete. The questionnaire is similar to the previous one developed for the first part, but includes two new questions. Question 4 is included to identify the strengths of the framework and the aspects thereof that the experts believe adds the most value. Question 6, does not focus on a particular research criteria, but allows the expert to raise their opinion on general comments on the framework, its applicability and relevance in the industry.

The other questions evaluate the same four key aspects or criteria of the framework as stated in the first part of the validation process. The validation questions provided in the second document were as follows:

1. Is there a need to identify the barriers to economic growth for specific mineral value chains and to determine their severity and prevalence? Please explain briefly.

2. Do you believe that the proposed framework would be useful as a barrier identification and analysis tool for the government, policymakers or companies in the specific value chain? Please explain briefly.

3. Are there other frameworks in place that produce similar results that you are aware of? Please explain briefly.

4. What are the strengths and contributions of the proposed framework? Please explain briefly.

5. Are there any shortcomings of the listed results obtained or the methodology employed by the proposed framework? Please explain briefly.

6. Please provide any other feedback / comments on the proposed framework, results and/or research in general.

9.3.4 Feedback from expert analysis

i. **Is there a need to identify the barriers to economic growth for specific mineral value chains and to determine their severity and prevalence? Please explain briefly.**

The following feedback was given on the need to identify barriers in mineral value chains:

- Consensus was unanimously reached with all the respondents stating that there is a definite a need for such a framework.

- **NB** thoroughly agreed that such a framework is required and explained his reasoning behind it: *"Since there has and continues to be a significant need to identify the barriers to economic growth and their severity and prevalence for most, if not all, the specific mineral chains in South Africa and how these compare with those in a global context. The mining and related mineral industries and downstream added value products chain has many complex challenges that relate to both specific aspects of the minerals concerned as well as common ones that affect the industry as a whole. There are many factors that have impacted historical growth that continue to be act as barriers to current operations and will constrain future development unless these are clearly identified and well understood so that appropriate solutions can be found and the necessary measures can be implemented."*

- **OW** stated the importance of realising the similarities between mineral value chains, but that the differences also need to be taken into account, like the framework makes provision for: "*A general industry attractiveness analysis can be performed fairly similarly across different mining industries, but the differences are still important and need a more thorough review to identify them and assess them*".

- **OW** also emphasises the need and value of conducting the analysis from a value chain perspective: *"Looking at an industry from a value chain perspective has the advantage of understanding more holistically where the problems (or opportunities, from a business perspective) lie".*

- **AR** concurs and highlights the lack of support from the state to address this issue, especially the lack of research and development from the DMR: *"This used to be one of the key functions of the department of mineral and energy (now DMR). Unfortunately, the DMR has developed over the past 20 years into a political … entity, with too much focus on (other issues) and too little on research and development. It remains a function of the state to implement strategic programs and capital to stimulate the mineral value chains in partnership with the private sector."*

- **AR** continues his point through an example: *"If we take manganese as an example, it is clear that the absence of proper research into the global market, has led to uncontrolled production and an oversupply in SA manganese and typically resulted in value destruction for both the producer and the state. No one is making money in an oversupply market, not the producer and not the country and its people – thus one can almost argue that we (SA) is giving away* *our mineral assets to the international markets for free (at no margin). Thus, the country and its people is losing out on large value proportions that may have exist through proper research and unlocking the value chain. The current SA government state organs is too much politically caught up in trying to get control over mineral resources and in the process, has lost its focus on its strategic research role."*

- **DvV** answer for this question perfectly summarises the general consensus of the need for such a framework and aligns perfectly with this study's primary research aim: *"Whereas it is a socio-economic imperative to grow the economy of South Africa and the mineral resources of South Africa play a key role in the economy, it is a logical conclusion that all means that can contribute to the growth of specific mineral value chains are relevant. In particular, it would be of significant value if the barriers to growth are properly understood so that actions can be taken to overcome the barriers."*

ii. Do you believe that the proposed framework used to produce these results for a specific mineral value chain, would be useful as a barrier identification and analysis tool for the government, policymakers or companies in the specific value chain? Please explain briefly.

The following points were made on the usefulness of the framework for role players in the industry:

- **OW** believes that the framework has varying degrees of usefulness and has reservations as to the different possible uses for the framework. He believes that the framework might be a divisive tool since not all role player's interests are aligned, since what one group might consider to be a barrier, might be a benefit for another.

- *"I do believe this framework has application, but I would caution that the uses would be very different depending on who the user is. Companies that are incumbents to a part of the value chain will look at it differently to new entrants, and governments and regulators would also have a very different take on the results. In a sense, certain characteristics of an industry could be seen as protecting specific interests within the value chain, i.e. government regulation regarding employment that benefits workers, which would be seen as a positive for some regulators but as a 'barrier' to some companies. Equally new entrants may be discouraged by seeing high capital intensity as a barrier to entering a part of the value chain, whereas incumbents would consider this as an advantage perhaps,"* **~ OW**.

- The idea behind the framework, however, is to some degree exactly this point made by **OW**. Due to the complexities of these chains and the various role players involved, each user's application for such a framework will be different, yet the framework is versatile to adapt to each user's specific need. This aim coincides with how **NB** envisages the use of the framework: *"Yes, indeed since the proposed framework has identified a very objective and constructive manner in which to present identified barriers. This approach will support a more effective analysis and provide very useful methodology and a very practical approach with tools that all relevant stakeholders can use individually and collectively."*

- **DvV** also agrees with the usefulness of the framework and the results it can deliver: *"To me the approach looks logical and the outcome from the analyses of the manganese value chain is insightful."*

- **AR** believes that the frameworks practical value could bridge the gap between the public and private sector in order to engage on common issues that could be of great benefit to all parties involved: *"Our government needs a mind shift in a sense that much more time, money and energy needs to be allocated to strategic matters, a willingness to tackle the key barriers (that I honestly believe the government are fully aware of) and to form partnerships with the private sector on a win-win bases."*

- **DB** agrees that the framework has great value to offer, but includes a suggestion for improvement: *"You have focussed on barriers, but I think also considering the opportunities and ways to deal with (or navigate around) them will make it a more positive and useful framework tool."*

iii. Are there other frameworks in place that produce similar results that you are aware of? Please explain briefly.

The following feedback was given on if similar frameworks exist that identify barriers in mineral value chains:

- Responses varied to some degree with regards to the existence of similar frameworks. **DB**, **AR** and **DvV** siad that they are not aware of similar frameworks that exists. N**B** and **OW** stated that similar frameworks exist but only to a limited extent.

- *"…only to some extent and they have not been updated or applied on an ongoing basis to take account of significant regional and global changes in the past 10 to 15 years. A framework tool that can be used on an ongoing basis and developed and adapted to meet the needs of the minerals industry and specific areas in particular would assist in supporting sustainable development,"* **~ NB**.

- *"… (some of the tools included in the framework) are by themselves useful tools in understanding barriers in an industry, however, they don't typically include a value-chain perspective and rather look at subsections of the value chain. Integrating a value chain approach to these frameworks is a useful combination that enhances the analysis."* **~ OW**.

iv. What are the strengths and contributions of the proposed framework? Please explain briefly.

The following feedback was given on the strengths and contributions of the framework:

- *"A very logical and systematic approach to a multi-faceted and complex subject. The framework concept captures the essence of the challenges involved and the ranking of the barriers in the different sectors is very credible. The framework developed has established a good basis to build on if this type of effort can be continued further with support from all the relevant stakeholders."* **~ NB**.

- *"The effort to look at the value chain in a holistic manner including considerations of issues that are not apparent from typical market studies."* **~ DvV**.

- *"Differentiation between the different sectors by analysing barriers for each sector along the value chain."* **~ DvV**.

- *"It combines several existing frameworks into a step by step analytical process that has the potential to generate more holistic outcomes."* **~ OW**.

- "There is strength in going after the root causes of the potential barriers; sometimes only identifying what seems like a barrier may hide the underlying problem." **~ OW**.

- *"Including the regulatory and social aspects of the value chain in the different relevant geographies also has the advantage of a systemic analysis to the worldwide market of a given commodity."* **~ OW**.

- *"Such an integrated framework could prove useful in understanding local decision making global impacts on specific parts of the mining value chain."* **~ OW**.

- *"The strength of the proposed framework is exactly the fact that it was derived from the industry in practice, from those who work and understand the mining and commodity industry from a practical experience."* **~ AR**.

v. Are there any shortcomings or feedback on the listed results obtained or the methodology employed by the proposed framework? Please explain briefly.

The following feedback was given on any shortcomings or recommendations of the framework:

- *"There is nothing too significant in regards to any shortcomings. However, … case examples of successfully overcoming some of the barriers and where this has not been the case, (could have been included)."* **~ NB**.

- **DvV** suggested providing information regarding value in monetary terms along the value chain. He also believes that it would be informative to have a sense of the cost drivers along the value chain, e.g. the cost of ore, how much electricity is required and the cost thereof, etc.

- **DvV** also requested to identify the main or dominant commercial companies that operate in the different sectors along the value chain.

- The only shortcoming identified by **OW**, is not including proprietary technology and copyright as a potential barrier. Even though the barriers were identified and validated through an iterative process by industry experts, it serves as an indication that the process should maybe be broaden to cover a greater scope.

- **DB** recommended implementing a systems perspective for the framework and include linkages and connections between the various barriers, as well as the consequences or costs arising from these barriers.

vi. **Please provide any other feedback / comments on the proposed framework, results and/or research in general.**

The following feedback was given on any general comments on the framework:

- *"I hope my feedback helps the development of your framework, clearly a lot of thinking has gone behind it and it shows."* **~ OW.**
- *"This approach will support a more effective analysis and provide very useful methodology and a very practical approach with tools that all relevant stakeholders can use individually and collectively."* **~ NB.**
- *"A very logical and systematic approach to a multi-faceted and complex subject. The Framework concept captures the essence of the challenges involved and the ranking of the barriers in the different sectors is very credible. The framework developed has established a good basis to build on if this type of effort can be continued further with support from all the relevant stakeholders."* **~ NB.**
- *"To me the approach looks logical and the outcome from the analyses of the manganese value chain is insightful."* **~ DvV.**
- *"You have done a great job and it is a very comprehensive piece of work and will be valuable to build on and develop for other industries."* **~ DB**.

9.4 Validation conclusions

The following conclusions were reached for key aspects of the framework from the validation feedback and analysis.

9.4.1 The framework's application

All the respondents that partook in the validation process agreed that there is undeniably a need for a framework such as the one proposed, for a number of reasons. Due to the socio-economic imperative that exists to develop South Africa's economy and since its mineral resource plays a key role in the economy, it can be concluded that any contribution that can add to the growth of specific value chains are relevant. It was also stated that by properly understanding the barriers to growth so that actions can be taken to address them would be of significant value and is required by policymakers.

Many of the respondents emphasised the complex challenges that relate to both specific aspects in the mineral industries, as well as common challenges that affect the industry as a whole. Investigating the industry from a value chain perspective, does provide an advantage of understanding holistically where the constraining factors lie. The respondents concurred that the approach will support a more effective analysis and provide very useful methodology and a very practical approach with tools that all relevant stakeholders can use individually and collectively.

9.4.2 The framework's value and unique contribution

According to the expert's feedback, the framework provides new research in the mineral production field that has not yet been presented as comprehensively. The framework tool is believed to be dynamic and designed to be used in an ongoing basis. It is said that the framework is developed to be adaptable and to meet the needs of the minerals industry and specific areas therein, that would assist in supporting sustainable development.

The framework was admired for its differentiation approach between the various sectors by analysing barriers for each of the sectors along the value chain, as well as the effort to incorporate the value change in a holistic manner, which included considerations of issues that are not apparent from typical market studies.

Another unique contribution is the fact that the barriers are derived directly from the industry in practice from individuals who work and understand the mining and commodity industry from a practical experience. The framework was overall described as a very logical and systematic approach to a multi-faceted and complex subject. The framework concept captures the essence of the challenges involved and the ranking of the barriers in the different sectors is very credible and has established a good basis to build on if this type of effort can be continued further with support from all the relevant stakeholders.

9.4.3 The framework's limitations

Even with the overwhelming amount of positive feedback and valuable contributions that were identified by the experts from different fields within the mineral industry, there were some recommendations that were made to potentially improve the framework. These limitations and how it was addressed and implemented in the framework are as follows:

a) *Would like to see the potential consequences or costs arising from the barriers, as well as a sense of the cost drivers along the chain.*

   It would be very informative if the effects of the barriers could be quantified in monetary terms. It would provide a better understanding of the effect that the barriers have on a business and how severely it cuts into their profit margin. This has been included to some degree during the interview conducted with the industry experts, with some information being gathered regarding how the barriers has influences the company's business strategy and expenditures. The majority of the respondents were, however, very hesitant to provide such a level of detail and none allowed for it to be made public in the study.

   It is very difficult to provide accurate estimates of the impact of the barriers on specific role players in monetary terms with a lack of access and knowledge of a company's operations. To determine the full scope of a barrier's influence, is a very long process. It can be approached as an entire analysis study on its own and falls outside of the scope of this research. The aim of this research is to provide the reader with a framework to identify and understand barriers within a MVC and providing all of the steps required to achieve this goal through illustrating the framework application through a case study. The case study is, however, serves only as an example and is not perfect or totally complete.

The severity survey provided to the industry experts after the barriers have been identified was incorporated to address this issue. Since many companies are reluctant to provide details on the degree to which they are affected by each barrier, it was asked that they score each barrier according to its severity. This information was then used to determine the barriers impact on the industry. For completeness purposes, the cost drivers and effect of the barriers in the electricity cluster in monetary terms, were included in the RCA chapter. It provides an example of how the framework should be applied and the value it contributes to understanding the impact of the barriers.

b) *Some of the framework tools seem to be superfluous.*

Sections 2.3-2.5 elaborates on the specific reasons for inclusion of each of the respective tools incorporated within the framework. Even though some tools might have similar outcomes, such as the PESTLE analysis and the summary of key aspects of the specific MVC, each tool analyses the chain from a different perspective which contributes to the primary research aim, as indicated in Table 2-3, Table 2-4 and Table 2-5. These sections were not included in the validation document, to keep it as short and to the point as possible.

c) *Missed the inclusion of proprietary technology and copyright as potential barriers.*

Even though the barriers were identified and validated through an iterative process by industry experts, this comment might suggest that the sampling size might need to be broadened. It is more likely that these barriers might be too specific and not perceived as a major threat by the majority of role players within the chain. This is reason is more likely, since the Delphi process is iterative and included a large number of interviewees from various backgrounds. Furthermore, it can be expected that not every single minor barrier will be identified.

d) *Provide examples of barriers that were successfully overcome and others where this has not been the case.*

Evident examples of how certain barriers have been overcome are discussed in the literature review and are elaborated in the RCA process where possible.

9.5 Chapter 9 summary

This chapter explains the validation process implemented to assess the proposed framework and the results that it generated when it was applied to the case study. The validation process was divided in two stages: through the use of the South African manganese industry as a case study and secondly, expert analysis. The former was conducted through a questionnaire focusing on the results of the case study, which was provided to delegates of the 2nd School on Manganese Ferroalloy Production presented at Mintek in Johannesburg on 27th and 28th June 2016. The focus of the event was the identification of techno-economic challenges faced by role players in the South African manganese industry and finding ways to address these challenges and was attended by many role players within the South African manganese industry.

The stage of validation entailed expert opinion from representatives from different backgrounds and expertise, yet associated with the minerals industry. They were also provided with a questionnaire and the results of the case study, but focus shifted as to not be engrossed by the specifics of the results, but rather for them to be more attentive on the process of how the results were gathered. The sampled validators include five individuals with experience in different minerals, to ensure that the framework is not only applicable to the manganese industry. Everyone involved in the validation process concluded that there is a definitive need for the framework, that it can be of immense use by a variety of role players within a mineral value chain, that no similar frameworks to such an extent as the one proposed in this research exists, and that it produces a very unique and valuable contribution. The framework is generally validated as being credible, relevant and adaptable to different mineral value chains.

Some recommendations were made by the validators, with the primary suggestion being to add a sense of the cost drivers along the chain and the impact of the barriers in monetary terms. These aspects have been addressed in the revision of Phase 6 of the framework, Root cause analysis. A more comprehensive barrier review was incorporated in the chapter, which conveys quantitatively how the barriers affect certain role players which was further illustrated with a practical example in section 8.4.3. All of the initial framework shortcomings identified by the validators, were addressed and improved in a revision of specific sections of the framework.

Chapter 10

10 Conclusion and recommendations

The purpose of this chapter is to provide the final conclusions on the research. This will be done by reviewing the research aim and discussing if and how it has been achieved. This will be followed by providing a summary of the thesis, which indicates how the framework fulfilled the research objectives, as well as to convey the key findings derived in each chapter. The chapter is concluded with recommendations for future work.

10.1 Aim of the research

The research problem, as stated in section 1.2.1, is:

South Africa's comparative advantage brought about its immense wealth in mineral resource endowment, has in recent years failed to fully translate to a national competitive advantage due to particular constraints. These barriers hinder the local industry from capturing a more prominent share of the further-processed mineral market and transitioning the country to a stronger economic position through enabling South Africa to derive greater value from its mineral resources. The key barriers to economic growth and business development which restrain role players in the value chain has not yet been sufficiently identified nor has their extent and impact on the industry properly been established. Furthermore, no consistent system or guidelines exist which enables users to identify current barriers, which are unique to particular sectors of a value chain. It is thus unclear how prominent certain problems are in specific mineral industries.

Specific sets of barriers for a particular MVC, time and context might be found through extensive research, but a tool to enable companies, government or researchers to determine these factors, has not yet been discovered in literature. The research aim was to develop a framework that can identify the latest/current barriers, which are specific to respective sectors of a value chain and catering directly to the role players involved in the chain. The research aim was described in section 1.2.2 as follows:

The primary aim of this research is to develop an analytical framework to identify and analyse the barriers to economic growth in mineral value chains (MVCs). In other words, a framework will be developed that can be applied to any specific mineral value chain to identify barriers in different sectors of the chain and provide a better understanding of these barriers.

The emerging literature reviews and findings from the research and framework design process were analysed in order to answer the overall research question:

Can a framework be developed which addresses the need to identify barriers in MVCs?

The answer to this question is a combination of the framework overview presented in Figure 2-9, the framework phase methodologies and application in Chapter 3 to Chapter 8, and the validation conclusions discussed in section 9.4. Table 10-1 shows how the chapters in this thesis contributed to the research methodology as stated in section 1.3.

Table 10-1: The completion of the research methodology

	1. Problem articulation	2. Background and literature review	3. Framework design	4. Application of framework on a case	5. Validation of the framework	6. Research conclusions
1. Introduction	✓	✓				
2. Framework design methodology		✓	✓			
3. Phase 1: Data gathering and interpretation		✓	✓	✓		
4. Phase 2: Defining the value chain		✓	✓	✓		
5. Phase 3: Determining the context of the GVC		✓	✓	✓		
6. Phase 4: Identifying and defining barriers in the VC		✓	✓	✓		
7. Phase 5: Ranking and classification of the identified barriers		✓	✓	✓		
8. Phase 6: Barrier root cause analysis		✓	✓	✓		
9. Validation of framework and results					✓	
10. Conclusion and recommendations						✓

10.2 Document summary

The following chapter summaries provide an outline of the research that has been conducted in this thesis and briefly refers to key findings derived from the framework methodology and its application on the case study:

Chapter 1 – Introduction

This chapter introduces the reader to the entire background scope of this thesis. Background information and the rationale of the study are provided, followed by the research design, which consists of the problem statement, research aim and objectives, and the scope and limitations of the study. An overview of the research methodology was discussed, which was followed by a description of the data collection approach and the ethical approval of the research. The chapter was concluded with an overview of the thesis structure.

Chapter 2 – Framework design methodology

The purpose of this chapter was to define and develop the framework design methodology for the thesis by designing the proposed framework for understanding the barriers in a MVC. The main outline of the framework consists of the three framework design requirements. A strategy to identify the tools and processes required to achieve each design requirement was described and implemented in this chapter. The outcome of this chapter is an outline which illustrates all the tools that are implemented in the framework. The framework design process was discussed in this chapter and described the six phases comprising the framework and their respective outcomes. The outline of the thesis is structured according to these phases, which group specific framework tools together that will analysis a specific element of the MVC and MVC environment.

Chapter 3 – Phase 1: Data gathering and interpretation

This chapter provides an overview of the South African manganese mineral industry, the case study for this research. It aids an understanding the different roles within the industry, various production activities and other key factors which has a significant impact on the value chain. The literature review investigates information gathered from related research and adds current information from interviews, company reports, news articles and other sources. This chapter contains a comprehensive and well-integrated summary of various aspects relevant to the manganese industry, including the background of manganese, its reserves, applications, production processes and local initiatives in the minerals industry of South Africa, such as beneficiation. The chapter concludes with a short analysis of the literature through a SWOT-analysis.

Case study findings (Phase 1):

South Africa is a dominant producer of the mineral, possessing between 75 to 80 per cent of the world's identified manganese resources and approximately 24 per cent of the world's reserves. Over 90 per cent of the reserves are located in the Kalahari Manganese Fields (KMF) located in the Northern Cape and has an estimated 4 billion tons of manganese reserves. The application of manganese is primarily used in alloy manufacturing, which is used in steel production. High-carbon ferromanganese, refined ferromanganese and silicomanganese, are the major alloys produced from manganese in South Africa. The mineral is also used to a lesser extent in the production of batteries and very small quantities in numerous chemical products.

Chapter 4 - Phase 2: Defining the value chain

This chapter addresses the first primary research objective, namely defining and describing the mineral value chain and its environment. In this chapter, the process of defining the value chain is described with the use of a combination of tools primarily comprised of Porter's Value Chain and GVC analysis' input-output structure. The methodology for identifying and describing the various activities that make up the chain, as well as the role player structures for each segment of the value chain, is discussed. A process-flow diagram is developed, which provides an overview of the entire chain and the products that are produced throughout. The chapter concludes with a summary of the steps required in defining the mineral value chain.

Case study findings (Phase 2):

The main activities comprising the South African manganese industry was identified as: Mineral production, Transport & logistics, Processing & fabrication, Marketing & sales. All the relevant supplementary activities and relevant role players involved in each activity was also identified. A process-level flow diagram was developed to model the industry's high-level production detail by conveying how inputs are processed to form outputs through a sequence of value-adding transformations. The diagram identified four key sectors of the manganese value chain that will be investigated throughout the study, namely: mining, alloy manufacturing, EMD production, and EMM production. The chapter concluded with a summary of the process used to define a MVC.

Chapter 5 – Phase 3: Determining the context of the global value chain

In this chapter, the focus is placed on integrating the mineral value chain within a global context by analysing the essential characteristics that define the chain environment. There are four key attributes that were investigated in this chapter. The first is the geographic scope of the GVC, which takes a look at the international supply and demand of the mineral products and who are the major local and global role players in the industry. The second attribute, is the governance structure of the chain which explains the dynamics between the inter-firm relationships in the chain and how the different role players affect one another. The third aspect is the institutional context in which the chain is placed. It focuses on the economic, social and institutional dynamics that the GVC is embedded within, which has a significant impact on local, national and international conditions, role players and policies. The final aspect focuses on integrating all these factors to identify key attributes of the chain, through the use of various analysis tools, namely a summary of key aspects of the GVC, PESTLE analysis, SWOT analysis and an influence diagram of the local manganese value chain.

Chapter 6 – Phase 4: Identifying and defining barriers in the value chain

This chapter describes the process of conducting interviews and surveys to identify barriers from experts within the specific mineral industry. Data was gathered through an iterative Delphi process and represented individuals from the four identified sectors of the chain. The identified barriers were distinctly defined, ensuring that there is no ambiguity in barrier definition. The process of setting up a survey to aid in determining the impact of each barrier on the different sectors, as well as the sampling strategy for the interviews and survey, were described in this chapter. It was concluded with a comprehensive list of all the identified barriers, from the various sectors comprising the South African manganese industry.

Case study findings (Phase 4):

Chapter 6 describe the four rounds of the Delphi process which is implemented to gather information on the barriers faced by role players in different sectors of the South African manganese industry. The first round entails the initial barrier identification process through interviews with experts on the extent of the barriers impact. During the second round, the list of barriers is reviewed and finalised.

The list contains 31 distinct barriers which are grouped together in 9 clusters, with each cluster representing a general constraining factor. The third round consisted of conducting a survey with the industry experts. The survey allowed them to score the impact of each barrier on their firm's growth. The Delphi process included three respondents representing the mining sector and alloy production sector respectively, and one representative from both the EMD and EMM sector for the survey. Nine representatives from the R&D sector were also included in the study to gain additional insight on the perceived barriers faced in the industry.

Chapter 7 – Phase 5: Ranking and classification of the identified barriers
During this chapter all of the data gathered from industry experts were analysed to determine the impact that each barrier has on specific sectors within the value chain. The top ten most severe barriers in each sector of the value chain were identified. This was followed by a simple variance analysis to determine if there were disparities between different sectors and between different respondents within the same sector. The prevalence of the barriers was determined to establish the scope of the impact of each barrier on the industry. The chapter concluded with the severity and prevalence scores used to classify of each barrier in one of four groups, which determines the level of priority for each barrier. The outcome can be used as a guide to determine which barriers are the most pressing within the industry.

Case study findings (Phase 5):
The top ten barriers of each sector are identified, with the highest-ranking barrier of each being: *High transport costs* (mining sector), *Unrest / Volatility in workforce* and *Rising electricity tariffs* (joint first in the alloy production sector), *Fluctuations in exchange rate* (EMD sector) and *Rising electricity tariffs* (EMM sector). The R&D representatives also ranked *Rising electricity tariffs* as the most severe barrier.

The nine barrier-clusters were ranked according to their respective barrier's total severity scores as well. *Market conditions* was the highest ranked cluster, while the *Labour* cluster was ranked second and contained the barriers with the highest average barrier score. The inter-sector variance revealed that the severity scores for the two electricity related barriers in the mining sector and *Resource nationalism* and *Social license to operate* in the alloy production sector vary immensely between the respondents. The could be an indication that these barriers differ in impact on the different companies within the sector, for example that the mining companies' electricity usage greatly vary from one another and thus the impact of these barriers would not be the same on all of them.

Through inspection, the disparity in barrier scores from the R&D responses become very evident, which serve as an indication that there is a gap in understanding between them and the active role players within the chain. It was revealed that the barriers that are most prevalent and thus affect the most role players within the industry are: *Competition / Oversaturated market, Rising electricity tariffs, Unreliable electricity supply, Rising cost of labour* and *Fluctuations in exchange rate*. It is also important to note that *Low efficiency* has a prevalent score of 0. This could mean that it might not be a true barrier in the industry.

Twelve barriers where classified in the group with the highest level of priority, which has a large impact on the industry and affects many role players across the chain. Through inspection, it was evident that the *Oversaturated market* is the most severe and prevalent barrier to economic growth in the manganese industry of South Africa. *Rising electricity costs* also have a substantial impact on economic growth and is the second most severe barrier.

Chapter 8 – Phase 6: Barrier root cause analysis

The final step required to reach the research aim of understanding the barriers in a MVC, is to review the identified barriers to identify their origins, the influencers responsible for addressing them and possible alleviation strategies to address them. In this chapter the root cause analysis (RCA) process was developed and implemented on the manganese value chain to determine the causal factors for these barriers, as well as quantitively determining the impact that it has on role players and the industry as a whole. The process consists of five steps, starting with data collection on the identified barriers. This was followed by the review and discussion of the barriers, which described their impact in monetary terms or with similar information, to convey to what degree the barriers are affecting economic growth. The third step entails the barrier's causal factor and alleviation strategy identification. The last two steps of the RCA process involve the barrier's influencer identification, which determines the major contributors who are responsible for the barrier or in the best position to address them, and finally, the presentation of the results in a sunburst diagram and causal factor summary table.

Case study findings (Phase 6):

The RCA process was applied to the *Electricity concerns* barrier-cluster, during which a comprehensive overview of the origins and impact of these barriers were provided. The economic effects of the two electricity barriers on the industry was discussed in quantitative terms and was concluded with a practical example of the implications of these barriers on an alloy producer (the sector affected the most by this barrier-cluster). Five causes and/or solutions for the unreliable supply of electricity has been identified and four for the rising electricity tariffs. It was found that government is predominantly responsible for these barriers and have the most to contribute by addressing these issues.

Chapter 9 – Validation of framework and results

The main purpose of chapter 9 was to validate the outcomes and the assumed value of the proposed framework. Expert opinion was used to assess the validity of the results provided by the framework on the manganese case study, as well as the methodology implemented within the framework to better understand the barriers within a mineral value chain. A validation strategy for both the framework and the results that it delivered, were developed. All the validators concurred that there is a definitive need for the framework, that it can be of immense use by a variety of role players within a mineral value chain, that no similar frameworks to such an extent as the one proposed in this research exists, and that it produces a very unique and valuable contribution. The framework is generally validated as being credible, relevant and adaptable to different mineral value chains.

Some recommendations were made by the validators, with the primary suggestion being to add a sense of the cost drivers along the chain and the impact of the barriers in monetary terms. These aspects have been addressed in the revision of Phase 6 of the framework, Root cause analysis. A more comprehensive barrier review was incorporated in the chapter, which conveys quantitatively how the barriers affect certain role players which was further illustrated with a practical example in section 8.4.3. All the initial framework shortcomings identified by the validators, were addressed and improved in a revision of specific sections of the framework.

Chapter 10 – Conclusion and recommendations

This chapter concludes the research. It provides summaries of each of the chapters with regards to how it addressed the research objectives or framework requirements and reached valid and relevant conclusions. This chapter also presents suggestions for improvements and recommendations for future work.

10.3 Recommendations for future work

During the process of conducting this research, potential recommendations for future work were identified:

i. **Application to more case studies**

In order to ensure that the framework is indeed flexible and able to adapt to all mineral value chains, it has to implemented to more case studies. The case used throughout this study was applied to the South African manganese industry, which as all other mineral industries, has its own characteristics and dynamics. By branching out the framework application to a variety of fields and refining its utility, will enhance its applicability. This will also allow users to identify if there are any shortcomings when the framework is applied to other industries that has different structures, role players and complexities.

ii. **Refine the implemented tools and methodologies**

Another suggestion is to enable more people to use the framework and implement it themselves, especially individuals such as policymakers, to whom such a framework could potentially be of great value. The tools and procedures implemented in the framework, could in turn be refined to improve the framework's efficiency. This process could also determine whether the framework is relatively easy to use and if all of the framework steps are useful.

iii. **Integrate similar tools**

Phase 3 of the framework incorporates similar tools while investigating the MVC's institutional context and value chain characteristics. During this analysis, an overlap of the findings occurred which in some instances lead to repetition. It is recommended that similar tools within the framework, such as the institutional context analysis, summary of key aspects, PESTLE and SWOT analysis, are integrated into a single tool.

iv. **Develop a supplementary framework that enables user to identify and evaluate strategies to address the identified barriers**

Even though the issue to address major barriers are addressed to some extent in Phase 6 of the framework (*Barrier root cause analysis*), more comprehensive alleviation strategies would be required. This would further add on the practical value of the proposed framework, since the next logical step after the barriers are identified, is designing strategies to address them.

v. Update framework by adding or replacing tools

As time passes and more research is done on MVC analysis and barrier identification strategies, new tools could be identified that could improve the framework. These tools can simply be added to the framework or replace an existing tool that has a similar function. Since the framework is applied to an industry that is constantly changing, new and innovative ways to identify barriers in this field should be searched for continuously.

11 List of references

Afarak Group, 2014. Annual Report 2014.

African Rainbow Minerals, 2014. Integrated Annual Report.

ArcelorMittal, 2015. Operations: Coke & Chemicals Overview. Available at: http://www.arcelormittalsa.com/operations/cokechemicals/overview.aspx [Accessed June 29, 2015].

Asia Metal, 2014. Manganese: uses. *Metalpedia*. Available at: http://metalpedia.asianmetal.com/metal/manganese/application.shtml [Accessed June 22, 2015].

ASQ, 2016. Root Cause Analysis Processes & Methods. Available at: http://asq.org/learn-about-quality/root-cause-analysis/overview/conducting-root-cause.html [Accessed November 2, 2016].

Van Averbeke, N. et al., 2005. South Africa's Mineral Industry. , pp.1–187.

Baartjes, N., 2011. From deposit to mine from mine to mining value chains: Diversifying a Mineral Based Economy.

De Backer, K. & Miroudot, S., 2014. *Mapping Global Value Chains*,

Bair, J., 2005. Global Capitalism and Commodity Chains: Looking Back, Going Forward. , 9(2), pp.153–180.

Basson, J., Curr, T.R. & Gericke, W. a., 2007. South Africa's Ferro Alloys Industry - Present Status and Future Outlook. In *Infacon XI: Innovation in Ferroalloy Industry*. pp. 3–24. Available at: http://www.mintek.co.za/Pyromet/Files/2007Curr.pdf.

Baxter, R., 2013. Facilitating further Minerals Beneficiation in South Africa. In *Presentation to GIBS Forum*. pp. 1–22.

Baxter, R., 2014. The South African mining sector – challenges and opportunities. In *Presentation to African Iron Ore Conference*.

Von Below, M.A., 1992. Planning for Future Ferroalloy Production in South Africa. , 1, pp.261–268.

Bonga, M.W., 2008. *An Overview of South Africa's Iron, Manganese and Steel Industry for the Period 1986 to 2006*,

Booyens, Y., 2012. Manganese industry has big potential, not enough support. *Mining Weekly*. Available at: http://www.miningweekly.com/article/manganese-industry-has-big-potential-not-enough-support-2012-06-13.

Brand South Africa, 2016. South Africa's mineral wealth. Available at: http://www.southafrica.info/about/416221.htm#mining [Accessed October 29, 2016].

BusinessTech, 2015. Electricity prices: South Africa vs the world. Available at: http://businesstech.co.za/news/energy/99494/electricity-prices-south-africa-vs-the-world/ [Accessed November 4, 2016].

Cairncross, B., Beukes, N. & Gutzmer, J., 1997. *The Manganese Adventure - the South African Manganese Fields*, Associated Ore & Metal Corporation.

Callaghan, C., 2014. Mineral Resource Based Growth Pole Industrialisation - Ferrous Metals Report. , pp.1–179. Available at: trademarksa.org/rirn.

Callaghan, C., 2013. Mineral Resource Based Growth Pole Industrialisation - Growth Poles and Value Chains. Available at: Trademarksa.org/rirn.

CDE, 2008. South Africa's Electricity Crisis. , (10), pp.1–32.

Chamber of Mines of South Africa, 2014. Facts & Figures 2013/2014.

Coe, N.M., 2013. Global Value Chains/Global Production Networks: Organizing the Global Economy. , (November 2013).

Creamer, M., 2015. Across-board ARM review as earnings plunge 56%. *Mining Weekly*. Available at: http://www.engineeringnews.co.za/article/across-board-arm-review-as-earnings-plunge-56-2015-03-16.

D'Harambure, A., 2015. Overview of the Global Manganese Industry.

Delbecq, A.L., Van de Ven, A.H. & Gustafson, H.D., 1975. *Group techniques for program planning*, Glenview: Scott, Foresman, and Co.

Department of Government Communication and Information Systems, 2015. FACT SHEET : South Africa's competitiveness at a glance. *25th AU Summit*. Available at: http://www.gov.za/sites/www.gov.za/files/gcis_documents/AU Summit Fact Sheet Competition.pdf.

Department of Mineral Resources RSA, 2011. A beneficiation strategy for the minerals industry of South Africa. , pp.1–23.

Department of Mineral Resources RSA, 2015a. Operating Mines. Available at: http://www.dmr.gov.za/publications/viewdownload/121/1168.html.

Department of Mineral Resources RSA, 2015b. *SOUTH AFRICA'S MINERAL INDUSTRY*,

Department of Trade & Industry, 2015. *Strategic Plan 2015/2020*,

Dicken, P., 2011. *Global Shift: Mapping the Changing Contours of the World Economy* 6th ed., Los Angeles, CA, USA: Sage.

Dolan, C.S. & Humphrey, J., 2004. Changing Governance Patterns in the Trade in Fresh Vegetables between Africa and the United Kingdom. *Environmental Planning*, 36(3), pp.491–509.

Drost, S., Van Wijk, J. & Vellema, S., 2010. Development Value Chains meet Business Supply Chains:

The concept of Global Value Chains unraveled. *Working Paper Series*, (November), pp.1–13.

Dworzanowski, M., 2013. The role of metallurgy in enhancing beneficiation in the South African mining industry. *The Journal fo the Southern African Institute of Mining and Metallurgy*, 113(August), pp.677–683.

Edinger, H., 2014. Outlook of South Africa's Manganese Sector. , (May).

Elliot, M., 2012. Business risks facing mining and metals 2011–2012. *Business*, p.34.

Elliot, M., 2014. Business risks facing mining and metals 2013–2014. *Business*, p.34.

Elliot, M., 2015a. Business risks facing mining and metals 2014–2015. *Business*, p.34.

Elliot, M., 2015b. Business risks facing mining and metals 2015–2016. *Business*, p.34.

Eskom, 2011. Tariffs & Charges 2010/2011.

European Integrated Pollution Prevention and Control Bureau, 2014. Processes to Produce Ferro-Alloys. *Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metal Industries*, (July), pp.847–961. Available at: http://www.eurometaux.eu/Publications/Reports.aspx.

Fedderke, J. & Fedderke, J., 2012. The Cost of Rigidity: The Case of the South African Labor Market. , (June).

FICCI, 2014. Using steel slag in infrastructure development. Available at: http://blog.ficci.com/steel-slag/5291/ [Accessed August 1, 2016].

Fichte, R., 2000. Ferroalloys. *Ullmann's Encyclopedia of Industrial Chemistry*. Available at: http://onlinelibrary.wiley.com/doi/10.1002/14356007.a10_305/abstract.

Ford, K., Hobbs, D. & Urquhart, R., 2007. CIS Ferro Alloys Industry: Commercial Opportunities, Technical Challenges and Strategic Implications. *Infacon XI: Innovation in Ferroalloy Industry*.

Frederick, S., 2014. Combining the Global Value Chain and global I-O approaches.

Fripp, C., 2015. South Africa's Electricity Pricing Compared to the Rest of the World. Available at: http://www.htxt.co.za/2015/06/26/south-africas-electricity-pricing-compared-to-the-rest-of-the-world/ [Accessed May 22, 2016].

Frost & Sullivan, 2012. African Electricity Pricing Analysis: Balancing Cost-reflective Tariffs and Government Intervention for Affordable Electricity Provision. Available at: http://www.frost.com/sublib/ [Accessed November 5, 2016].

Gajigo, O., Mutambatsere, E. & Adjei, E., 2011. Manganese Industry Analysis: Implications for Project Finance. *Working Paper Series*, 2534(132).

Gereffi, G., 1995. Global Production Systems and Third World Development. In Cambridge; New York and Melbourne: Cambridge University Press, pp. 100–142.

Gereffi, G., 1994. The organization of buyer-driven global commodity chains: How U.S. retailers shape overseas production networks. *Commodity Chains and Global Capitalism*, (January 1994), pp.95–122.

Gereffi, G. & Fernandez-Stark, K., 2011. Global Value Chain Analysis: A Primer.

Gereffi, G., Humphrey, J. & Sturgeon, T.J., 2005. The governance of global value chains. *Review of International Political Economy*, 12(1), pp.78–104. Available at: http://www.tandfonline.com/doi/abs/10.1080/09692290500049805.

Gereffi, G. & Lee, J., 2012. Why the World Suddenly Cares about Global Supply Chains. , 48(3), pp.24–32.

Global Slag, 2015. Korea develops cement from reduced metal slag. *Global Slag News*. Available at: http://www.globalslag.com/news/item/16-korea-develops-cement-from-reduced-metal-slag [Accessed August 1, 2016].

Globalvaluechains.org, 2016. Concept & Tools. Available at: https://globalvaluechains.org/concept-tools [Accessed June 12, 2016].

Grote, U. & Winter, E., 2009. Value Chain Analysis Methodologies in the Context of Environment and Trade Research.

Heizer, J. & Render, B., 2001. *Operations Management* 6th ed., Prentice Hall.

Henderson, J. et al., 2011. Global production networks and the analysis of economic development. *Review of International Political Economy*, (August), pp.436–464. Available at: http://www.tandfonline.com/doi/abs/10.1080/09692290210150842#.VaFlYnidLzI.

Hopkins, T.K. & Wallerstein, I., 1986. Commodity Chains in the World-Economy. , 10(1), pp.157–170.

Hsu, C. & Sandford, B., 2007. The delphi technique: making sense of consensus. *Practical Assessment, Research & Evaluation*, 12(10), pp.1–8.

Humphrey, J. & Schmitz, H., 2001. Governance in Global Value Chains. *IDS Bulletin*.

IFM, 2016. Porter's Value Chain. Available at: http://www.ifm.eng.cam.ac.uk/research/dstools/value-chain-/ [Accessed June 21, 2016].

IMA, 1996. Value Chain Analysis for Assessing Competitive Advantage. *Practice of Management Accountanting*, pp.1–33. Available at: http://www.imanet.org/PDFs/Public/Research/SMA/Value Chain Analysis.pdf.

International Council on Mining and Metals, 2006. Maximizing Value: Guidance on implementing materials stewardship in the minerals and metals value chain. , (September).

International Manganese Institute, 2014a. 2013 Annual Report. , 10, pp.1–158.

International Manganese Institute, 2014b. Applications. Available at: http://www.manganese.org/about-mn/applications [Accessed June 20, 2015].

International Manganese Institute, 2014c. Essential Manganese. *Annual Review 2014*.

International Manganese Institute, 2015. Essential Manganese: Annual Review 2015. *Essential Manganese*.

International Manganese Institute, 2014d. The environmental profile of manganese alloys.

International Manganese Institute & RPA, 2015. Manganese: The Global Picture - A Socio Economic Assessment. *Report for the International Manganese Institute*.

Jabareen, Y., 2009. Building a conceptual framework: Philopspohy, Definition, and Procedure. *International Journal of Qualitative Methods*, 8(4), pp.49–62.

Kalagadi Manganese, 2006. Manganese industry overview. Available at: http://kalahariresources.co.za/oldsite/index.php/about-us/industry-overview [Accessed June 22, 2015].

Kaplinsky, R. & Morris, M., 2000. Handbook for Value Chain Research. , (September).

Kazadi, D. et al., 2013. Utilization of ferromanganese slags for manganese extraction and as cement additive. In *International Conference on Advances in Cement and Concrete Technology in Africa*. Available at: www.accta2013.com.

Klingspor, M. & Stripple, H., 2008. A Nordic contribution concerning the revision of the IPPC Reference Document on Best Available Techniques in the Non Ferrous Metals Industries. , (June). Available at: http://www3.ivl.se/rapporter/pdf/B1916.pdf.

Landeta, J., 2006. Current validity of the Delphi method in social sciences. *Technological Forecasting and Social Change*, 73(5), pp.467–482.

Ludwig, B.G., 1994. *Internationalizing Extension: An exploration of the characteristics evident in a state university extension system that achieves internationalization.* Ohio State University.

Maia, J., 2015. Unlocking economic value through the development of mineral value chains in South Africa – the context (Presentation at conference on mineral value chains, National Research Foundation).

Mind Tools, 2016. Porter's Value Chain. Available at: https://www.mindtools.com/pages/article/newSTR_66.htm [Accessed July 30, 2016].

MMC, 2016. Manganese Metal Company. Available at: http://www.mmc.co.za/ [Accessed November 2, 2015].

Moolman, S., 2015. Infographic: Eskom tariff increases vs inflation since 1988 (with projections to 2017). *PowerOptimal*. Available at: http://www.poweroptimal.com/infographic-eskom-tariff-increases-vs-inflation-since-1988/ [Accessed November 4, 2016].

Okoli, C. & Pawlowski, S.D., 2004. The Delphi Method as a Research Tool: An Example, Design Considerations and Applications. *Information & Management*, 42(1), pp.15–29. Available at: http://dx.doi.org/10.1016/j.im.2003.11.002.

Olsen, S.E. & Tangstad, M., 2004. *Silicomanganese Production – Process Understanding*, Cape Town, South Africa: INFACON X: Transformation Through Technology.

Olsen, S.E., Tangstad, M. & Lindstad, T., 2007. *Production of Manganese Ferroalloys*, Trondheim, Norway: Tapir Academic Press.

Oxford Business Group, 2013. The Report: South Africa 2013. Available at: https://books.google.co.za/books?id=fSANAQAAQBAJ&pg=PA102&lpg=PA102&dq=citibank+report+south+africa+non-energy&source=bl&ots=mXxuhV32Rs&sig=ykR5GwBvC8SJgmW1IZAYJXknjcw&hl=en&sa=X&ei=RXqKVYeNIa2v7AaXsYOABw&ved=0CEEQ6AEwBQ#v=onepage&q=citibank report south.

Oxford Dictionaries, 2016. Multidisciplinary. Available at: http://www.oxforddictionaries.com/definition/english/multidisciplinary [Accessed May 5, 2016].

Parker, J. a. L. & Loveday, G.K., 1996. Recovery of metal from slag in the ferro-alloy industry. In *Hidden Wealth*. Johannesburg, pp. 7–15.

PESTLE Analysis.com, 2016. What is PESTLE Analysis? A Tool for Business Analysis. Available at: http://pestleanalysis.com/what-is-pestle-analysis/ [Accessed August 26, 2016].

Pistorius, P.C., 2002. Reductant selection in ferro-alloy production: The case for the importance of dissolution in the metal. *Journal of The South African Institute of Mining and Metallurgy*, January/Fe(February), pp.33–36.

Pooe, R.I.D. & Mhelembe, K., 2014. Exploring the challenges associated with the greening of supply chains in the South African manganese and phosphate mining industry. *Journal of Transport and Supply Chain Management*, 8(1), pp.1–9. Available at: http://www.jtscm.co.za/index.php/jtscm/article/view/139.

Porter, M.E., 1985. *The Competitive Advantage: Creating and Sustaining Superior Performance* (Republish., NY: Free Press.

Pretorius, W. & Le Cordeur, M., 2016. Nersa approves 9.4% electricity price hike. *Fin24*. Available at: http://www.fin24.com/Economy/nersa-approves-94-electricity-price-hike-20160301 [Accessed November 4, 2016].

Professional Academy, 2016a. Marketing Theories – PESTEL Analysis. Available at: http://www.professionalacademy.com/blogs-and-advice/marketing-theories---pestel-analysis [Accessed August 26, 2016].

QuickMBA, 2010. The Value Chain. Available at: http://www.quickmba.com/strategy/value-chain/ [Accessed June 22, 2016].

Radebe, J.T., 2005. National Freight Logistics Strategy. *National Freight Logistics Strategy*. Available at: http://www.portsregulator.org/images/documents/National_Freight_Logistics_Strategy.pdf.

Raikes, B.P., Jensen, M.F. & Ponte, S., 1999. Global Commodity Chain Analysis and the French Filière Approach: Comparison and Critique. , pp.1–30.

Rajagopalan, G., 2015. Industry Value Chain: Understand its Importance and Application to the Mining Industry.

Ramyia, J., 2013. NERSA allows yearly 8% electricity price increase for 2013-2018. *UrbanEarth*. Available at: http://www.urbanearth.co.za/articles/nersa-allows-yearly-8-electricity-price-increase-2013-2018 [Accessed November 10, 2016].

Ratshomo, K., 2013. *South Africa's Manganese Industry Developments 2004-2011*,

Van Reenen, J.H., Thiele, H. & Bergman, C., 2004. *Recovery of chrome and manganese alloy fines from slag*, INFACON X Transformation Through Technology.

Reuter, M., Xiao, Y. & Boin, U., 2004. Recycling and environmental issues of metallurgical slags and salt fluxes. *… on Molten Slags Salts and Fluxes*, (Symposium Series S36), pp.349–356. Available at: http://www.saimm.co.za/Conferences/Slags2004/050_Reuter.pdf.

Robinson, I.C. & Von Below, M.A., 1990. The role of the domestic market in promoting the beneficiation of raw materials in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy*, 90(4), pp.91–98. Available at: http://www.saimm.co.za/Journal/v090n04p091.pdf.

Rooney, J.J. & Heuvel, L.N. Vanden, 2004. Root Cause Analysis For Beginners. , (July), pp.45–53.

Rowe, G., Wright, G. & Bolger, F., 1991. Delphi: A reevaluation of research and theory. Technological Forecasting and Social Change.

RPA, 2012. Socio-Economic Importance of Manganese. , pp.1–2.

Sedumedi, B.K. & Pan, X., 2014. Improve Ferromanganese Smelting Processes Using Benchmarking Techniques. , pp.11–16.

Steenkamp, J.D. & Basson, J., 2013. The manganese ferroalloys industry in southern Africa. *Journal of the Southern African Institute of Mining and Metallurgy*, 113(8), pp.667–676. Available at: http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-223X2013000800014&lng=en&nrm=iso&tlng=en [Accessed March 25, 2015].

Stock, J.R. & Lambert, D.M., 2001. *Strategic Logistics Management* 4th ed., McGraw-Hill.

Sturgeon, T.J., 2001. How Do We Define Value Chains and Production Networks? *IDS Bulletin*, 32(3), pp.9–18. Available at: http://dx.doi.org/10.1111/j.1759-5436.2001.mp32003002.x.

Sturgeon, T.J. & Gereffi, G., 2009. Measuring success in the global economy : international trade, industrial upgrading, and business function outsourcing in global value chains.

Surbhi, S., 2015. Difference Between Supply Chain and Value Chain. *Key Differences*. Available at: http://keydifferences.com/difference-between-supply-chain-and-value-chain.html [Accessed October 23, 2016].

Suss, S. et al., 2012. Integrating Quebec SMEs Into Production Networks : A Spur to Competitiveness. , (March).

TIA, 2012. The Mining Sector Innovation Strategies Implementation Plan. , pp.1–40.

Transnet, 2013. Economic Dividends. *Sustainability Performance Review*. Available at: http://overendstudio.co.za/online_reports/transnet_ar2013/sustainability/per-economic.php.

U.S. Environmental Protection Agency, 1995. *Compilation of Air Pollutant Emission Factors* 5th ed., Available at: http://www.epa.gov/ttnchie1/ap42/ch12/final/c12s04.pdf.

Ullmann's Encyclopedia, 1996. Ferroalloys. *Ullman's Encyclopedia of Industrial Chemistry*.

UNCTAD, 2013. *World Investment Report 2013*, Available at: unctad.org/en/PublicationsLibrary/wir2013_en.pdf.

US Department of Transportation: FHWA, 1997. User Guidelines for Waste and Byproduct Materials in Pavement Construction. *FHWA-RD-97-148*. Available at: https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/ssa1.cfm [Accessed August 19, 2016].

US International Trade Commission, 2003. *Electrolytic Manganese Dioxide From Australia, China, Greece, Ireland, Japan and South Africa*,

Le Vie, D.S., 2000. Understanding Data Flow Diagrams. *Proceedings of the 47th annual conference on Society for Technical Communications*.

World Steel Association, 2014. WORLD STEEL IN FIGURES 2014.

Write Content Solutions, 2016. Data Triangulation: How the Triangulation of Data Strengthens Your Research. Available at: http://www.write.com/writing-guides/research-writing/research-process/data-triangulation-how-the-triangulation-of-data-strengthens-your-research/ [Accessed April 19, 2016].

Van Zyl, H., Bam, W.G. & Steenkamp, J., 2016. Identifying barriers faced by key role players in the South African manganese industry. In *27th SAIIE Annual Conference*. pp. 1–15.

Appendix A – Ethical Clearance

11-Sep-2015
Van Zyl, Hermanus HJ

Proposal #: SU-HSD-000713
Title: An Analysis of the Manganese Industry and the Impact of the Barriers of Beneficiation in South Africa

Dear Mr. Hermanus Van Zyl,

Your **New Application** received on **07-Aug-2015**, was reviewed
Please note the following information about your approved research proposal:

Proposal Approval Period: **07-Sep-2015** -**06-Sep-2016**

The following stipulations are relevant to the approval of your project and must be adhered to:
Due to the nature of the questions asked in the interview, the researcher should obtain formal permission from the participating organisation to approach their members/employees as research participants of this study.

Please provide a letter of response to all the points raised IN ADDITION to HIGHLIGHTING or using the TRACK CHANGES function to indicate ALL the corrections/amendments of ALL DOCUMENTS clearly in order to allow rapid scrutiny and appraisal.

Please take note of the general Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

Please remember to use your **proposal number** (**SU-HSD-000713**) on any documents or correspondence with the REC concerning your research proposal.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Also note that a progress report should be submitted to the Committee before the approval period has expired if a continuation is required. The Committee will then consider the continuation of the project for a further year (if necessary).

This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki and the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health). Annually a number of projects may be selected randomly for an external audit.

National Health Research Ethics Committee (NHREC) registration number REC-050411-032.

We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at 218089183.

Included Documents:
DESC Report - Ficker, Tanya
REC: Humanities New Application

Sincerely,

Clarissa Graham
REC Coordinator
Research Ethics Committee: Human Research (Humanities)

Investigator Responsibilities

Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1.Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2.Participant Enrollment. You may not recruit or enroll participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use. If you need to recruit more participants than was noted in your REC approval letter, you must submit an amendment requesting an increase in the number of participants.

3.Informed Consent. You are responsible for obtaining and documenting effective informed consent using only the REC-approved consent documents, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4.Continuing Review. The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is no grace period. Prior to the date on which the REC approval of the research expires, it is your responsibility to submit the continuing review report in a timely fashion to ensure a lapse in REC approval does not occur. If REC approval of your research lapses, you must stop new participant enrollment, and contact the REC office immediately.

5.Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, number of participants, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You may not initiate any amendments or changes to your research without first obtaining written REC review and approval. The only exception is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6.Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouch within five (5) days of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch Universtiy Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7.Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC.

8.Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

9.Final reports. When you have completed (no further participant enrollment, interactions, interventions or data analysis) or stopped work on your research, you must submit a Final Report to the REC.

10.On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.

Appendix B – Consent Form

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

STELLENBOSCH UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

An Analysis of the Economic Barriers Faced by Key Role Players in the South African Manganese Industry

You are asked to participate in a research study conducted by Herman van Zyl, B.Eng (Electric and Electronic), currently enrolled for a M.Eng (Engineering Management) at the Industrial Engineering Department at Stellenbosch University, to contribute towards his thesis. You were selected as a possible participant in this study due to your position in the manganese industry.

1. PURPOSE OF THE STUDY

The purpose of the study is to determine and analyze an in-depth overview of the value chain of the South African manganese industry, determining the impact of the role players on the industry, as well as to identify the factors which cause constraints or possible opportunities for economic growth experienced by each role player. The final result would thus be an analysis of the impact of each of these factors on the industry and where the problems and opportunities lie for economic growth. An assessment will be conducted on the major barriers faced in the industry, which would provide an indication of the severity of each barrier.

2. PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following:

- Partake in an interview where questions will be asked about your role in the South African manganese industry. You will be asked to name the barriers your business faces in terms of increasing profit and adding value to products, plans of overcoming these barriers, and the effects that these barriers have on your business. Other questions will focus more on the operations and logistics behind the company to determine the company's involvement in the supply chain. Each interview will take 60 minutes or less. The interview will take place at a location of your preference.
- Potentially review the results gathered, at a later stage, and express your opinion towards it.
- Answer potential follow-up questions by means of electronic communication.

3. POTENTIAL RISKS AND DISCOMFORTS

All data collected is confidential and certain details will be shared only once the required permissions are given. After the research is completed, no further contributions are expected, and you would not be inconvenienced with any questions, surveys, etc. whatsoever.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

It is expected that this research will provide an analysis of the business management practices applied in the manganese industry, to provide information to possibly improve current production processes, receive an in-depth look at the different role-players in the market and their relationship with one another, and gather general information that may provide an overall economic advantage for the industry. It is also expected that the research will provide information on the impact that current economic constraints have on the different role players in the industry.

This would thus ensure that South Africa would produce much higher value products and allow for economic growth within the country, transforming our economy from a major exporter of manganese-bearing raw materials to a producer of higher value products. It would allow more value to be retained within the country while increasing skilled labour and creating jobs. It presents opportunities for development of new entrepreneurs in large and small mining industries. The research is expected to promote the local industry and transform South Africa's mineral sector from a predominantly commodity exporter to an exporter of higher value products from processed minerals.

5. PAYMENT FOR PARTICIPATION

No payment will be made to the subject for the participation in the research.

6. CONFIDENTIALITY

Any information that is obtained in connection with this study that can be identified with you, will remain confidential, and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of limited access to identifiable information, securely stored data documents at Stellenbosch University's Engineering Faculty within locked locations and security codes assigned to the computerized records. This data will only be accessible by the primary researcher, Herman van Zyl.

The information gathered will remain secure and only after all the data is processed, might it be released to my supervisor, Wouter Bam, and/or co-supervisor, Joalet Steenkamp, when validating results. If the interview is to be recorded, the subject has the right to review and edit the recording. You may also request the restriction of access to these recordings. If any recordings are made, it will be erased after the completion of the research.

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to partake in this study or not. If you volunteer to partake in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

- Herman van Zyl (Principal Investigator)
  Cell: 076 173 5275
  Email: 16593588@sun.ac.za

- Wouter Bam (Supervisor)
  Cell: 083 271 8612
  Email: wouterb@sun.ac.za

Office hours are between 08:00 – 17:00

- Dr. Joalet Steenkamp (Co-Supervisor)
  Office: +27 11 709 4181
  Email: joalets@mintek.co.za

Office hours are between 07:00 – 15:30

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to [*me/the subject/the participant]* by [*name of relevant person]* in [*Afrikaans/English/Xhosa/other]* and [*I am/the subject is/the participant is]* in command of this language or it was satisfactorily translated to [*me/him/her*]. [*I/the participant/the subject]* was given the opportunity to ask questions and these questions were answered to *[my/his/her]* satisfaction.

[I hereby consent voluntarily to participate in this study/I hereby consent that the subject/participant may participate in this study.] I have been given a copy of this form.

____

Name of Subject/Participant

____

Name of Legal Representative (if applicable)

____ _______________

Signature of Subject/Participant or Legal Representative Date

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to __________________ [*name of the subject/participant]* and/or [*his/her*] representative ____________________ [*name of the representative]. [He/she*] was encouraged, and given ample time, to ask me any questions. This conversation was conducted in [*Afrikaans/*English/*Xhosa/*Other*] and [*no translator was used/this conversation was translated into* ___________ by _______________________].

______________________________________ ______________

Signature of Investigator Date

Appendix C – Validation Document 1 (SAIMM Manganese School)

Identifying Barriers to Growth in Mineral Value Chains: An Analytical Framework Approach

Assessment framework validation

H.J. van Zyl
Primary Researcher
Department of Industrial Engineering
University of Stellenbosch, South Africa
16593588@sun.ac.za

W.G. Bam
Department of Industrial Engineering
University of Stellenbosch, South Africa
Wouterb@sun.ac.za

J.D. Steenkamp
Pyrometallurgy Division
MINTEK, South Africa
joalets@mintek.co.za

Purpose

This questionnaire serves to evaluate the potential utility and perceived shortcomings of a proposed framework for the identification and ranking of barriers faced by role players in different sectors of a mineral value chain.

The framework was developed with the aim to define and analyse specific value chains, in order to identify the factors which cause constraints on economic growth experienced by the various role players therein. Ultimately, the framework is focused on providing high level guidance to companies, government, policymakers and other relevant parties, to determine the barriers in their participating value chain, as well as the severity thereof on economic growth.

Description

The framework is composed of various steps to identify and analyse the barriers. It makes use of different data sources, most notably numerous interviews and surveys conducted with industry experts, to identify these barriers and rank them according to their impact on the different sectors of the value chain. For this instance, the framework is applied to the South African manganese industry. The sectors identified for this case study are: the mining, alloy manufacturing, and EMD production sector. Results were also gathered from the research and development sector to gain a broader insight.

Through the use of this framework, 25 barriers were identified. These barriers were scored by representatives of the various sectors comprising the South African manganese value chain (as mentioned above) on a scale of 1 to 10 with regards to its constraint on economic growth. These results are processed and the following three results sets were produced.

*Please evaluate the utility of proposed framework by answering the questions in **Section E** after the results and email your response to **Herman van Zyl (16593588@sun.ac.za)**, before **22 July 2016**.*

Ranking of severity of barrier per sector

A ranking of the top 10 barriers per sector according to severity:

Table C-1: Top 10 barriers in the mining sector

MINING SECTOR		
Rank	Barrier	Score
1	High transport costs	9.33
2	Under-developed infrastructure and facilities	7.67
3	Poor governmental execution	7.67
4	Low productivity of workforce	7
5	Lack of railway capacity	6.67
6	Skills shortage	6.33
7	Restricted access to capital	6
8	Resource nationalism	6
9	Lack of port facilities	5.67
10	Mining Charter concerns	5.67
11	Obtaining mining license	5.67
12	Poor corporate project execution & Mismanagement	5.67

Table C-2: Top 10 barriers in the EMD sector

EMD SECTOR		
Rank	Barrier	Score
1	High transport costs	9
2	Rising cost of labour	9
=	Unreliable supply	9
=	Rising tariffs	9
5	Restricted access to capital	8
6	Lack of research & development and innovation	8
7	Underdeveloped technology	7
8	Lack of railway capacity	7
9	Unrest / Volatility in workforce	7
10	Low productivity of workforce	7
11	Environmental concerns	7

Table *C*-3: Top 10 barriers in the alloy manufacturing sector

ALLOY MANUFACTURING SECTOR		
Rank	Barrier	Score
1	Unrest / Volatility in workforce	9
2	Rising electricity tariffs	9
3	Rising cost of labour	8.67
4	Low productivity of workforce	8.67
5	Environmental concerns	8.67
6	Skills shortage	8.33
7	Disposal of slag	8.33
8	High transport costs	8
9	Obtaining mining license	8
10	Lack of railway capacity	7.67

Table *C*-4: Top 10 barriers in the research sector

RESEARCH ON INDUSTRY		
Rank	Barrier	Score
1	Rising tariffs	7.83
2	Unreliable supply	7.50
3	High transport costs	7.17
4	Skills shortage	7.17
5	Under-developed infrastructure and facilities	7
6	Restricted access to capital	6.83
7	Underdeveloped technology	6.83
8	Low productivity of workforce	6.67
9	Rising cost of labour	6.17
10	Poor governmental execution	6.17

Prevalence of barriers in the industry

Number times that a barrier was listed as a major barrier by a respondent (value out of 10):

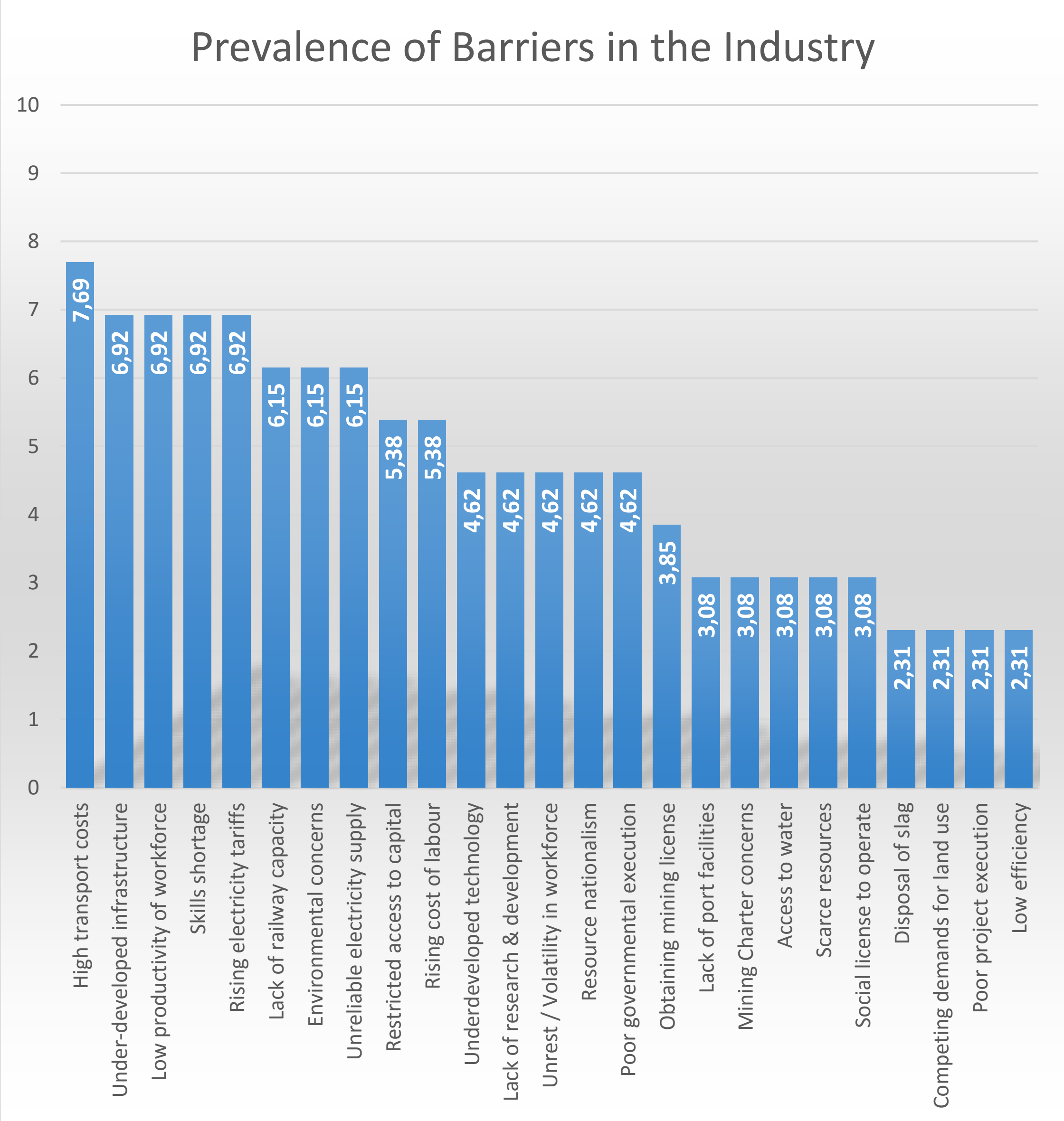


Figure C-4: Prevalence of the barriers across the South African manganese value chain

Categorization of barriers

The severity and prevalence of the barriers, as determined in the previous steps, are used to categorise the barriers into 4 classes according to their severity and prevalence rating, as shown in Figure 0-5. From the graph it is possible to determine which barriers has the largest impact and which affects the most role players in the value chain. This makes it possible to prioritize how barriers should be addressed.

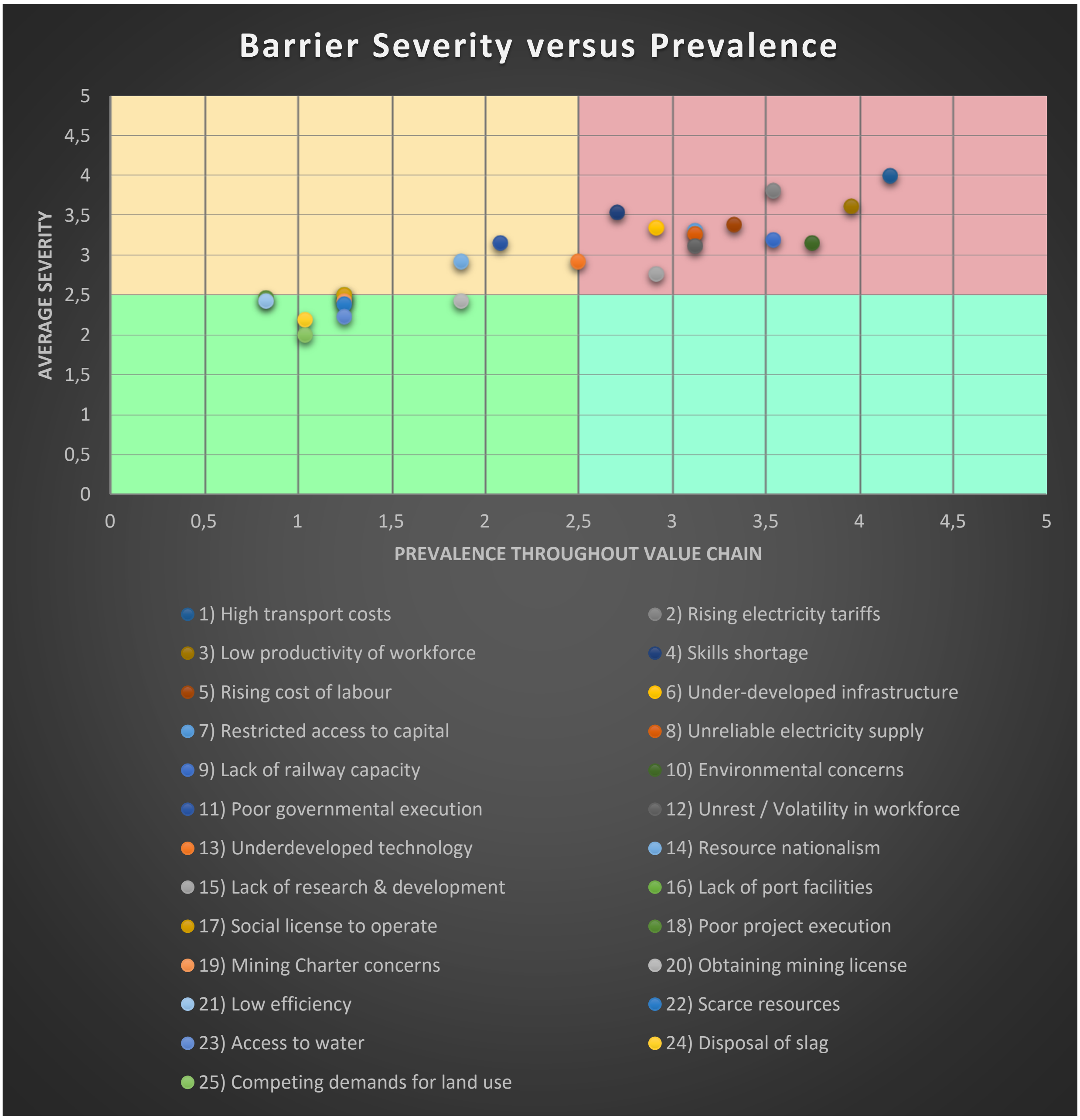


Figure 0-5: Barriers classified according to their severity and prevalence in the manganese industry. (Barriers are ranked according to their severity, y-axis, in the legend).

Key Findings

High transport costs seems to be the most severe and prevalent barrier to the growth of the manganese industry in South Africa. Rising electricity costs also have a substantial impact on economic growth in the industry and is slightly less severe than the high transport costs. It seems that across the industry, problems within the workforce are the cause of many concerns. The low productivity of the SA workforce appears to be particularly prevalent throughout the value chain. This, together with the high severity of skills shortage, and highly prevalent barriers such as the rising cost of labour and the volatility of the workforce, conveys that labour related issues are a growing concern. It is clear that the SA manganese industry is facing several headwinds and a tough economic climate. It is hoped that this research will enable the identification and prioritisation of actions to address these barriers.

Validation Questions

Please answer the following question:

1) Is there a need to identify the barriers to economic growth for specific mineral value chains and to determine their severity and prevalence? Please explain briefly.

2) Do you believe that the proposed framework used to produce these results for a specific mineral value chain, would be useful as a barrier identification and analysis tool for the government, policymakers or companies in the specific value chain? Please explain briefly.

3) Are there other frameworks in place that produce similar results that you are aware of? Please explain briefly.

4) Are there any shortcomings or feedback on the listed results obtained or the methodology employed by the proposed framework? Please explain briefly.

*Please complete the questions and email your response to **Herman van Zyl (16593588@sun.ac.za)**, before **22 July 2016**. Thank you for your assistance and feedback, it is greatly appreciated!*

Appendix D – Validation Document 2 (Expert Analysis)

Identifying Barriers to Growth in Mineral Value Chains: An Analytical Framework Approach

Assessment framework validation

H.J. van Zyl
Primary Researcher
Department of Industrial Engineering
University of Stellenbosch, South Africa
16593588@sun.ac.za

W.G. Bam
Department of Industrial Engineering
University of Stellenbosch, South Africa
Wouterb@sun.ac.za

J.D. Steenkamp
Pyrometallurgy Division
MINTEK, South Africa
joalets@mintek.co.za

Purpose

This questionnaire serves to evaluate the potential utility and perceived shortcomings of a proposed framework for the identification and ranking of barriers faced by role players in different sectors of a mineral value chain.

The framework was developed with the aim to define and analyse specific value chains, in order to identify the factors that cause constraints on economic growth experienced by the various role players therein. Ultimately, the framework is focused on providing high level guidance to companies, government, policymakers and other relevant parties, to determine the barriers in their participating value chain, as well as the severity thereof on economic growth.

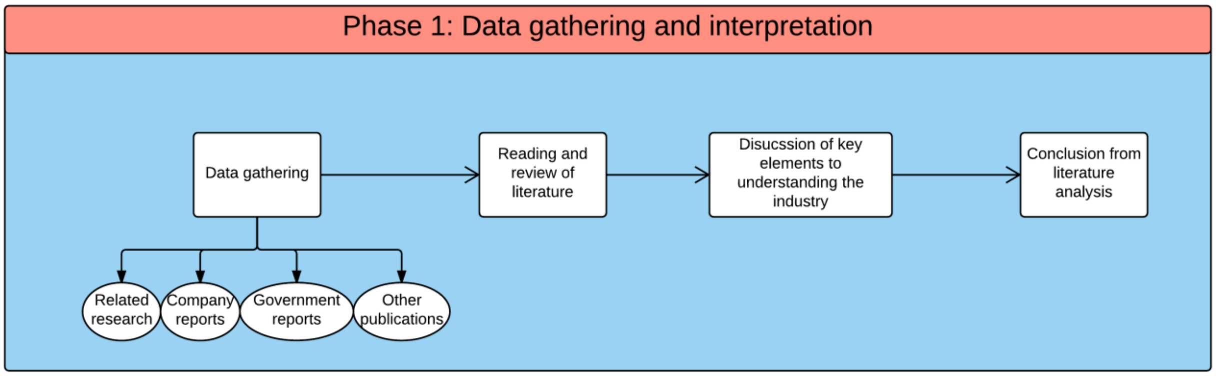
Description

The framework is composed of six phases, each comprised of different steps, to identify and analyse the barriers. It makes use of different data sources, most notably numerous interviews and surveys conducted with industry experts, to identify these barriers and rank them according to their impact on the different sectors of the value chain. In order to provide insight as to the functioning of the framework, every phase thereof was applied to the South African manganese industry.
The framework is illustrated in the introduction and a description of each phase appears at the beginning of each section. It is very important that these phases are validated. Some of the framework results are also presented to provide a better understanding of what each phase entails.

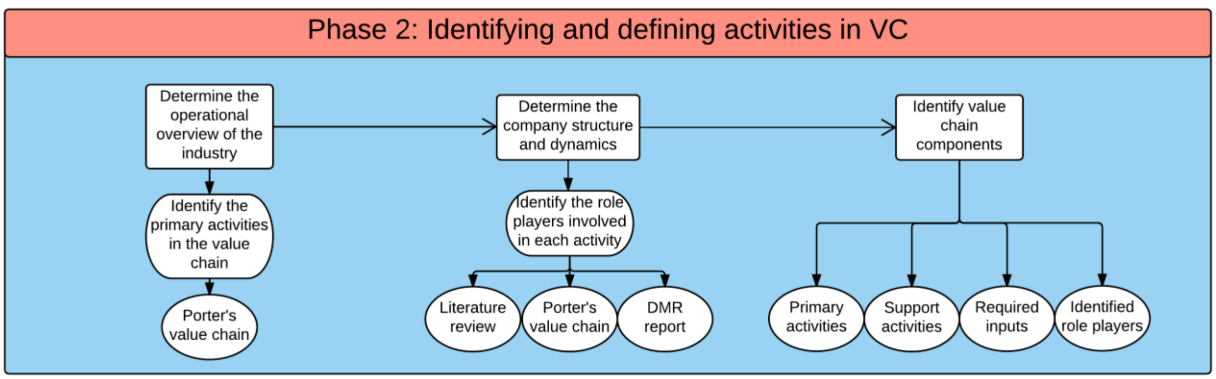
Please evaluate the utility of the proposed framework by answering the questions in ***Section 7 Validation Questions*** *and email your response to* ***Herman van Zyl (16593588@sun.ac.za)****, by* ***Monday 22 August 2016****.*

Introduction

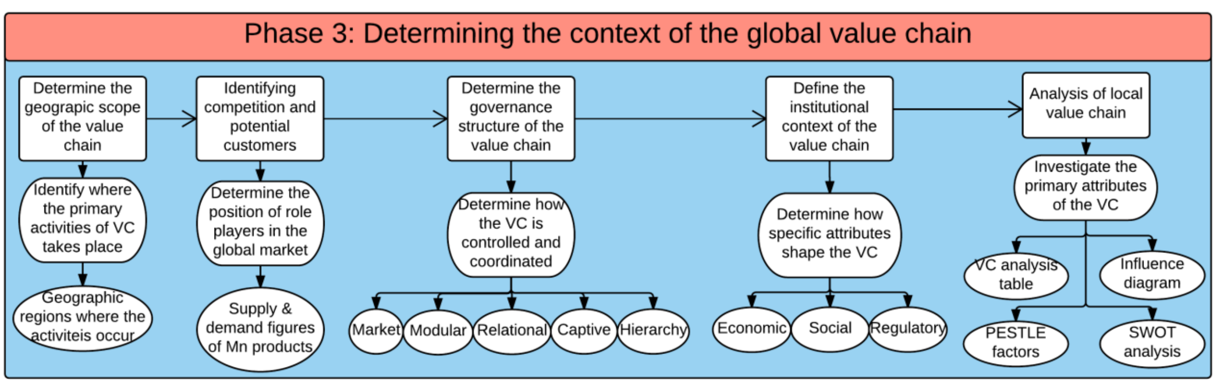
The following diagrams are a step-by-step representation of the six phases comprising the proposed framework. Each figure provides an outline of the processes involved in each phase.



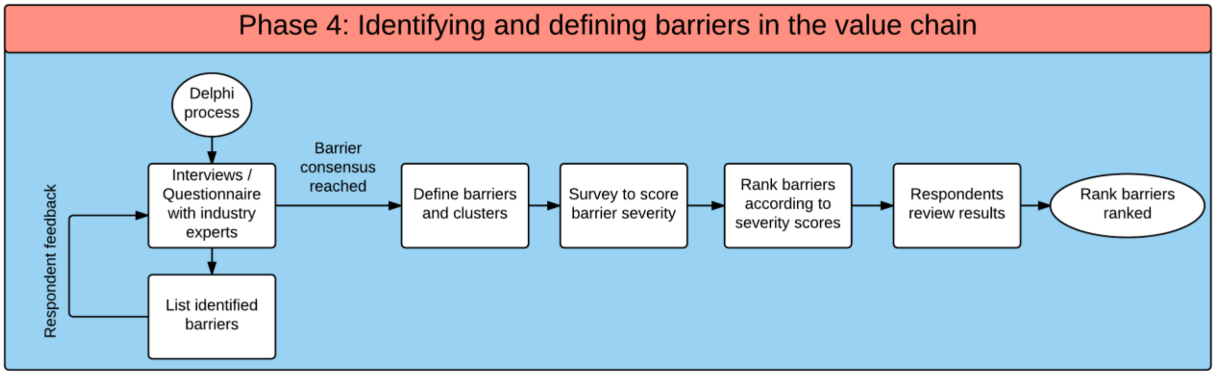
Phase 1 of the proposed framework



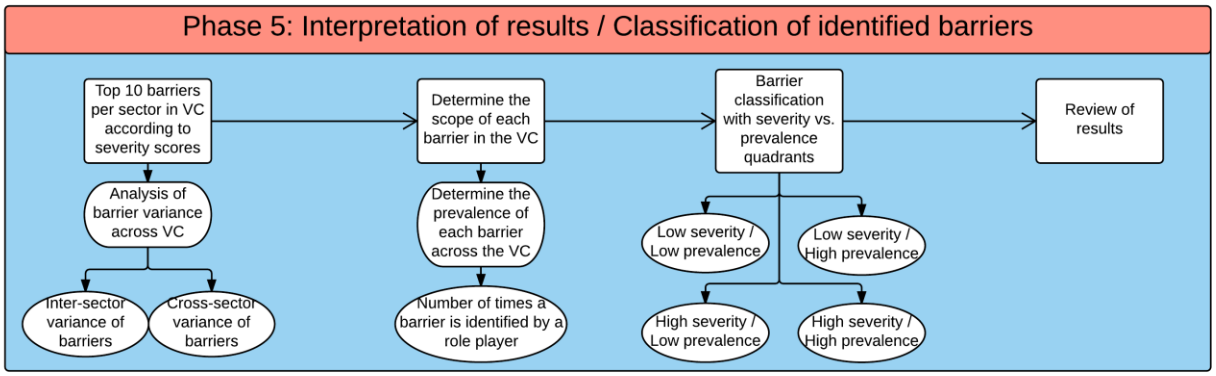
Phase 2 of the proposed framework



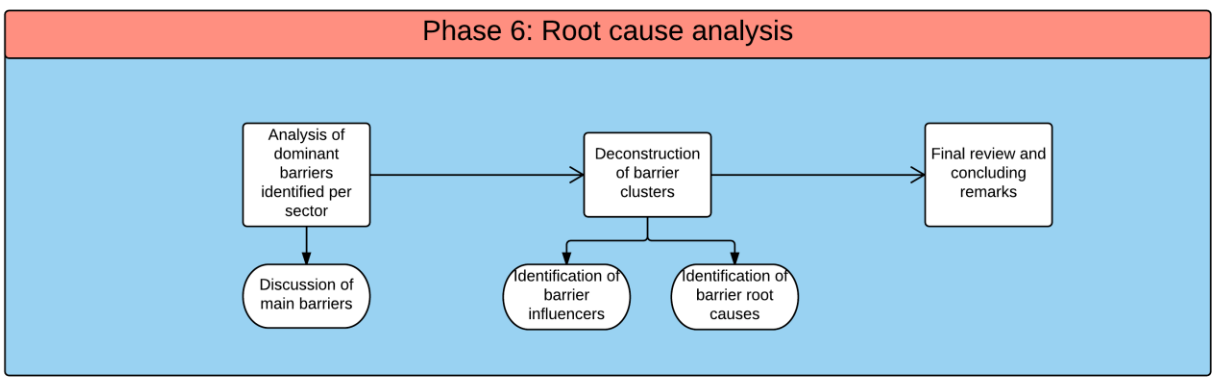
Phase 3 of the proposed framework



Phase 4 of the proposed framework



Phase 5 of the proposed framework



Phase 6 of the proposed framework

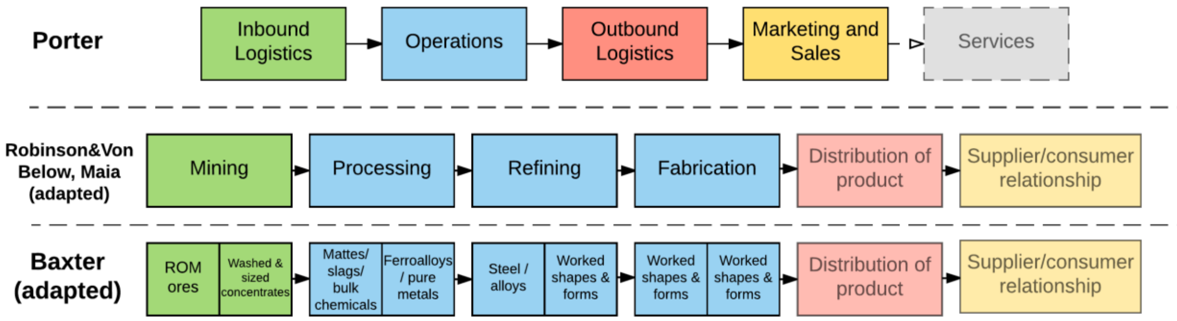
Phase 1: Data gathering and interpretation

<table>
<tr><th colspan="3">Phase 1: Data gathering and interpretation</th></tr>
<tr><td colspan="3"><u>Description:</u>
The literature review provides an overview of all the relevant background information, disciplines and theories relating to the specific mineral industry. This information is used, firstly to provide a solid platform to understanding the various aspects of the industry, and secondly, to ensure that new contributions are made through this research and not merely duplication work that has already been done.</td></tr>
<tr><th colspan="3">Key objectives</th></tr>
<tr><td>• Mineral background information
• Mineral reserves / resources data
• Related mineral products and applications
• Processes involved in product manufacturing</td><td>• Outline of industry practices
• Information on specific acts / policies which affects industry
• Investigate constraining factors</td><td>• News in the industry
• Information on different role players involved
• Gain better understanding of the industry</td></tr>
<tr><th colspan="3">Tools used in phase / Outputs:</th></tr>
<tr><td colspan="3">• Literature review</td></tr>
</table>

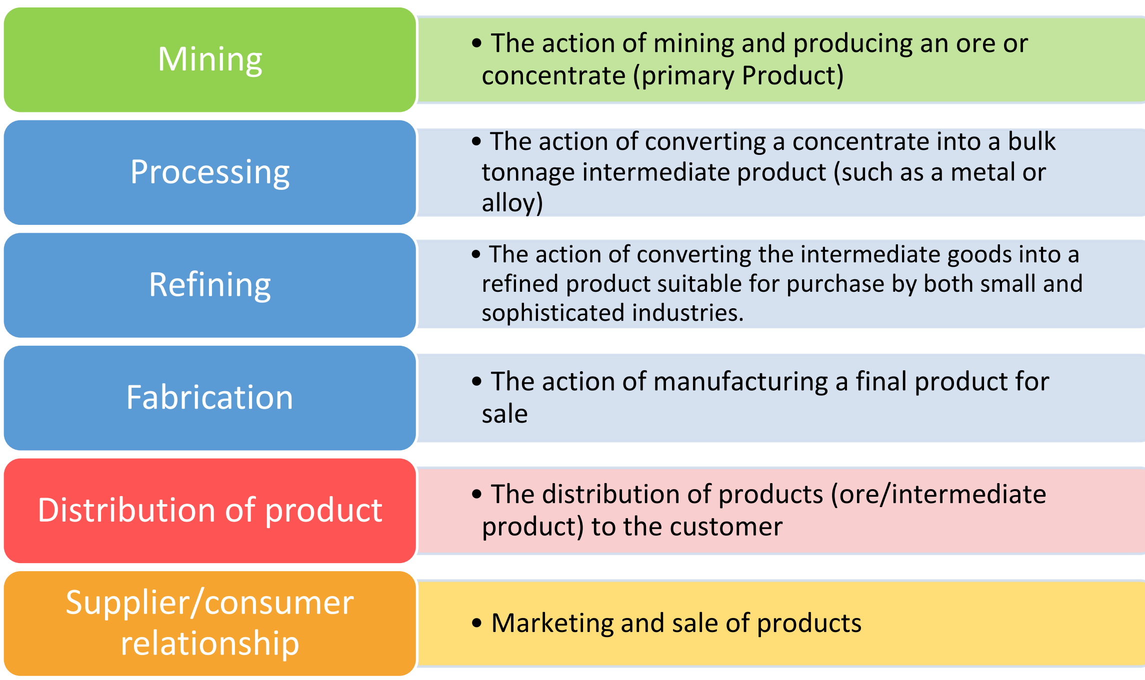
Phase 2: Identifying and defining activities in VC

<table>
<tr><th colspan="3">Phase 2: Identifying and defining activities in VC</th></tr>
<tr><td colspan="3"><u>Description:</u>
Once there is general knowledge and an overview of the mineral and the related industry, sectors of the chain can be differentiated by the value they add to each output in the process. The chain is separated into segments representing the general activities or processes in order to provide a general representation of the various sectors/segments comprising the value chain. This in turn provides an understanding of the structure of the chain, the inputs and outputs in each activity and lastly, the different role players involved in the processes.</td></tr>
<tr><th colspan="3">Key objectives</th></tr>
<tr><td>• Identify the activities in the VC
• Define the primary and support activities
• Define the output flow of the VC</td><td>• Develop the basic layout of the VC
• Determine the role player structure in the VC</td><td>• Develop complete mineral VC
• Develop the product roadmap of the industry</td></tr>
<tr><th colspan="3">Tools used in phase / Outputs:</th></tr>
<tr><td>• VC analysis methods, such as Porter’s value chain
• Manganese value chain representation</td><td>• Definition of VC activities
• Manganese value chain structure</td><td>• Manganese product roadmap
• Identification of main sectors comprising manganese VC</td></tr>
</table>

Identify the main activities/segments in a global value chain

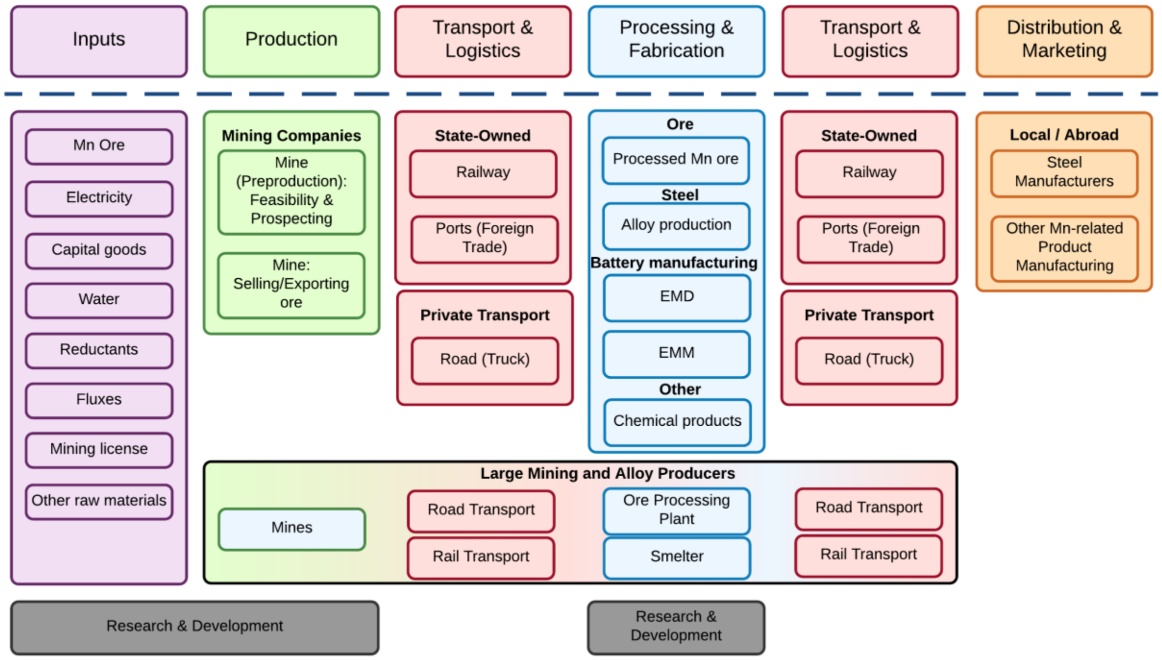


Generic overview of the main activities and products in the mineral value chain. Sources: (Baxter 2013; Maia 2015; Porter 1985; Robinson & Von Below 1990)



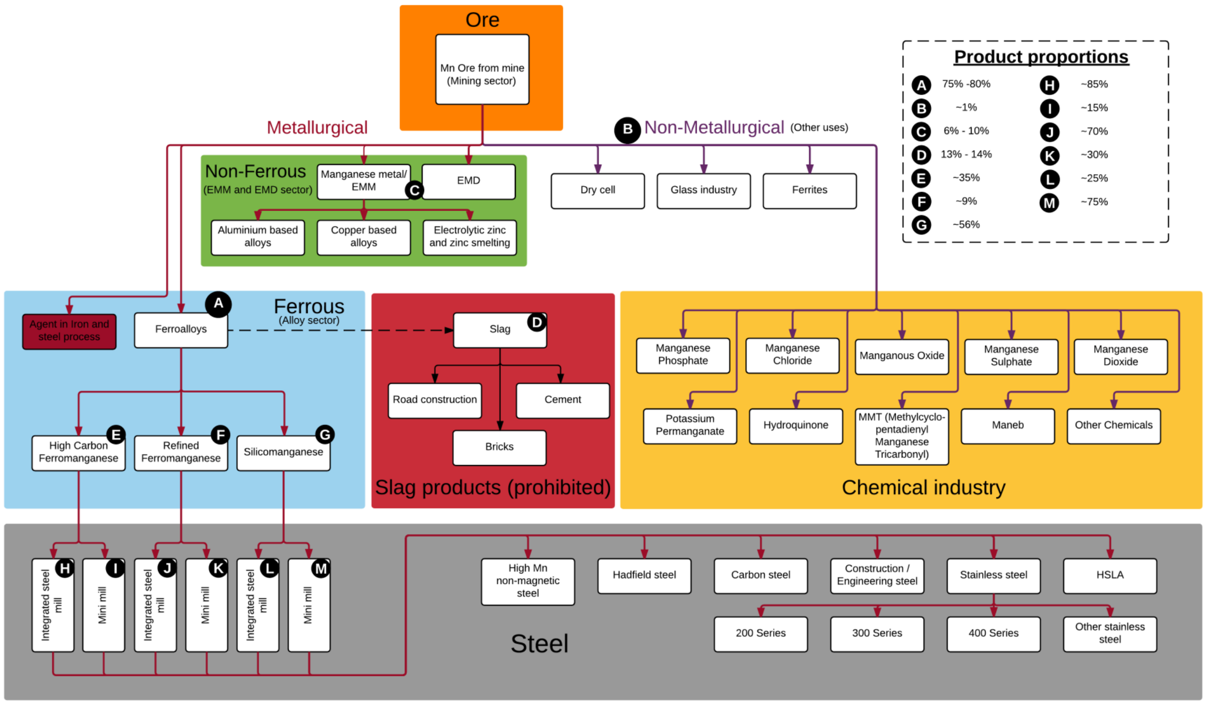
Description of activities in the mineral value chain

Identify the dynamic and structure of companies under each segment of the value chain



The South African manganese value chain overview

Determine the different segments of the value chain through the development of a product roadmap



Manganese industry product roadmap.

Data from: (Gajigo et al. 2011; RPA 2012; International Manganese Institute & RPA 2015; Callaghan 2013)

Phase 3: Determining the context of the global value chain

Phase 3: Determining the context of the global value chain		
Description: The deconstruction of the entire value chain in order to identify its main attributes, characteristics, assumptions and the impact they have on the industry through integrating these various aspects and determining its context in the global value chain. This phase investigates how these specific attributes affect the role players, as well as the industry itself. These attributes range from the geographic scope of the activities to market conditions and governance structure of the value chain.		
Key objectives		
• Determine geographic scope of activities • Investigate the market of the mineral (supply and demand) • Identify the global role players in the VC	• Determine the hierarchy of role players in VC • Domestic industry's position in global context • Determine governance structure of VC	• Determine attributes of VC and institutional context (Economic, social and regulatory) • Analysis of key features of VC • PESTLE factor analysis • SWOT analysis
Tools used in phase / Outputs:		
• Geographic scope analysis • Investigation of economic, social and regulatory institutional context of SA manganese industry	• Supply and demand analysis • Value chain governance structure analysis • PESTLE factors of SA manganese industry	• SWOT analysis of SA manganese industry • VC influencer diagram

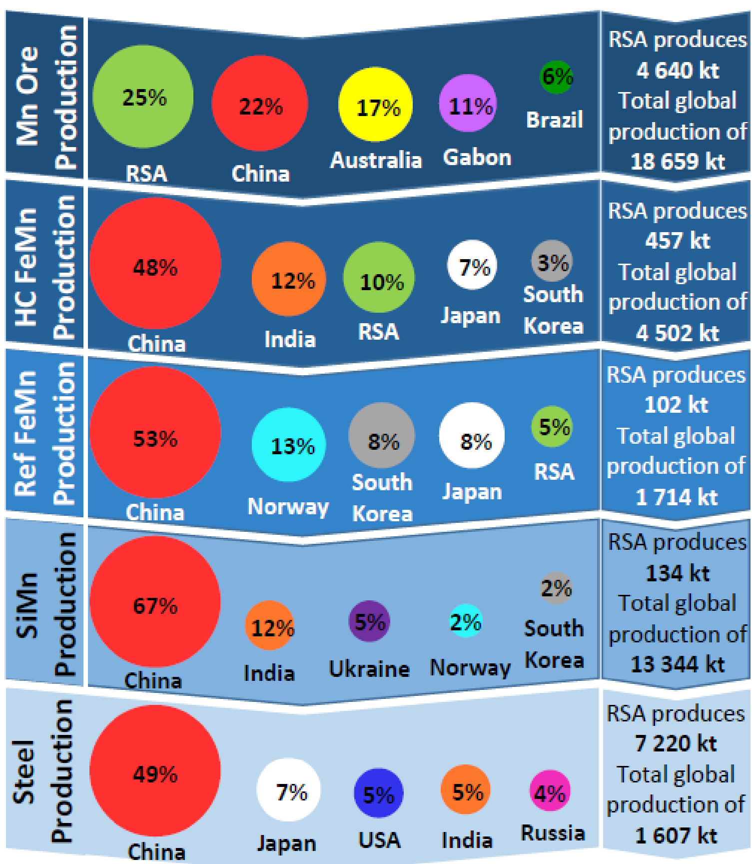
Geographic scope

Manganese ore and manganese alloy producing countries.

Source: (International Manganese Institute 2014d)

Manganese ore production per grade (000 mt wet tons) (International Manganese Institute 2014a)

Country	≥ 44% (High)	≥30% and <44% (Medium)	< 30% (Low)	Total
China	0	0	23 000	23 000
South Africa	3 544	7 993	0	11 537
Australia	5 873	1 438	0	7 311
Gabon	3 697	600	0	4 297
Brazil	2 252	71	116	2 440
India	370	1 513	381	2 264
Ghana	0	0	1 912	1 912
Ukraine	0	1 353	0	1 353
Kazakhstan	0	1 202	0	1 202
Malaysia	0	1 111	0	1 111
Others	*407*	*1 626*	*23 210*	*25 244*
Total	**16 143**	**16 907**	**25 619**	**58 669**



SA's position in global market

PESTLE factors

PESTLE factors impacting the local manganese mining and mineral industry (TIA 2012)

Political	Economic	Social	Technological	Legal	Environmental
• Acts / Policies • MPRDA • Mining Charter • Research & Technology competitive edge • Partnerships with R&D institutions • Integrated sustainable development approach • Comparative advantage to competitive advantage	• Commodity needs in fast growing economies • Uncompetitive labour productivity • Exchange rate • Infrastructure • Electricity tariff increase • Commodity market volatility	• Skills shortage • High average age of mining professional • Literacy • HIV/AIDS • Respiratory diseases • Social license to operate • Unrest in workforce	• Innovation constraints • Productivity improvement • Safety • Emerging technologies • R&D contracted to overseas agencies	• Resource taxes and royalties • Licensing • Safety performance • Anti-dumping fees	• Industrial water usage • Acid Mine Drainage • Air pollution • Noise pollution • Land rehabilitation • Waste management / Slag disposal

SWOT analysis

The South African manganese mineral industry SWOT analysis (TIA 2012)

Strengths	Weaknesses
• Resource abundance • Foreign direct investment • High level expertise in limited areas • Primary processing facilities • Global leader in some technologies	• State of research institutions • Limited R&D funding • Skills shortage • Low minerals value addition • Low international R&D collaboration • Slow sector transformation • Few new entrants • Adoption of innovation
Opportunities	**Threats**
• Supply side/upstream industry expansion • Health and safety and hazards management environment development • Local manufacturing • Downstream beneficiation • Employment creation • Wealth creation	• Declining R&D funding • Electricity supply shortages • Skills affected productivity and safety • Non-generation of new skills • Lack of local R&D collaboration by industry • Transport infrastructure deficiencies • Imports of products and services

• Development of sustainable livelihoods • Lateral migration of technology	

Phase 4: Identifying and defining barriers in the value chain

Phase 4: Identifying and defining barriers in the value chain		
Description: Identify the barriers to economic growth faced by role players in different sectors of the value chain through various forms of communication with experts in different fields of the specific industry. This will be conducted through a Delphi process during which various iterations will be undergone in order to identify an extensive list of barriers. These barriers are then defined and scored by the industry experts with regards to the severity of their impact on their business.		
Key objectives		
• Identify representatives of major sectors in the industry • Investigate operation details which could aid in identifying barriers • Identify barriers from gathered responses	• Define identified barriers • Group similar barriers in clusters • Determine if consensus is reached by respondents	• Gather respective barrier score with regards to severity • Analyse feedback from respondents
Tools used in phase / Outputs:		
• Delphi process • Interviews • Questionnaires • Survey	• Identification of barriers in industry • Ranking of barriers per sector	• Identification of barrier clusters

Identified barriers definitions grouped by cluster

Barrier	Description
DEVELOPMENT	
Restricted access to capital	Capital scarcity for long-term capital-intensive investments is a major constraining factor of an expanded mineral industry in South Africa. Relatively high levels of investor expectations and corporate tax rates cause the cost of capital in South Africa to be very high in comparison to many other major mineral producing countries. Many players in the industry, especially juniors, struggle to access capital. Many foreign businesses have reservations towards supporting major planned investments in new production facilities in South Africa. These perceptions have caused many attractive potential projects to be implemented in other countries.
Technology	The mining and metals sector is constantly forced to look for innovative ways to cut costs and increase efficiencies. Many companies are turning to new technologies to advance exploration, increase productivity, improve recovery rates, decrease energy usage, etc. Many new technologies can potentially

	disrupt the status quo of the market, leaving companies that are unable or unwilling to adapt to these technologies in a disadvantaged economic position.
Lack of research & development and innovation	South Africa's investment in R&D has been in steady decline for the past few years. This indicator is regarded as fundamental contributor to innovation led economic growth and competitiveness and South Africa pales in comparison to most of its BRICS counterparts and the international average. Increase in R&D and innovation could lead to more efficient product processing, delivery of new products which provides businesses with a unique selling point, and ultimately provide a competitive advantage to increase economic growth.
LACK OF PROPER INFRASTRUCTURE	
Under-developed infrastructure and facilities	The continued growth in mineral demand challenges mining and metals companies to look for new sources of supply which are often situated in remote locations that lack access to infrastructure. Developing mines, plants or other mineral processing facilities is often very complex when taking factors, such as difficult terrain, less stable political or regulatory management and the need to build social infrastructure at these regions, into account. These economic and social costs could add considerably to the total cost of an operation. These factors can also cause delays in delivery or places a limiting factor on the amount of products that can be transported via roads, railways and ports.
Lack of railway capacity	The freight system in South Africa is currently suffering from inefficiencies rendering most of the manganese products incapable of being optimally distributed to domestic and international markets. Since the country's transport infrastructure has been found inadequate of supporting higher export volumes to the international market, greater efforts are to be made to improve the efficiency of South Africa's rail utilities. Accelerated economic growth and lack of adequate maintenance and upgrading, however, have rendered the transport system in urgent need of corrective measures. The demand for rail capacity far outstrips the supply from government owned Transnet. Companies receive a limited tonnage entitlement to use the railway in order to transport products across the country, which forces other more expensive forms of transport to be used. The railway capacity is insufficient for a large number of companies.
Lack of port facilities	Port Elizabeth is the only dedicated port for manganese export. The development of the Port of Ngqura, also to be used as a manganese terminal, is continually pushed back due to various reasons. The port capacity does not comply with the demand and mines have to compete with a variety of other commodities and products to be delivered abroad.
High transport costs	High costs for transporting goods via rail, road and ports are becoming ever present. These escalating transport costs cuts into company profits and

	disables companies distributing their products at a profitable rate if the right deal cannot be made.
LABOUR ISSUES	
Rising cost of labour	South Africa's weak economic growth, rising costs, high unemployment and numerous socio-economic challenges have resulted in many problems and unrest in labour cost and efficiency. The cost of labour is one of the largest expenditures in a mining company. With the raise in strikes and workforce unrest, the increase in worker wages are regularly increasing.
Unrest / Volatility in workforce	Unrest in workers has led to decreased labour productivity which undermines companies' profitability and threaten the sustainability of the business. The current perception that the workforce unrest is a high risk is discouraging potential investors in the industry. This extreme financial pressure has been evident in extended strikes in the platinum and metal industries.
Low productivity of workforce	Low productivity of the workforce cause delays in operations and leads to project schedules not being met. Low productivity often leads to the occurrence of financial losses.
Skills shortage	Increase interest in mining and mineral product manufacturing has led to the development of many new projects to ramp up production in mining and alloy manufacturing. This increased investment is in turn driving demand for skilled workers. As supply increases, the number of skilled workers also needs to increase in order to maintain the higher levels of production. The risk is that a skills shortage could slow growth and increase cost.
RISING REGULATIONS / POLICIES	
Environmental concerns	Mining and metals companies are constantly under scrutiny by regulators, external stakeholders, local communities and activist NGOs to adopt a more sustainable approach to operations. Climate change concerns have increased the sensitivity of all the stakeholders, resulting in legal or punitive action on the companies. The impact is not only on the performance and brand image of the specific company, but also on the industry and employees.
Resource nationalism	Resource nationalism can be described as a balancing act between promoting investment and maximizing local benefits. Many governments, including South Africa's, have begun to promote initiatives to attract mining investments into their jurisdictions. Despite a decline in commodity prices, there is still a growth in resource nationalism to gain a greater share of shrinking returns from the mining and metals sector. Mandated beneficiation and state ownership is becoming a very popular political tool as governments seek to capture more value from their resources by implementing regulations that forces minerals to be processed locally prior to export. In order to ensure national beneficiation, governments are ensuring export levies or export bans on unrefined ore.

Mining Charter concerns	The South African Mining Charter presents legislative uncertainty for many stakeholders in mining companies. There are uncertainties pertaining to its context, especially regarding the Mining and Petroleum Resource Development Bill and the BEE ownership requirements. These uncertainties cause difficulty in mitigating risks.
Obtaining mining license	Obtaining the necessary legal documents for mining is often an onerous process. It is strictly controlled by government and administrative mismanagement from their side can lead to delays in production. They ultimately decide when and to whom mining licenses can be issued.
Disposal of slag	In South Africa the slag that is created as a by-product during manganese alloy production, is discarded on slag dumps and classified as a hazardous material. It is estimated that approximately 20 Mt of HCFeMn and SiMn slag is discarded on dumps in South Africa(Kazadi et al. 2013). Commercially viable options to reduce the size of these slag dumps are continuously investigated by various interested and affected parties, even though many countries utilise the product in construction materials. This product cannot be sold in South Africa and large expenses is made to properly ensure that the slag is properly disposed according to environmental policies.
MARKET CONDITIONS	
Market volatility	Commodity prices are often affected by external factors which many times cannot be controlled by producers. All commodities are subject to wide fluctuation, especially minerals used for alloy and steel manufacturing. Manganese supply and demand are closely dependent to the iron and steel market with all manganese products following a similar trend to these resources. This causes price volatility which can have adverse effects on a company's operating results, asset values and cash flows. If commodity prices remain weak for sustained periods, growth projects could not be longer perceived as viable options. China's dominance in the steel market also determines many trends in the industry.
Fluctuations in exchange rate	Volatile exchange rates create an element of uncertainty in projecting future income and expenditure scenarios, which in turn casts doubt on project feasibility. By stabilizing the rand exchange rates, the South African authorities could create an environment more conducive to future expanded ferroalloy production.
Competition / Oversaturated market	An upsurge in local commodity companies has resulted in the oversaturation of the market. This increase in competition has limited the number of available resources and fragmented the power of product pricing from a handful of companies to an expanding number.

Sizeable domestic market / Proximity to market	South African alloy producers have not always found it economic to exploit rising demand for manganese products due to its distance from the markets, despite the existing excess production capacity to do so. Competitors that are located closer to the markets have traditionally had a competitive advantage over producers from abroad.
Anti-dumping duty	This protectionist tariff is imposed by domestic governments on foreign imports that is believed to be priced below fair market value. This is to protect local companies from being pushed out of the market by foreign companies selling their products at uncompetitive prices. In some countries the duty is so high, that it is no longer economically viable for South Africa to enter these markets.
Geopolitical uncertainty	Geopolitics is about the competition over the control of territory and the extraction of resources. Geopolitical uncertainty is a risk that lies outside the control of a company, but can have a major effect on its growth plans. It can also threaten disrupt operations and destroy shareholder equity. The impact of geopolitical instability can extend further down the value chain and cause a collapse in consumer demand, an increase in currency volatility and disrupt critical infrastructure and transportation networks.
ACCESS TO RESOURCES	
Access to water	The availability, accessibility, quality and active management of water is crucial for the operational success of mining and metals companies, especially where they expand into remote and arid areas of the country.
Competing demands for land use	Land access remains a significant risk to the mining sector especially, that often faces community opposition over environmental concerns and land usage, with the resulting national and local governing laws becoming more stringent about land use. This opposition can increase start-up costs and cause significant delays to operationalizing a project.
Scarce resources	South Africa has been self-sufficient for many years with respect to rich mineral resources and raw materials for the production of mineral products. In recent years, however, many resources required for operation have become scarce, such as high-grade ore, reductants and other raw materials. This could lead to increases in material costs and delays in production.
ELECTRICITY ISSUES	
Unreliable supply	Since 2008, the mining sector has faced electricity rationing that limited production due to electricity shortage in South Africa. The establishment of any new plant is dependent on the availability of electricity. Electricity limitations are a major constraint in the manganese industry and are effecting all the major role players on a large scale. Unscheduled electricity supply interruptions affect many businesses' ability to achieve their production targets.

Rising tariffs	South Africa is no longer an international competitive low cost electricity supplier. Excessive energy costs affect the profitability of all businesses and the annual increase in tariffs are eating away at profits.
SOCIAL	
Social license to operate	To ensure that specific social factors are properly addressed and maintaining a social license to operate (SLTO), is becoming an increasingly multifaceted and multi-stakeholder risk. Poor working conditions, dangerous practices and environmentally hazardous activities which could potentially threaten the health and safety of employees and local communities, could lead to business closure. Losing a social licence is a very real and potentially very expensive risk to a business.
MANAGEMENT	
Poor governmental execution	Lack of support in policy and capital investment from government has a constraining effect on local role players in the manganese industry. Incentives are promised when certain beneficiation objectives are met, but it is often not delivered upon.
Poor corporate project execution & Mismanagement	Poor project execution and mismanagement of operations in an industry that is filled with risks, can have extremely detrimental consequences on the company and lead to huge losses.
Low efficiency	Efficiency is defined as the comparison of what is actually produced or performed with what can be achieved with the same consumption of resources (money, time, labour, etc.). Efficiency has been declining significantly in the mining industry over the past decade, with more money and labour being utilised to extract ore as quickly as possible, instead of making provision and implementing sustainable structures for efficient systematic mining which could produce the same yield with the use of less resources. It is an important factor in determination of productivity. It was a conscious choice by industry participants to pursue volume at any cost during an unprecedented boom in commodity prices, leading to low efficiency. Mines were developed to get product out as quickly as possible, not as efficiently as possible.

Phase 5: Interpretation of results / Classification of identified barriers

Phase 5: Interpretation of results / Classification of identified barriers		
Description: The analysis of the results gathered from the industry experts in order to provide insight to what the primary constraining factors are faced by the different role players in the value chain. The main barriers are placed in context and determined how it affects the different sectors comprising the value chain.		
Key objectives		
• Identify main barriers per sector according to severity scores • Determine the prevalence of the barriers across the VC	• Determine the variance in barrier scores across the industry • Classification of barriers	• Interpret final results
Tools used in phase / Outputs:		
• Top 10 barriers per sector • Ranking of prevalence of barriers across the VC	• Determine and analyse the inter-sector variance of barrier scores • Determine and analyse the cross-sector variance of barrier scores	• Classify barriers in severity vs. prevalence quadrants

Top 10 barriers in the mining sector

MINING SECTOR		
Rank	**Barrier**	**Score**
1	High transport costs	9.33
2	Competition / Oversaturated market	9.00
3	Under-developed infrastructure and facilities	7.67
=	Poor governmental execution	7.67
5	Low productivity of workforce	7.00
=	Market volatility	7.00
7	Lack of railway capacity	6.67
8	Skills shortage	6.33
9	Restricted access to capital	6.00
=	Resource nationalism	6.00

Top 10 barriers in the alloy manufacturing sector

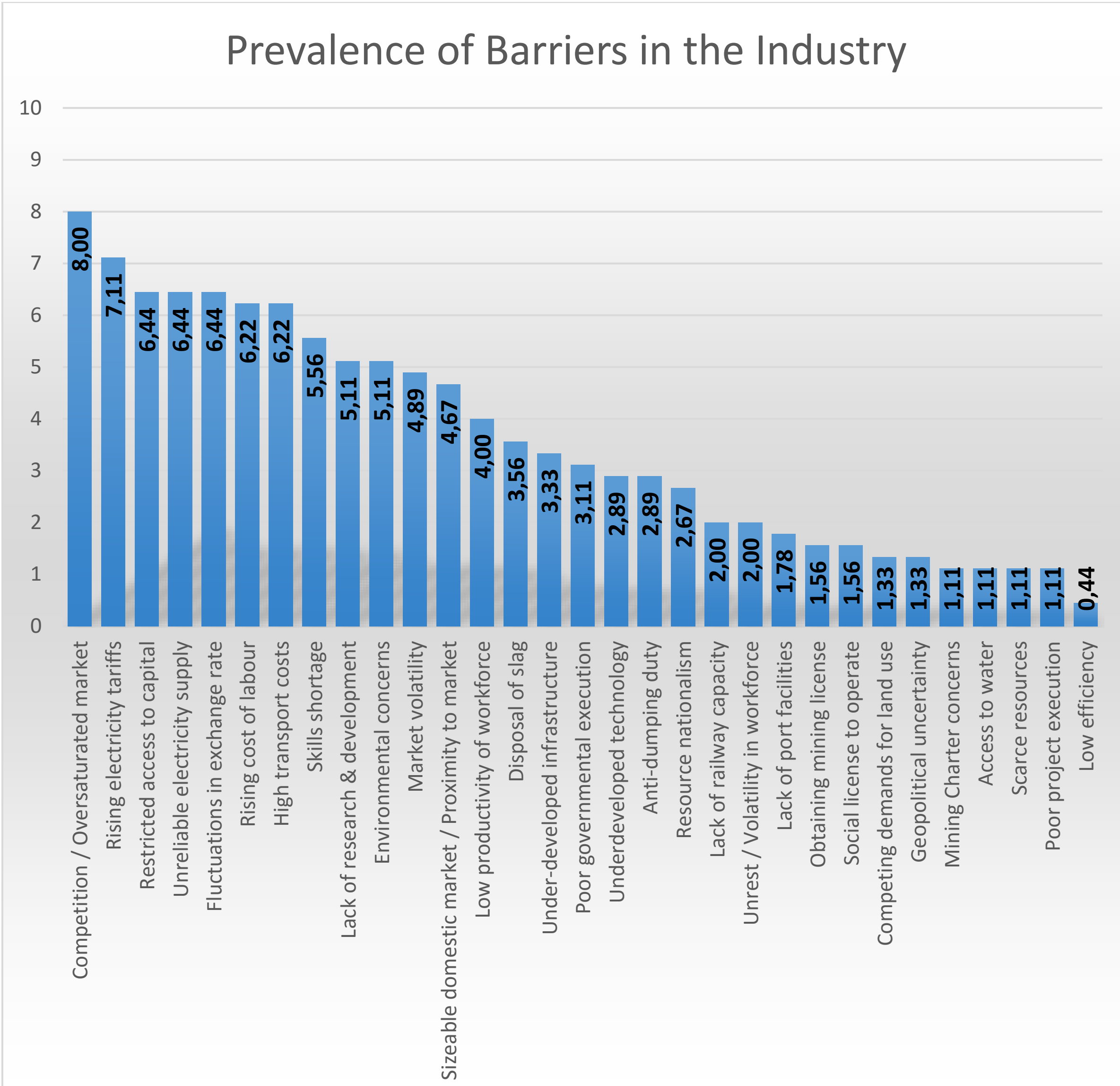
ALLOY MANUFACTURING SECTOR		
Rank	**Barrier**	**Score**
1	Unrest / Volatility in workforce	9.00
=	Rising electricity tariffs	9.00
3	Rising cost of labour	8.67
=	Low productivity of workforce	8.67
=	Environmental concerns	8.67
6	Skills shortage	8.33
=	Disposal of slag	8.33
=	Competition / Oversaturated market	8.33
9	High transport costs	8.00
=	Obtaining mining license	8.00

Top 10 barriers in the EMD sector

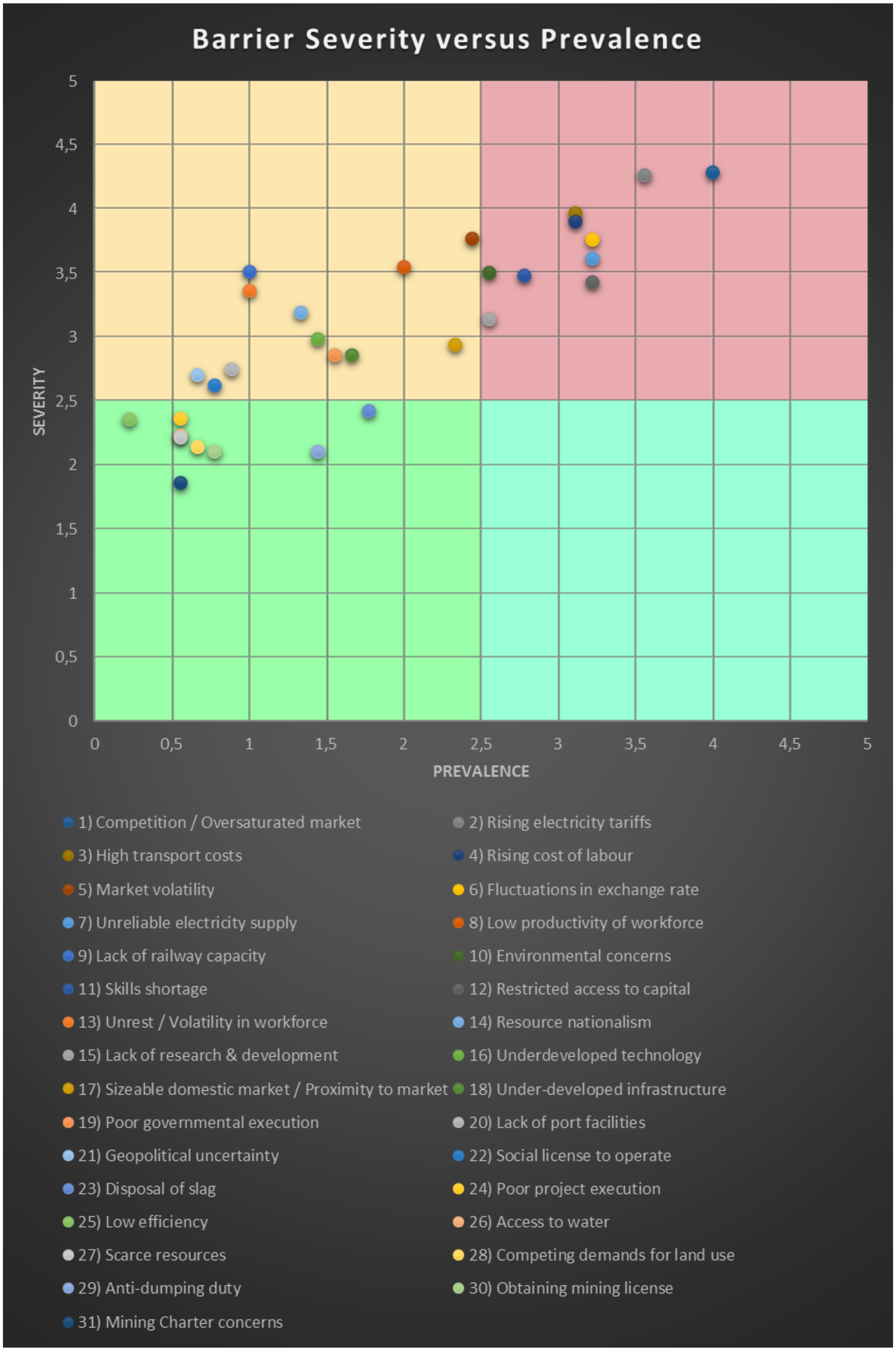
EMD SECTOR		
Rank	Barrier	Score
1	Fluctuations in exchange rate	10
2	High transport costs	9
=	Rising cost of labour	9
=	Unreliable electricity supply	9
=	Rising electricity tariffs	9
=	Competition / Oversaturated market	9
=	Sizeable domestic market / Proximity to market	9
=	Anti-dumping duty	9
9	Restricted access to capital	8
=	Lack of research & development and innovation	8

Top 10 barriers in the EMM sector

EMM SECTOR		
Rank	Barrier	Score
1	Rising electricity tariffs	10
=	Competition / Oversaturated market	10
3	Rising cost of labour	9
=	Market volatility	9
5	Restricted access to capital	8
=	Underdeveloped technology	8
=	Lack of research & development and innovation	8
=	Skills shortage	8
=	Environmental concerns	8
=	Disposal of slag	8
=	Unreliable electricity supply	8
=	Fluctuations in exchange rate	8



Prevalence of the barriers across the South African manganese industry



Barriers classified according to their severity and prevalence in the manganese industry. (Barriers are listed in order of severity in the legend).

Phase 6: Root cause analysis

Phase 6: Root cause analysis		
Description: A review of the results as well as the final conclusions on the barriers faced by role players across the industry. This phase focuses on the influencers of the barriers as well as the root causes of these problems, with the aim of serving as a starting platform to alleviate these constraints.		
Key objectives		
• Review of identified barriers in each sector • Link influencers to respective barriers	• Identify root causes of respective barriers	• Review of findings
Tools used in phase / Outputs:		
• Analysis and discussion of main barriers faced across the value chain	• Sunburst diagram: Barrier cluster conveying influencers and causes of barriers	• Final review and conclusions of results

Root cause analysis diagram

The sunburst diagram below is a representation of the root cause analysis of the *Sustained Development* barrier cluster. There are nine barrier clusters identified, namely:

1. Sustained Development
2. Lack of proper infrastructure
3. Labour issues
4. Rising regulations / policies
5. Market conditions
6. Access to resources
7. Electricity issues
8. Social issues
9. Management

The diagram consists of barrier related segments, which are comprised of three levels:

- Inner level – Barriers in cluster
- Middle level – Influencers of the barrier
- Outer level – Root causes of the barrier

These diagrams are not the final conclusion of the research, but a tool to aid in the review and analysis of the barriers.

Root cause diagram for Restrictive Development barrier cluster.

Legend for root cause diagram

Root cause	Alleviate
RC 1.1	Require political certainty to reassure investors that the country is well managed.
RC 1.2	Mismanagement of subsidies promised by government to businesses, leads to loss of expected capital.
RC 1.3	Delays in government regulations, such as EIA processes and the issuing of permits / licences, leads to project delays and the loss of capital.
RC 1.4	Juniors struggling to gain footing in market and gain access to investments.
RC 1.5	M&A activity is hampered by global macroeconomic uncertainties.

RC 1.6	Global markets are tight and investor sentiment in minerals are weak.
RC 1.7	Risk premium attached to SA mining investments, due to volatile labour conditions.
RC 1.8	Companies are separating global assets from SA assets to raise capital for international operations.
RC 1.9	Lacklustre commodity performance results in the abandonment of projects which do not offer high enough returns.
RC 1.10	Focus is on short-term gain instead of developing technologic and operation systems to improve efficiency and reduce wastage.
RC 1.11	SA's cheap labour often does not economically justify expensive technologic and operational upgrades.
RC 1.12	Government places priority on job creation rather than invest in technology development which could decrease employment.
RC 1.13	SA's annual invest in R&D is low compared to the international average since more resources are assigned to other sectors such as health and education services.

Validation Questions

Please answer the following question (you can do so via email):

1) Is there a need to identify the barriers to economic growth for specific mineral value chains and to determine their severity and prevalence? Please explain briefly.

2) Do you believe that the proposed framework would be useful as a barrier identification and analysis tool for the government, policymakers or companies in the specific value chain? Please explain briefly.

3) Are there other frameworks in place that produce similar results that you are aware of? Please explain briefly.

4) What are the strengths and contributions of the proposed framework? Please explain briefly.

5) Are there any shortcomings of the listed results obtained or the methodology employed by the proposed framework? Please explain briefly.

6) Please provide any other feedback / comments on the proposed framework, results and/or research in general.

Please complete the questions and email your response to ***Herman van Zyl (16593588@sun.ac.za)****, by* ***Monday 22 August 2016****. Thank you for your assistance and feedback, it is greatly appreciated!*

Appendix E – Additional RCA Examples

Sustained Development

Table E-1: Causal factor summary of sustained development barriers
Source: (Edinger 2014; Elliot 2012; Elliot 2015b)

Barrier	Influencer	Root cause	Causal Factor / Alleviation strategy
Restricted access to capital	Government	RC 1.1	Require political certainty to reassure investors that the country is well managed
		RC 1.2	Mismanagement of subsidies promised by government to businesses, leads to loss of expected capital
		RC 1.3	Delays in government regulations, such as EIA processes and the issuing of permits / licences, leads to project delays and the loss of capital
	Domestic businesses	RC 1.4	Juniors struggling to gain footing in market and gain access to investments
	Local and foreign investors	RC 1.5	M&A activity is hampered by global macroeconomic uncertainties
		RC 1.6	Global markets are tight and investor sentiment in minerals are weak
		RC 1.7	Risk premium attached to SA mining investments, due to volatile labour conditions
		RC 1.8	Companies are separating global assets from SA assets to raise capital for international operations
		RC 1.9	Lacklustre commodity performance results in the abandonment of projects which do not offer high enough returns
Underdeveloped technology	Domestic businesses	RC 1.10	Focus is on short-term gain instead of developing technologic and operation

			systems to improve efficiency and reduce wastage
		RC 1.11	SA's cheap labour often does not economically justify expensive technologic and operational upgrades
	Government	RC 1.12	Government places priority on job creation rather than invest in technology development which could decrease employment
	Government	RC 1.13	SA's annual invest in R&D is low compared to the international average since more resources are assigned to other sectors such as health and education services
	R&D facilities	RC 1.14	The interests of R&D companies and role players partaking in mineral value chains are often misaligned, resulting in R&D often focusing on issues that are not major concerns for such role players. Thus, leaving pressing issues that can be alleviated through research, unaddressed.

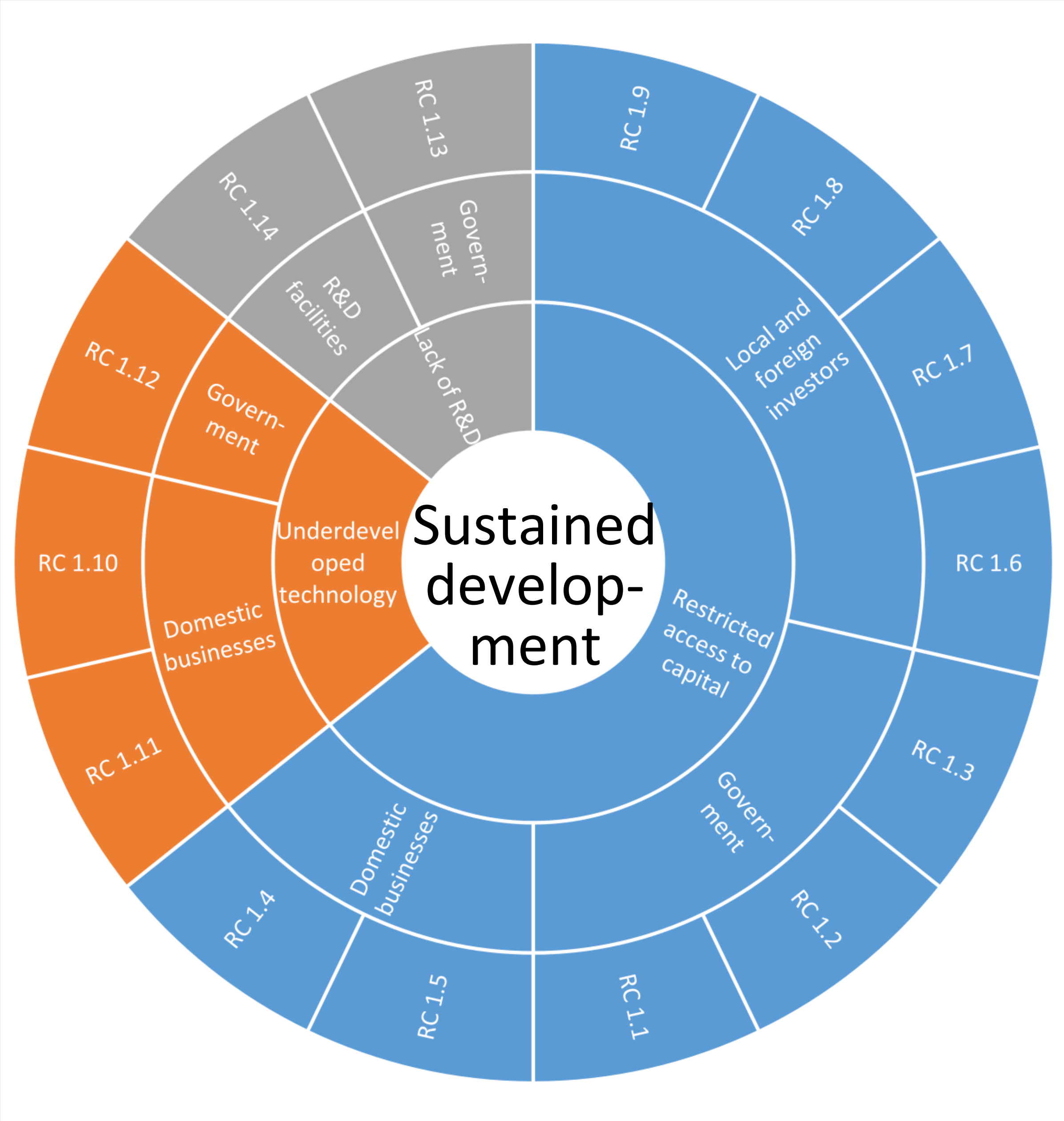


Figure E-1: Sunburst diagram for sustained development barriers

Labour

Table E-2: Causal factor summary of labour barriers
Source: (Fedderke & Fedderke 2012; Elliot 2012; Elliot 2014)

Barrier	Influencer	Root cause	Causal Factor / Alleviation strategy
Rising cost of labour	Economy	RC 2.1	Inflation increases each year, causing significant downward pressure on wage settlements. Wage inflation will need to be contained.
	SA workforce	RC 2.2	Labour costs are increasing with competition for scarce skills. A national shortage of skills increases the portability of skilled mining industry personnel. If more trained workers are available, the costs will decrease.
	SA workforce / Government	RC 2.3	Since many of the activities involved in the MVC are very technical, companies must hire employees who are highly literate and have specialized skill sets. Their labour costs are higher than organizations that can quickly train employees to do simple and repetitive tasks. Workers who have unusual combinations of skills can often command the highest wages.
	Domestic business	RC 2.4	Companies with workers constrained by inefficiencies, such as poorly maintained equipment, unproductive meetings, and shortages of essential materials, face labour cost increases. Inefficient scheduling that results in overtime is another

			culprit behind high labour costs. Better management of activity processes and the workforce can reduce these costs.
Unrest / Volatility in workforce	Domestic business / Unions	RC 2.5	Wage increases not met
	Domestic business	RC 2.6	Better working conditions (safer)
Low productivity of workforce	Domestic business	RC 2.7	Improved management of the workforce can shift focus towards optimizing productivity through capital structure, and more rational use of labour and equipment.
		RC 2.8	During the commodity boom, miners accelerated recruitment in a time of severe skills shortages. This meant that they were recruiting inexperienced staff and managers leading to a steady decline in labour productivity. Training and recruitment of skilled workers can improve productivity.
Skills shortage	Domestic business (management)	RC 2.9	Strong commodity prices and confidence in the long-term sector fundamentals have reinvigorated investment in mining and metals to quickly develop new projects or to ramp up production from existing ones. This often results in a instant need for workers at the cost of experience or training.
	Domestic business (management)	RC 2.10	Companies have to reassess longer-term demand for specific skills in light of expected automation. Several companies are working to adopt automation technologies that could be applicable at a broader level across the industry. With this in mind, some training

			programmes can be decreased.
	Domestic business (management)	RC 2.11	Companies need to incorporate innovative programs to develop new career paths. The traditional model, wherein a worker joins the sector after completing an undergraduate program and stays in the job and/or organization for years, is a historical one since employees are more likely to change jobs and even sectors fairly frequently. Mining and metals companies can facilitate these changes by opening up different experiences for their staff and thereby maintain their talent pool, for instance providing new and existing employees with broad-based training applicable across all its operations.

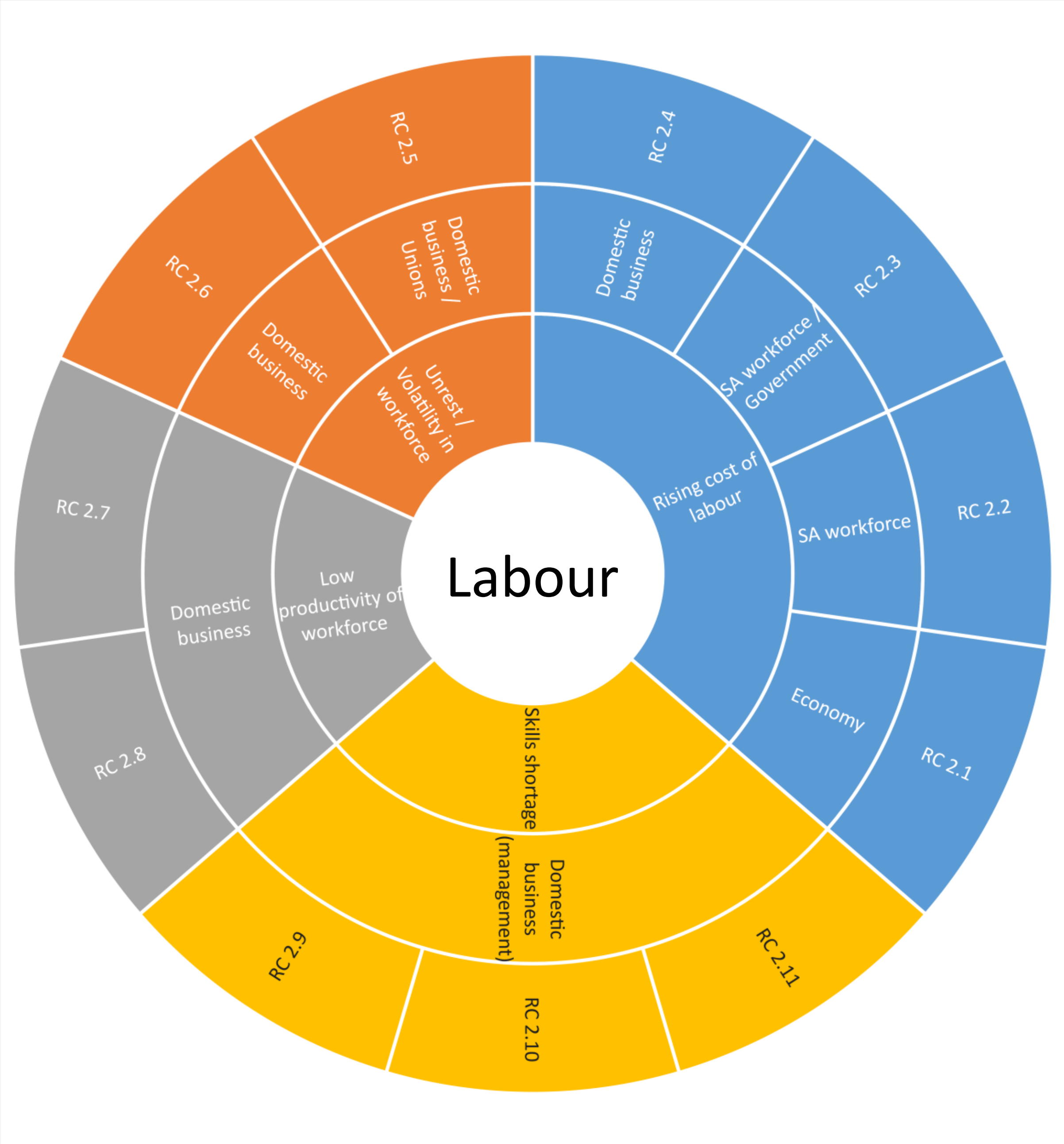


Figure E-2: Sunburst diagram for labour barriers

Market Conditions

Table E-3: Causal factor summary of market conditions barriers
Source: (Elliot 2014)

Barrier	Influencer	Root cause	Causal Factor / Alleviation strategy
Market volatility	Economy	RC 3.1	Demand for most commodities, driven by China and other rapid-growth economies, has outstripped supply for the best part of the past decade, fuelling higher prices and encouraging new supply. As supply and demand now approach equilibrium, longer lead times in changing production are leading to overcorrection and under correction in supply, causing increased price volatility.
Fluctuations in exchange rate	Economy	RC 3.2	A fall in global commodity prices has negatively impacted the currencies of commodity-producing countries, such as South Africa. Other causes include the increasing price of crude oil, a lack of foreign investment, an increased current account deficit, a struggling manufacturing sector, strikes (specifically in the mining industry), the on-going power crisis, insufficient local savings and a weak gross domestic product.
Competition / Oversaturated market	Local role players	RC 3.3	An increase in new entrants, has lead to greater competition for market share and also the use of essential infrastructure, such as railway capacity and port facilities.
		RC 3.4	The fragmentation of the local South African mining sector, has consequently lead to a share of power industry. Where price, infrastructure and other resources were previously controlled by one or two entities, these factors are determined by a number of companies. This splintering of the local market share has spread

			profits thinly across many role players involved in this field.
	Government	RC 3.5	Government provides many incentives and capital investments to new entrants in the industry which often do not have a lot of experience in the industry, which lead to the mismanagement of operations. This has a ripple effect to other role players in the industry.
Sizeable domestic market / Proximity to market	Local role players	RC 3.6	South Africa has a strong mineral production economy with characterized by downstream activities. Many of the locally produced products goes through value-adding steps and are exported abroad to countries where there is a stronger focus on beneficiation and further processing of these materials.
	Foreign role players	RC 3.7	Consumers tend to support local businesses, meaning that with the addition of logistical costs on South African products in transporting goods abroad, foreign companies rather have trade agreements with local producers of similar products.
	Government	RC 3.8	Up until recently, little done to promote local production and value-adding of products
Anti-dumping duty	International market	RC 3.9	Anti-dumping duty is imposed on the import of foreign products. The economic advantage that South Africa inherits from its abundance in natural resources and the processing their of, dissolves with the addition anti-dumping duty that has to be incurred in its costs.
Geopolitical uncertainty	Government	RC 3.10	Political instability can cause a collapse in consumer demand, an increase in currency volatility and disrupt critical infrastructure and transportation networks. Proper initiatives to curb corruption, restore economic stability and promote confidence for investors, are lacking in government and consequently causing these problems.

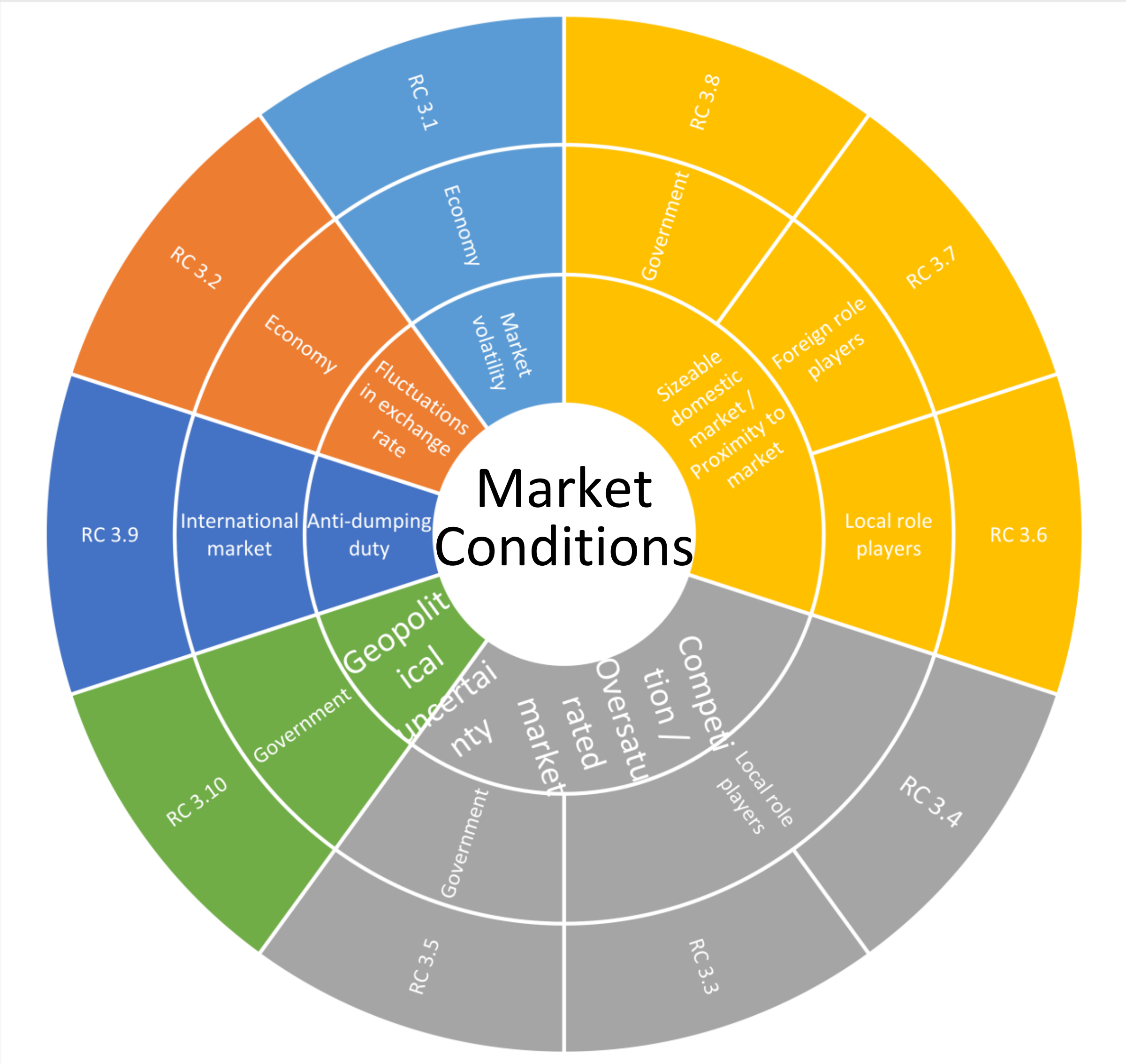


Figure E-3: Sunburst diagram for market conditions barriers

Regulations/Policies

Table E-4: Causal factor summary of regulations/policies barriers
Source: (Elliot 2014; Elliot 2015a)

Barrier	Influencer	Root cause	Causal Factor / Alleviation strategy
Environmental concerns	Government	RC 4.1	Government is implementing stricter policies and regulations towards applying sustainable operating models for companies. These companies need to align their business strategy with these policies in order to avoid paying penalties and in some cases receive incentives from the state.
		RC 4.2	Government officials often have to perform an environmental impact assessment (EIA) before the construction of operating facilities, such as mines, and for the disposal of waste products. These assessments are very time consuming and often delayed due to poor communication and mismanagement.
	Local communities	RC 4.3	Companies opening operations with new industrial facilities experience pressure from local communities to cause as little disruption to the local environment as possible. These operations often face immense resistance from the communities when more sustainable approaches to operations are not implemented.
	International pressure	RC 4.4	Mineral companies are constantly under scrutiny by regulators, external stakeholders, and activist NGOs to adopt a more sustainable approach to operations. Climate change concerns have increased the sensitivity of all the stakeholders, resulting in legal or punitive action on the companies. Operational strategies has to be reviewed to ensure that activities are in

			accordance with environmental protocols.
	Customers	RC 4.5	There is increasing pressure from the public to change the energy mix, implementing measures to reduce greenhouse gas emissions and adopt a more sustainable approach to operations. This ethical investing is on the rise and impacts not only the brand image, but also the performance of the specific company if it is not properly addressed.
Resource nationalism	Government	RC 4.6	In order to ensure mandated national beneficiation, governments are ensuring export levies or export bans on unrefined ore. This forces companies to adjust their business strategy to deploy beneficiated activities which impacts foreign trade relationships.
Mining Charter concerns	Government	RC 4.7	The South African Mining Charter presents legislative uncertainty for many stakeholders in mining companies. There are uncertainties pertaining to its context, especially regarding the Mining and Petroleum Resource Development Bill and the BEE ownership requirements. These uncertainties cause difficulty in mitigating risks.
Obtaining mining license	Government	RC 4.8	Obtaining the necessary legal documents for mining is often an onerous process. It is strictly controlled by government and administrative mismanagement from their side can lead to delays in production. They ultimately decide when and to whom mining licenses can be issued.
Disposal of slag	Government	RC 4.9	In South Africa the slag that is created as a by-product during manganese alloy production, is discarded on slag dumps and classified as a hazardous material. The slag is discarded on slag dumps despite that it is utilised by many countries around the world in construction materials. This slag cannot be sold in South Africa and large

			expenses is made to properly ensure that the slag is properly disposed according to environmental policies.
	R&D	RC 4.10	More research can be done to classify slag as a commercially viable option for construction materials and to reduce the possible risk for environmental concerns.

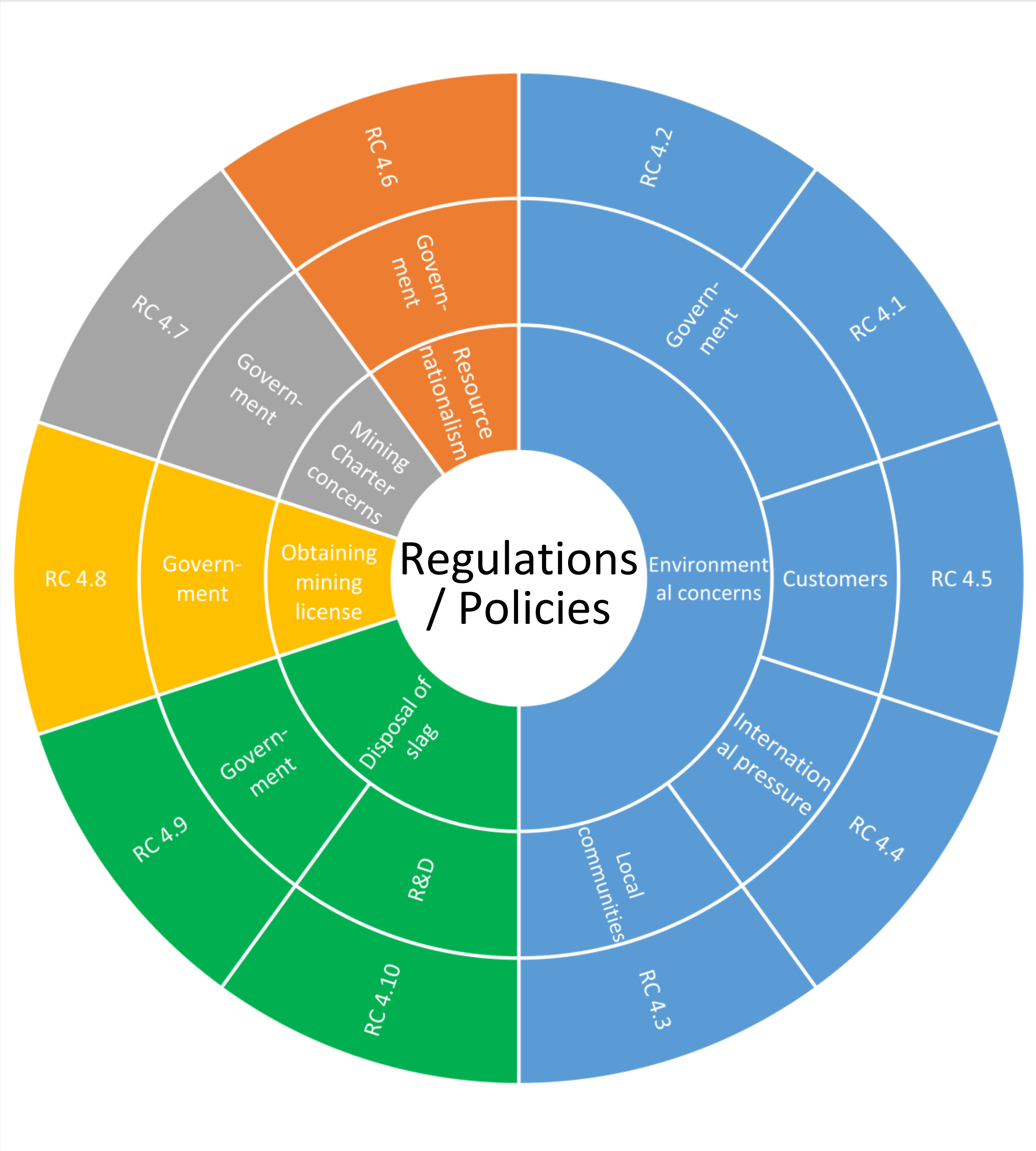


Figure E-4: Sunburst diagram for regulations/policies barriers