

**Investigating international
perceptions of selected South
African foundry products**

PG Diedericks

 **orcid.org/0000-0003-3484-3535**

Mini-dissertation accepted in fulfillment of the
requirements for the degree Master of *Business
Administration* at the North-West University

Supervisor: Dr JA Jordaan

Graduation: May 2022

Student number: 32993633

ABSTRACT

The perceptions from the international HSM steel market towards exported South African foundry products were tested through a qualitative research approach. Customer perception might be either positive or negative, based on several factors, including delivery time, cost, or quality of the foundry product. South African exporting foundries, which include the roll making foundry, experience several challenges associated with the operating environment, and these challenges contribute to potential cost elevations and/or delayed delivery time. Negative perceptions from global customers are subsequently experienced. International consumer perceptions towards South African foundry products need to be understood, as this information enables South African foundries to properly target the customer market. The results obtained from respondents based in various geographical markets were coded, analysed, and discussed in the study.

Research analyses performed on the geographical market showed that customer location plays a critical role in selecting the correct targeting strategy. The European markets tend to perceive the quality as well as price of South African foundry products as average. The North American market showed that, although South African foundry products are perceived to be price competitive, poor perceptions regarding on-time delivery are experienced. Asian markets typically perceive South African foundry products as expensive and on the price level of a European exporter. Total cost of ownership (TCO) was seen to be an important factor to consider across all the geographical markets.

The distance to the market can be seen as a limiting factor for the South African foundry industry, which forces organisations to think more critically on process improvements and rework. It is for this reason that an implementation plan, which includes the application of the change management process of Kotter (1996), was included in the study.

Keywords: International, perception, foundry, exports, hot strip mill, TCO

ACKNOWLEDGEMENTS

First and foremost, I would like to thank God Almighty for enabling me to commence and finalise this study. I am writing this acknowledgement with tears in my eyes, as two weeks prior to submission my youngest son was unexpectedly diagnosed with Leukaemia. I dedicate all my work completed in the MBA programme to him, Andries Gerhardus Diedericks. I am also extremely grateful to my wife, Wilma Diedericks, who stood by me during this two-year period, I know the common notion is that this programme is called the 'divorce course', but we went through this as a team, and for that I will always be grateful.

To my parents and family, I also thank you all for the patience and understanding over the past two years.

Dr Johan Jordaan, thank you for your guidance and mentorship. You are truly an individual I will always look up to and remember.

To Harold Pretorius, thank you for believing in me and giving me this opportunity. Our conversations regarding strategies and business taught me a lot and enabled me to grow as a manager.

TABLE OF CONTENTS

CHAPTER 1: NATURE AND SCOPE OF STUDY 10

1.1 INTRODUCTION..... 10

1.2 BACKGROUND 10

1.3 PROBLEM STATEMENT 11

1.3.1 RESEARCH QUESTION..... 11

1.4 OBJECTIVES OF THE STUDY..... 14

1.4.1 PRIMARY OBJECTIVES 14

1.4.2 SECONDARY OBJECTIVES 14

1.5 IMPORTANCE AND BENEFITS OF THE PROPOSED STUDY 14

1.6 DELIMITATIONS (SCOPE)..... 14

1.7 ASSUMPTIONS 15

1.8 LITERATURE REVIEW..... 15

1.9 METHODOLOGY AND RESEARCH DESIGN 15

1.9.1 DESCRIPTION OF OVERALL RESEARCH DESIGN..... 15

1.10 STUDY POPULATION..... 16

1.11 SAMPLING STRATEGY 16

1.11.1 EXPECTED LIMITATIONS OF THE STUDY..... 17

1.11.2 DATA COLLECTION 20

1.11.3 DATA ANALYSIS 21

1.12 QUALITY AND RIGOUR OF THE RESEARCH DESIGN..... 21

1.12.1 QUALITY OF DATA..... 21

1.12.2 RELIABILITY 22

1.12.3 VALIDITY 22

1.13 RESEARCH ETHICS 22

CHAPTER 2: LITERATURE REVIEW 23

2.1 METAL CASTING IN A FOUNDRY	23
2.2 THE INTERNATIONAL FOUNDRY INDUSTRY.....	24
2.3 THE SOUTH AFRICAN FOUNDRY INDUSTRY	26
2.3.1 CHALLENGES IN THE SOUTH AFRICAN FOUNDRY INDUSTRY.....	28
2.4 THE ROLL MANUFACTURING FOUNDRY.....	31
2.5 THE HOT STRIP MILL (HSM).....	35
2.5.1 TOTAL COST OF OWNERSHIP	37
2.6 CONSUMER PERCEPTION OF MANUFACTURED PRODUCTS.....	38
2.7 ALTERING PERCEPTIONS.....	42
2.7.1 THEORY OF CHANGE MANAGEMENT.....	42
2.7.2 APPLYING CHANGE MANAGEMENT MODEL	42
CHAPTER 3: RESEARCH METHODOLOGY.....	45
3.1 INTRODUCTION.....	45
3.2 QUALITATIVE EMPIRICAL SETTING.....	45
3.3 SAMPLING	45
3.4 INTERVIEW PROTOCOL	46
3.5 DATA COLLECTION	46
3.5.1 DATA RECORDING.....	46
3.5.2 DATA ANALYSIS	47
3.5.3 STRATEGIES EMPLOYED TO ENSURE QUALITY DATA.....	47
3.5.4 REPORTING	48
3.5.5 ETHICAL CONSIDERATIONS.....	48
CHAPTER 4: RESULTS AND DISCUSSION.....	49
4.1 INTRODUCTION.....	49
4.2 QUALITATIVE RESULTS	49
4.2.1 THEMES IDENTIFIED.....	49

4.2.2 GEOGRAPHIC ANALYSIS	54
4.2.3 ORGANISATIONAL SECTION ANALYSIS	59
4.3 CUSTOMER BEHAVIOUR.....	59
CHAPTER 5: CONCLUSION AND RECOMMENDATIONS	62
5.1 INTRODUCTION	62
5.2 RECOMMENDATIONS	62
5.2.1 IMPROVEMENTS IN TARGETING THE CUSTOMER MARKET	62
5.3 IMPLEMENTATION PLAN.....	65
5.3.1 CHANGE MANAGEMENT	66
5.4 CONCLUSION	70
5.5 LIMITATIONS OF THE STUDY.....	70
5.6 FURTHER RESEARCH	71

LIST OF TABLES

Table 1: Abbreviations used in this documentix

Table 2: Units of analysis determined for the study 19

Table 3: SWOT analysis of South African foundries from the University of Johannesburg..... 30

Table 4: Revised units of analysis applicable to the study 46

Table 5: Questions as per the interview protocol 47

Table 6: Steel demand forecast per geographic region..... 64

Table 7: Proposed strategic implementation plan for South African foundries 67

LIST OF FIGURES

Figure 1: (a) South African export market, (b) production and sales trends of the metal products export category, (c) formal employment and remuneration trend of the metal product export category, and (d) employment composition trend of the metal product export category 13

Figure 2: Hot rolled product produced across the globe in 2018 16

Figure 3: Proposed data collection flow applicable to the study 21

Figure 4: Typical casting configuration in a foundry 23

Figure 5: Typical process flow of a foundry..... 24

Figure 6: Global casting production of grey iron, ductile iron and steel castings 25

Figure 7: Strategic challenges in the global foundry industry 27

Figure 8: (a) Markets served by South African foundries, and (b) foundry industry structure ... 28

Figure 9: South African manufacturing GDP for the past 10 years..... 29

Figure 10: Energy distribution of foundry processes 31

Figure 11: International electricity price survey showing the price difference from 2013 to 2014	32
Figure 12: Reduction of steel slab in a continuous hot strip mill.....	33
Figure 13: Typical roll manufacturing process. (a) Horizontal spin casting, and (b) vertical pouring of core material.....	33
Figure 14: Manufactured rolls for rolling mills	34
Figure 15: Rand value of rolls (H84553000) exported from South Africa since 1992	34
Figure 16: Iron and steelmaking process flow.....	35
Figure 17: Layout of typical HSM.....	36
Figure 18: Typical construction of a mill stand in a finishing mill	36
Figure 19: Major developments in HSM technology since 1950.....	37
Figure 20: Average performance (tonne/mm) of the seven stands in ArcelorMittal Dofasco. (HSS rolls and ICDP rolls)	38
Figure 21: (a) International customer rating vs South African company performance rating, (b) international customer rating vs international competitor performance rating, and (c) gap analysis between South African vs international competitor firm	41
Figure 22: Milestones of change management from 1990 to 2020	44
Figure 23: Qualitative analysis grouped theme: Negative influence	50
Figure 24: Qualitative analysis grouped theme: Positive influence	51
Figure 25: Qualitative analysis grouped theme: Price perception	51
Figure 26: Qualitative analysis grouped theme: Quality perception	52
Figure 27: Qualitative analysis grouped theme: Valued elements.....	52
Figure 28: Qualitative analysis grouped theme: Logistics	53
Figure 29: Geographic perception: South America, Brazil	55
Figure 30: Geographic perception: Asia, India.....	56

Figure 31: Geographic perception: North America, USA..... 57

Figure 32: Geographic perception: Europe, Germany 58

Figure 33: Geographic perception: Asia, Taiwan 59

Figure 34: Roll selection process..... 61

Figure 35: Crude steel production per geographic distribution (2020)..... 62

Figure 36: Targeting strategies employed in global markets 65

Figure 37: The marketing strategy implementation process..... 66

The list of abbreviations applicable to this study is depicted in Table 1.

Table 1: Abbreviations used in this document

Abbreviation	Meaning
BRICS	Brazil, Russia, India, China and South Africa
CAQDAS	Computer-Assisted Qualitative Data Analysis Software
COO	Country-Of-Origin
GDP	Gross Domestic Product
HiCr	High Chrome Rolls
HS Code	Harmonised System Code
HSS	High Speed Steel Rolls
HSM	Hot Strip Mill
ICDP	Indefinite Chilled Cast Iron Rolls
IDC	Industrial Development Corporation
KPI	Key Performance Indicator
NAFTA	North America Free Trade Agreement
SAIF	South African Institute of Foundrymen
TCO	Total Cost of Ownership

CHAPTER 1: NATURE AND SCOPE OF STUDY

1.1 Introduction

Selection of foundry products in the hot strip mill (HSM) was historically performed based on the perception by buyers of a given foundry product manufacturer (Webber, 2017). This customer perception might be either positive or negative, based on several factors, including delivery time, cost or quality. South African exporting foundries, which include the roll making foundry, experience several challenges contributing to potential cost elevations and/or delayed delivery time, subsequently leading to negative perceptions from global consumers.

1.2 Background

In 2003, a National Casting Technology Centre (NCTC) was established through the National Product Development Centre (NPDC) of the Council of Scientific and Industrial Research (CSIR). The primary objective of this technology centre is to ensure that expertise and casting capabilities are expanded within South Africa. Process development, skills development and technology transfer within South African foundries are also promoted by the NCTC. The NCTC benchmarks with international centres and subsequently promotes the international competitiveness of the South African foundry industry (Bean *et al.*, 2006).

South Africa is an exporter of HSM consumables, and must therefore participate in the international playing field, meaning that products exported from South African foundries are sold in a competitive global market. For foundries to increase their competitiveness and profits, the mitigation of risks associated with industry challenges must be managed. According to a report provided by the South African Institute of Foundrymen (SAIF) to the BRICS foundry forum in 2015, the following challenges were identified for South African foundries (Madzivhandila, 2015):

- Slow economic growth is causing a reduction in orders,
- Energy costs are significantly rising,
- The productivity of labour is poor,
- Skills development and training are lacking,
- Environmental legislation compliance is a concern,
- Elevated logistics costs,
- Accessing capital for improvement projects is difficult,
- Special skills are required for recent technological advances, and
- Foundry environment is not a welcoming workspace (hot and dirty).

To consolidate the findings by the SAIF, research performed by the University of Johannesburg (UJ) on the strengths, weaknesses, opportunities and threats (SWOT) of the South African foundry industry, includes the challenge in this industry contributed by poor international market perceptions (Mphasha, 2016).

1.3 Problem statement

According to the Industrial Development Corporation, a subsidiary of the Department of Trade Industry & Competition, South Africa had an export value of approximately R1.3 trillion (for 2019) with a geographical export footprint as depicted in Figure 1(a) (IDC, 2020). Approximately R17 billion of exports are attributed to the metal products category. This category refers to the Harmonised System (HS) Code 84 as classified by the World Customs Organization (WCO) (ITA, 2021). HS Code 84 is further subdivided in several industrial machinery sub-sections, including metal rolling mills and rolls (84.55), thereby inferring that consumables used in the HSM are included in this sub-section. Several other exports within HS Code 84 contribute to the overall metal products category. These exports include, but are not limited to, nuclear reactors, steam boilers, steam turbines, fork-lift trucks, agricultural machinery, machinery for making tobacco and moulding boxes for metal foundries. Data obtained from the IDC indicates the declining production volume as well as the deteriorating employment trend in this sector. Figure 1 (b)-(d) represents the trends for the past five years.

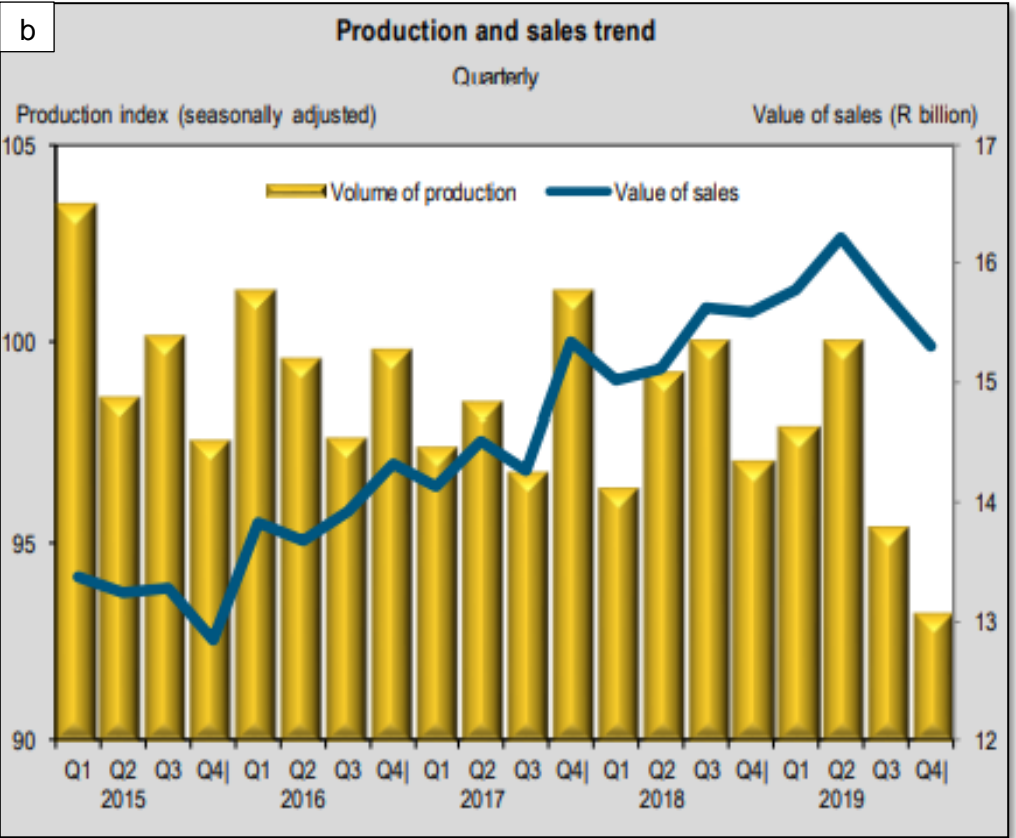
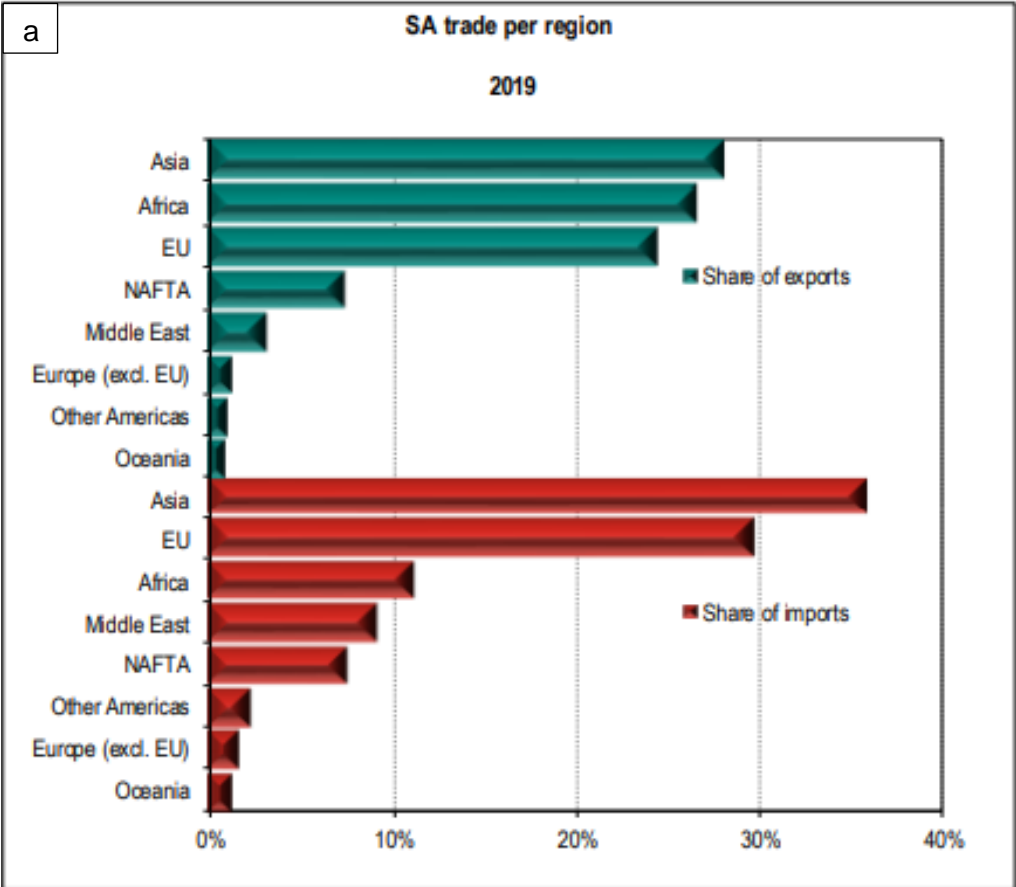
The foundry industry is a substantial contributor towards the manufacturing of products exported in HS Code 84. The castings produced at South African foundries are subject to severe operational and economic pressures as eluded to by the SAIF in 1.2 (Madzivhandila, 2015), thereby causing uncertainty regarding the sustainable continuance of exporting foundries in South Africa. Apart from operational challenges experienced in South Africa, competitiveness in the international market arena remains vital to business.

Perceptions of international clients on exported South African castings remain an important aspect that requires further evaluation. This study investigates the perception of international steel rolling customers, more specifically hot rolling producers, on the castings exported from South Africa.

1.3.1 Research question

The primary research question is constructed as:

What is the international perception on selected exported South African foundry products?



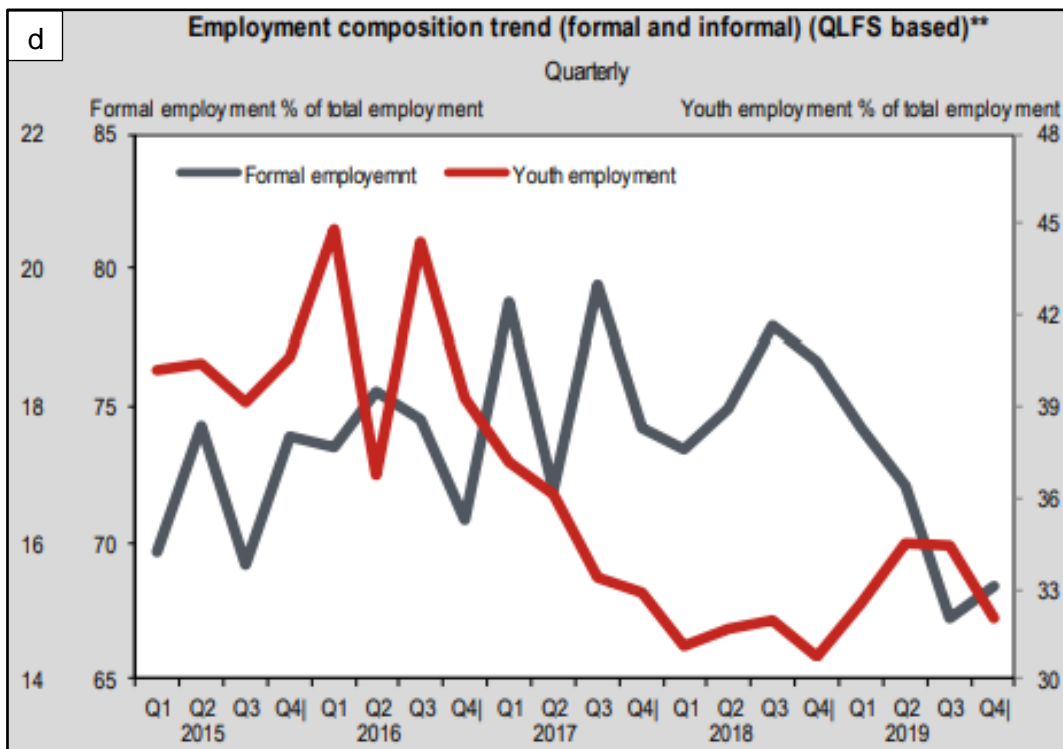
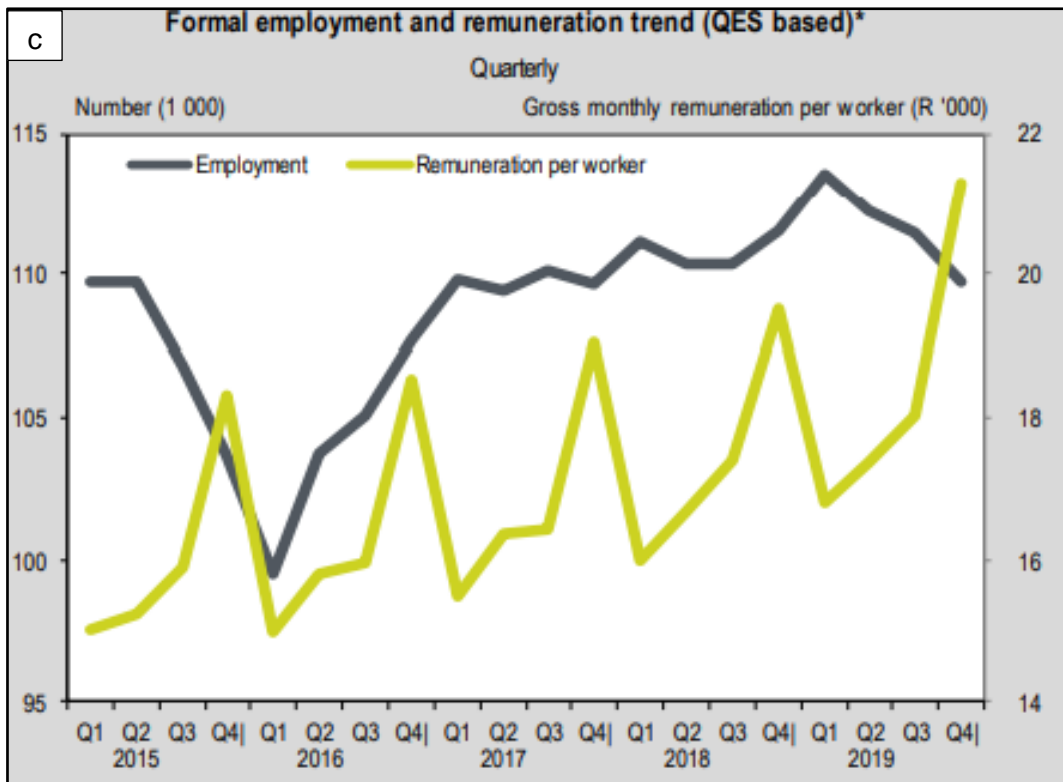


Figure 1: (a) South African export market, (b) production and sales trends of the metal products export category, (c) formal employment and remuneration trend of the metal product export category, and (d) employment composition trend of the metal product export category
Source: IDC (2020)

1.4 Objectives of the study

1.4.1 Primary objectives

The primary objective of the study is to investigate the international perceptions of HSM consumables exported from South African foundries.

1.4.2 Secondary objectives

The secondary objectives of the study are:

- to describe the South African foundry industry through a literature study,
- to understand the HSM consumable environment of South African exports through a literature study,
- to empirically investigate the international perception of global hot rolling companies, and
- to recommend actions that will improve customer perceptions and subsequently lead to greater export tonnage.

1.5 Importance and benefits of the proposed study

The managerial importance and benefits of this proposed study are:

- By analysing factors that contribute to the negative perception of exported consumables to the international steel market, South African foundry managers will be able to implement efficient strategies that will lead to improved customer-oriented thinking.
- Results linked to the effects of geographical location on perception can shift the marketing strategy of the South African foundry industry.
- This field of study further contributes to understanding the impact of the poor South African economy on this energy-intensive manufacturing sector.

1.6 Delimitations (scope)

The scope of this study was limited to companies producing hot rolled products (specifically flat products). These companies were interviewed regarding their perception of South African imported consumables for specific use in the HSM operation.

1.7 Assumptions

The main assumptions made in the proposed study are:

- Perceptions of international steel companies on South African imports vary according to geographical location.
- Multinational steel companies have separate buying departments.
- The perceptions of imported products vary between customer commercial and operational department.
- The outcomes from the sample selected for the geographical region represent the perceptions of the entire geographical market.

1.8 Literature review

The literature is discussed in Chapter 2 and deals with the detailed description of the international as well as South African foundry industry. The perceptions towards products exported from South African foundries are also studied in the literature. Theoretical models relating to change management are described to understand potential methods of altering customer perception.

1.9 Methodology and research design

The research methodology, including the design and sample population utilised for this study, is discussed in this section. Proposed data collection and assessment techniques are also discussed.

1.9.1 Description of overall research design

A qualitative study was performed for this study. The social phenomenon of individual perception towards a specific group of products was tested. This qualitative study attempted to analyse human nature with a series of interview questions.

A cross-sectional study is typically a short once-off study, normally analysing a specific concept or phenomenon in several cases. A longitudinal study, on the other hand, continues over an extended period of time, where the same sample is studied in various occasions to analyse differences in results. A longitudinal study can either be classified as a panel or cohort study (Bryman & Bell, 2014). The current study was cross-sectional, as the study was based on a single phenomenon (perception of international customers). The study was not performed over an extended time period.

1.10 Study population

The study looked at the perception of foundry products, specifically HSM consumables exported from South Africa to international steel companies. The markets selected for the study were based on the global steel manufacturing sector. The study population was more specifically based on steel plants that produce hot rolled products (specifically flat products). Figure 2 graphically depicts the latest available data (2018) for relative comparison of hot rolled products produced per geographic location. The total world production for hot rolled products was 1 682 437 thousand tonnes for 2018 (WorldSteel, 2019). As seen in this graphical distribution, hot rolled product manufacturing is concentrated in Asia, America and Europe. Appendix 1 (WorldSteel, 2018) refers to hot-rolled production figures per geographical region across the globe, while Appendix 2 (WorldSteel, 2020) indicates the top 104 steel companies across the globe. Appendix 2 further shows the company headquarters as well as respective crude steel tonnage (million) produced.

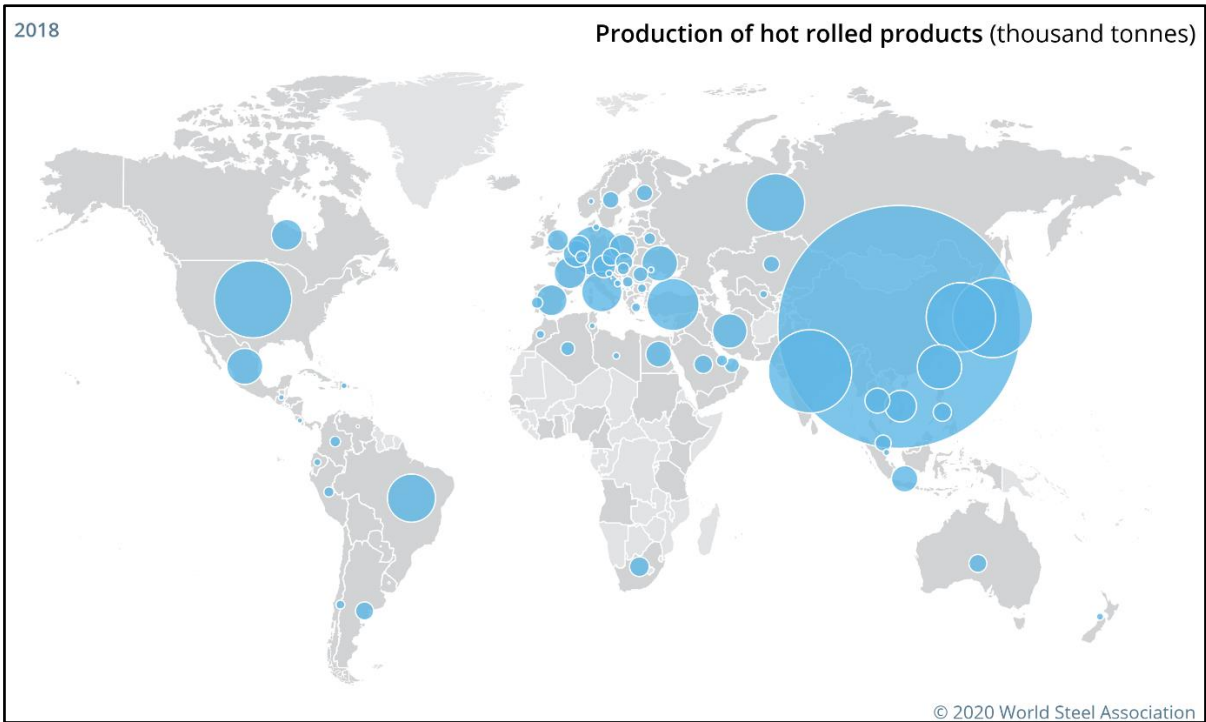


Figure 2: Hot rolled product produced across the globe in 2018
Source: WorldSteel (2018)

1.11 Sampling strategy

As the number of HSM plants across the globe is extensive, a sampling strategy that ensures an unbiased selection of hot rolling plants was performed. A snowball sampling technique was utilised to facilitate non-probability sampling. Sampling was performed until saturation was

reached. A list of six criteria was applied to data from Appendix 1 to generate the sample list. The following criteria were applied:

Criterion 1: Only hot rolled product producing companies (flat products) were selected for the study (relevant to all data on Appendix 1).

Criterion 2: Only steel companies in countries with production tonnages above 10 million tons per annum were selected.

Criterion 3: Only a maximum of four countries per geographical region were selected.

Criterion 4: Selection of companies associated per country as per Appendix 2 was done as far as possible.

Criterion 5: No duplication of sample companies was allowed.

Criterion 6: Discarding of countries associated with political tension was performed.

Table 2 depicts the results of the units of analysis upon application of the six criteria on data found in Appendices 1 and 2. The number of plants identified totals 15. The study requested interviews with two departments within the steel producing company; the first department interviewed performs the buying and importing of products (commercial department); while the second department is the end-users of the imported foundry product (operation environment). The total sample size for this study was therefore determined as 30.

The unit of analysis for the study will be steel producing companies producing hot rolled products. The data will be obtained from individuals employed in these private hot rolling manufacturing companies. The selected unit of analysis was tested against the research question, as the six criteria applied to the population gave representative information in terms of geographical location and hot-rolled product density.

1.11.1 Expected limitations of the study

The sampling difficulty was varied based on the geographical location, as barriers in terms of language played a vital part in sourcing useful data. Contact with many of the companies was less difficult, as these companies are customers to several foundries in South Africa. Contact details of companies not falling under the current customer base were requested from agents employed by foundries. As a final resort, contact details were obtained from information obtained on company websites. Additional limitations to the proposed study included the following:

- The researcher represents a roll manufacturing exporter in South Africa, and therefore the results and conclusions proposed in this study were not necessarily representing the views of all South African foundries.
- International customer perception might be different for a roll manufacturer compared to the overall perception of South African foundry exports.
- As a result of the limited time associated with the proposed research, not all hot rolling companies across the globe were approached, and possible valuable insights might be unexploited due to saturation of sampling.

Table 2: Units of analysis determined for the study

Geographical area	Country	Steel producer group	Division	Plant location
European Union	Germany	ThyssenKrupp	Bochum	Bochum, Germany
	Italy	Arvedi	Acciaieria Arvedi	Cremona, Italy
	France	ArcelorMittal Europe	ArcelorMittal Dunkerque	Dunkerque, France
	Spain	CELSA Steel group	CELSA Barcelona	Barcelona, Spain
Other European	Turkey	Erdemir Group	Eregli Iron and Steel Mill	Istanbul, Turkey
C.I.S	Russia	Novolipetsk Steel (NLMK)	Novolipetsk Steel	Lipetsk, Russia
	Ukraine	Metinvest Holdings	AZOVSTAL IRON & STEEL WORKS	Mariupol, Ukraine
North America	USA	Nucor Steel Corporation	Nucor-Yamato Steel	Blytheville, USA
	Mexico	Altos Hornos	Monclova	Monclova, Mexico
	Canada	ArcelorMittal	Dofasco	Hamilton, Canada
South America	Brazil	Gerdau S.A	Aços Longos e Planos Açominas	Ouro Branco, Brazil
Asia	China	Baowu Group	Baosteel - Main site	Shanghai NE, China
	India	Tata Group	Jamshedpur Plant	Jamshedpur, India
	Japan	Nippon Steel Corporation	East Nippon Works, Kashima Area	Kashima City, Japan
	South Korea	POSCO	Pohang Plant	Pohang-si, South Korea

1.11.2 Data collection

After a technical evaluation of the influence of factors associated with increased casting cost in South Africa, an initial introduction letter was sent followed by a telephone conversation with the commercial as well as production plant of each sample company. The introduction letter was mailed to the relevant individual to explain the nature of the study. The following methods were used to gain access to commercial and production employees:

- An internet search of the company website,
- Online professional platforms such as LinkedIn,
- Agents employed by the foundry industry; these agents know the hot-rolling customers very well as they sell consumables directly to the various hot-rolling plants,
- Contacts obtained from South African foundry marketing departments.

The introduction letter requested permission to perform and record a 20-minute video (Zoom/Teams) interview. The interview asked questions related to the perception of South African imported consumables. The various perceptions within the study includes:

- Negative perceptions,
- Positive perceptions,
- Perceptions towards logistics,
- Perceptions towards quality,
- Perceptions towards price,
- Perceptions towards valued elements.

Two different departments in each sample company were contacted and interviewed. Several interview questions were asked in the online session for both the commercial as well as production personnel of each sample company. Figure 3 indicates the data collection flow applicable to the study.

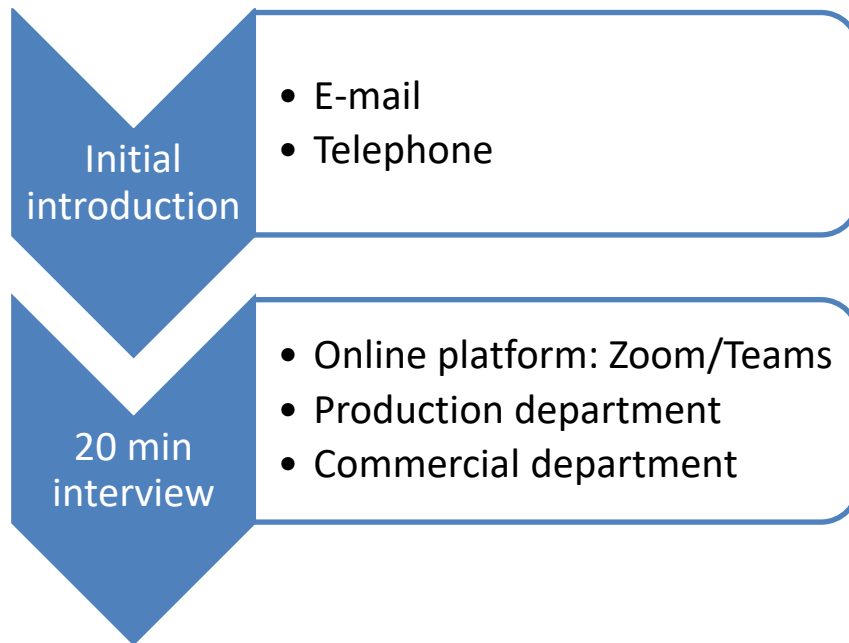


Figure 3: Proposed data collection flow applicable to the study

1.11.3 Data analysis

The recorded interviews were transcribed into text followed by coding through computer-assisted qualitative data analysis software (CAQDAS). The CAQDAS that was employed in the study was Atlas.ti. The analytical findings were portrayed in a network diagram, presenting analytical findings (perception feedback) per geographical region. A further distinction between interdepartmental perception differences (commercial versus operational) was also performed.

1.12 Quality and rigour of the research design

The quality of research data, including the reliability and validity of proposed measurements, was addressed in this section.

1.12.1 Quality of data

The data obtained in the research study answered the research objectives adequately. Data obtained in the study represented the perceptions of international steel producers regarding consumables obtained from South Africa. The research objectives posed in 1.4 were achieved through answering of the interview questions. The number of samples planned for the study amounted to 30. The data represented 15 samples applicable to the commercial department of the steel company, and 15 samples to the operational department. These samples represented data based on the criteria set in 1.11, providing results on customer perception as a function of geographical location.

1.12.2 Reliability

Reliability relates to the quality of data capturing rather than the quality of measures (Bryman & Bell, 2014). Reliability also relates to the repeatability of a set of measurements, seeking stable and consistent results upon repeated measurements of the same sample population and sample.

The method of sample determination is depicted in section 1.11. By utilising the same WorldSteel statistics (WorldSteel, 2019) and criteria, the reliability of data capturing is good as repeatability is obtainable.

1.12.3 Validity

The validity of research data can be separated into two main subsections (Bryman & Bell, 2014), namely:

- Internal validity: Typically weak for qualitative research due to difficulty of casual direction from data.
- External validity: Good for data obtained from randomly selected samples.

Validity measures the trustworthiness of data and indicates the meaningfulness of obtained data. One method of increasing trustworthiness in a research study is through reflexivity (Bryman & Bell, 2014). Reflexivity in business research indicates the reflection and hidden assumption of a researcher when approaching the research. The research approach undertaken aimed to have good external validity and trustworthiness.

1.13 Research ethics

Four main ethical principles need to be adhered to upon conducting business research (Bryman & Bell, 2014):

- Eliminate harm to participants,
- Eliminate lack of informed consent,
- Eliminate invasion of privacy,
- Eliminate deception that may be involved.

All principles as mentioned above were applied upon the planning phase of the research study. The informed consent form utilised in this study is depicted in Appendix 3.

CHAPTER 2: LITERATURE REVIEW

2.1 Metal casting in a foundry

The casting of melted metal into a mould (fabricated either by sand or steel) is one of the oldest metal shaping techniques, discovered around 3500 BC (Thiel, 2016). Solidified molten metal, upon removal from the mould, is referred to as a casting. Common metals utilised in metal castings are aluminium, copper, steel and cast iron. The modern industry as known today, where metals are cast, is called a foundry. A foundry consists of four distinctive sections (Thiel, 2016):

- Mould and core manufacturing,
- Melting of scrap and alloys,
- The casting of the molten metal, solidification and final casting removal from the mould,
- Finishing of the casting (includes heat treatment and machining).

An illustration of the typical process flow in a foundry is depicted in Figure 4 (Thiel, 2016). Raw materials are melted in a furnace and cast into a manufactured mould. Several melting furnace types and mould types are available in the industry. Casting of the molten metal can also be achieved through various processes, from gravitational pouring to centrifugal casting. Figure 5 (Thiel, 2016) shows a typical gravitational casting configuration utilised in a foundry. After separating the casting from the mould, further treatment in the form of elevated temperature (heat treatment) and/or casting clean-up (fettling) can be performed.

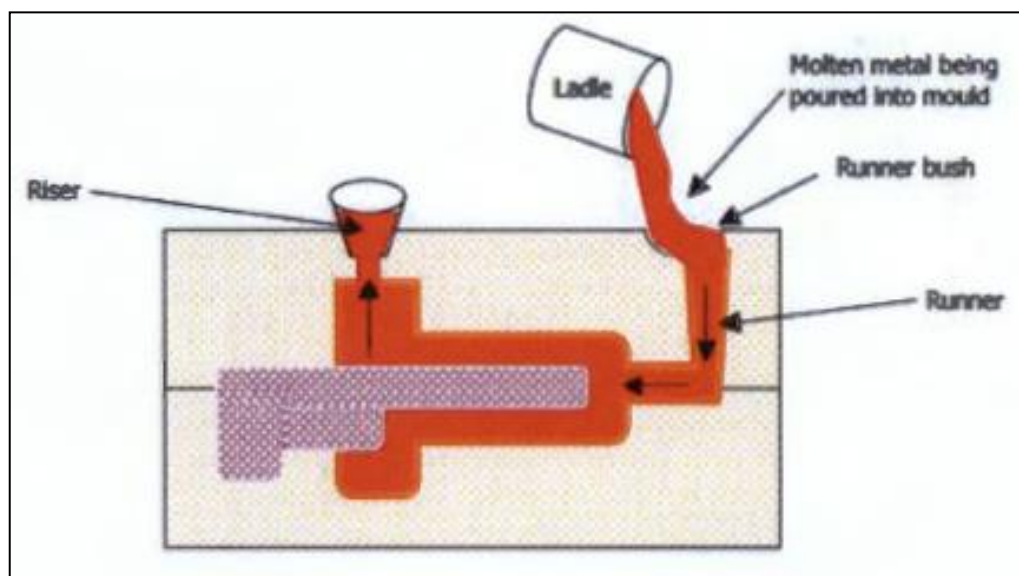


Figure 4: Typical casting configuration in a foundry

Source: Thiel (2016)

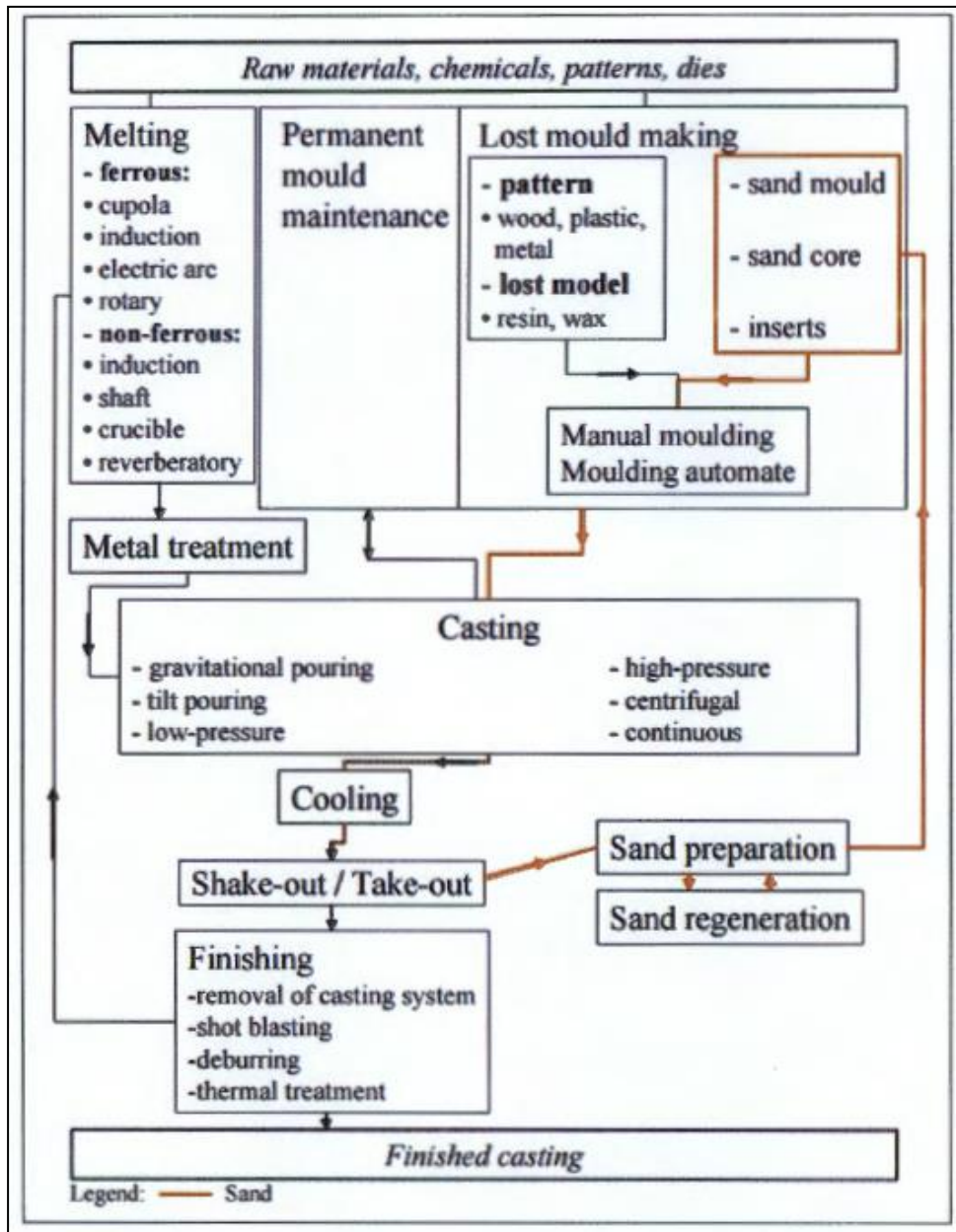


Figure 5: Typical process flow of a foundry
Source: Thiel (2016)

2.2 The international foundry industry

The international foundry industry remains a competitive environment, predominantly dominated by China as shown in research performed by the Deutsche Industriebank (Büchner, 2019). Figure 6 indicates the production of grey iron, ductile iron and steel castings (Büchner, 2019). A noteworthy point is that the global casting contribution from Africa is small compared to the large volume of casting-producing countries, which include the Americas, China and Europe.

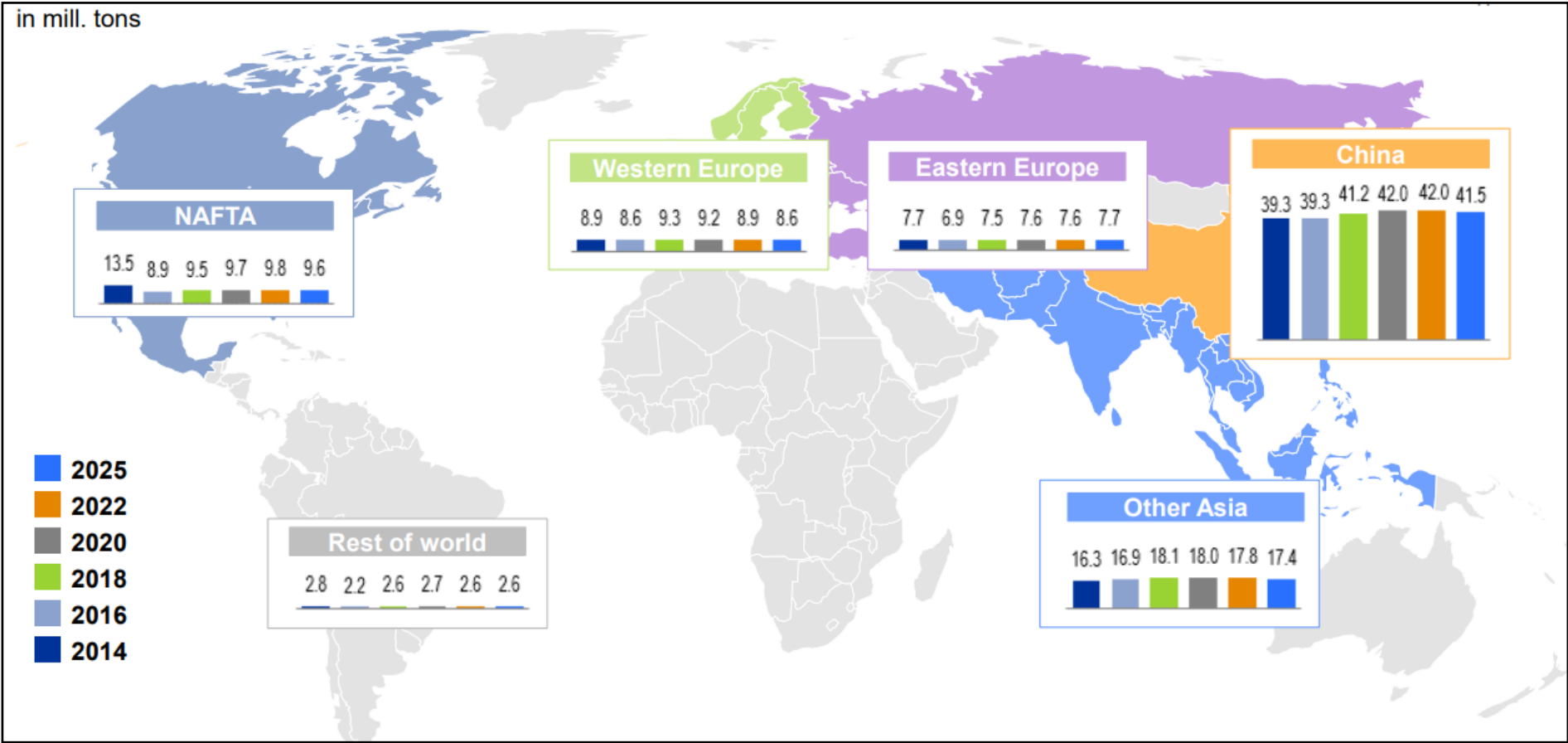


Figure 6: Global casting production of grey iron, ductile iron and steel castings
 Source: Büchner (2019)

International foundries are not immune to threats. The following weaknesses and treats are experienced by European foundries (Mphasha, 2016):

- Perception: Foundries are seen as old, dirty and dangerous,
- Energy: The foundry remains an energy-intensive industry,
- Raw material: Europe does not have any sources of essential raw materials,
- Competition: Substitution materials such as carbon fibre and plastic,
- Skills: Shortage of skilled workers and engineers, and
- Capital: Low levels of capital to innovate. R&D costs taken from customers.

Intensive investments at international foundries are required as metal alloy complexity is continuously increasing. Six segments of global strategic foundry challenges are identified by Büchner (2019) in Figure 7. Industry consolidation is required to deal with the technology changes experienced within the industry.

2.3 The South African foundry industry

The foundry industry in South Africa consists of a relatively wide market reach, as seen in Figure 8(a). The leading customers of foundry products include the automotive industry (wheel rims and chassis), the mining industry (crusher plates and mill components) and the manufacturing industry (steel mill components). In 2015, a total of 170 foundries were operational in South Africa, segregated into various foundry types (Madzivhandila, 2015). Figure 8(b) shows how the foundry industry has decreased since 2011, indicating the closure of 10 foundries in under four years. This closure in foundries comes from a preceding closure of at least 100 foundries since 2003 (SAIF, 2015).







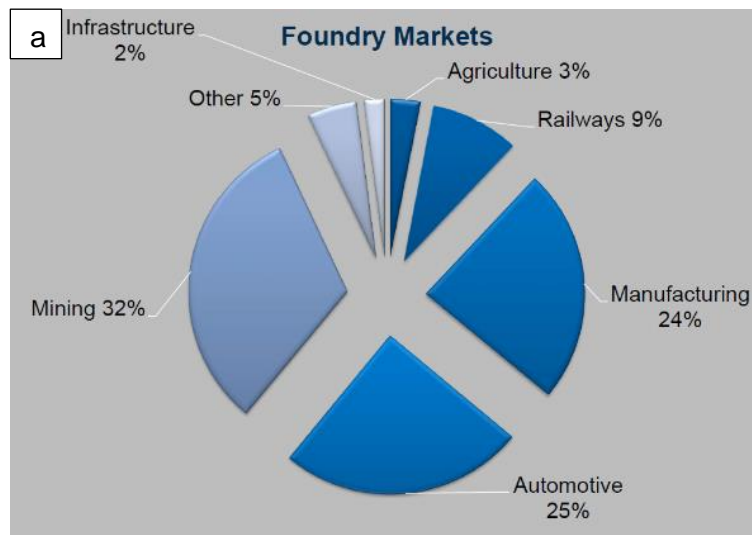
Globalization 	<ul style="list-style-type: none"> ➤ Emerging markets will account for the majority of demand growth ➤ The automotive industry in particular demands local production outside of Europe ➤ Increased requirement of a global presence close to the customer will raise logistics costs
Technological challenges 	<ul style="list-style-type: none"> ➤ Preservation of technology leadership is of high importance, especially for the foundry industry ➤ Pressure on weight reduction will continue (e.g. in automotive and machine construction) ➤ The E-Mobility discussion will significantly change the supply chain, especially in powertrain
Retaining qualified personnel 	<ul style="list-style-type: none"> ➤ Many qualified employees will retire in the upcoming years (primarily in Western Europe) ➤ Competition for qualified personnel intensifies due to changing demographics ➤ Need for new employee retention programs (e.g. balance between work and family) and training
Investment requirements 	<ul style="list-style-type: none"> ➤ Trend towards delivery of completely processed castings will demand corresponding investment ➤ Increased complexity of metal alloy will also demand investment ➤ High costs of energy will have to be managed
Margin pressure 	<ul style="list-style-type: none"> ➤ International competition in vehicle construction will go up ➤ This limits the possibility of cost transfer to the end customer ➤ OEMs could pass on cost pressure to suppliers
Industry consolidation 	<ul style="list-style-type: none"> ➤ Continuation of industry consolidation is expected ➤ Main reasons are globalization pressure and increased investment requirements ➤ Many family businesses face problems in terms of company succession in our point of view
<p>➤➤ The global foundry industry is facing increased investment requirements. In combination with technological changes this should intensify industry consolidation</p>	

Figure 7: Strategic challenges in the global foundry industry
Source: Büchner (2019)



Foundry Type	No. of foundries in '11	No. of foundries in '15	2014 v/s 2011 change in %
Ferrous (Iron and Steel)	74	88	+ 19%
Non-Ferrous (Aluminum, Brass & Zinc) Sand, Gravity, Low Pressure	70	54	- 22%
High Pressure Die-casters	31	23	- 26%
Investment Casting	5	5	0%
Total number of Foundries	180	170	- 6%

Figure 8: (a) Markets served by South African foundries, and (b) foundry industry structure
Source: Madzivhandila (2015)

The foundry industry in South Africa, like several other industries, contracted severely in 2020, mainly due to the Covid-19 pandemic. Figure 9 shows the manufacturing sector contraction with an average 30% during 2020 (IDC, 2021).

2.3.1 Challenges in the South African foundry industry

Results from research performed by the University of Johannesburg (UJ) on the strengths, weaknesses, opportunities and threats (SWOT) of the South African foundry industry are depicted in Table 3 (Mphasha, 2016).

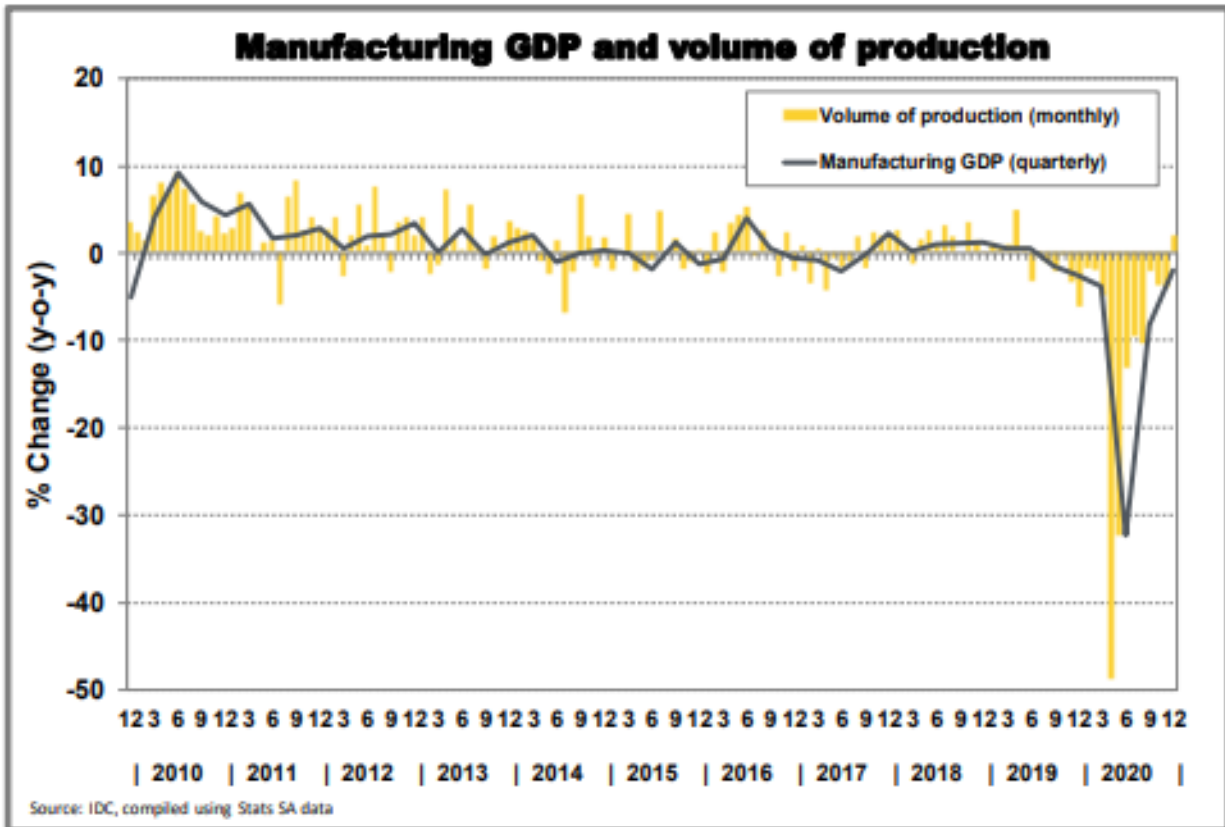


Figure 9: South African manufacturing GDP for the past 10 years
Source: IDC (2021)

South African foundries are prone to the same challenges as experienced in the global foundry industry, with investment requirement and lack of skilled workers identified as weaknesses. Additional South African threats include the political climate and corruption (Mphasha, 2016). Stable energy is a big concern for the foundry industry in South Africa. This is due to the high level of energy usage in this industry. Approximately 29% of the energy consumed is due to the iron and steel sector (Mphasha, 2016). The heart of the foundry is also the main energy consumer, as seen in Figure 10 (Mphasha, 2016), illustrating that 55% of energy consumption is due to melting, followed by heat treatment and mould making.

Table 3: SWOT analysis of South African foundries from the University of Johannesburg

Strength	Weakness	Opportunity	Treat
<ul style="list-style-type: none"> • Years of experience, versatility of material cast and product range from 1 to 10 tons. • Quality of castings and tooling, equipment, management and quality of castings. • Recent technology of machinery. • Professional service, client's interaction and advisory regarding technical and service issues. • Plant capacity and skilled workers. 	<ul style="list-style-type: none"> • Competitive market, investment in research and development and new products. • Not manufacturing to international standards. • Insufficient capital to expand. • Low prices due to market forces and it limits margins of mark-up. • Unskilled and aging workers. • Being poor and underutilisation. 	<ul style="list-style-type: none"> • New and global markets growing demand. • Assistance from NFTN. • Closure of competitors/ foundries, companies making similar castings. • First priority of supply to SOE. • Export to African countries. • Railway industry • Localisation of original equipment (OE) parts of the automotive, energy and communication industry. 	<ul style="list-style-type: none"> • Cheap imports • Black Economic Empowerment (BEE) and china markets, collapse of the property markets affecting all purchases. • Government's empathy to local supply which is caused by corruption. • Instability in the mining and crushing industry. • Political climate • Too many politics stopping local investments from overseas investors.

Source: Mphasha (2016)

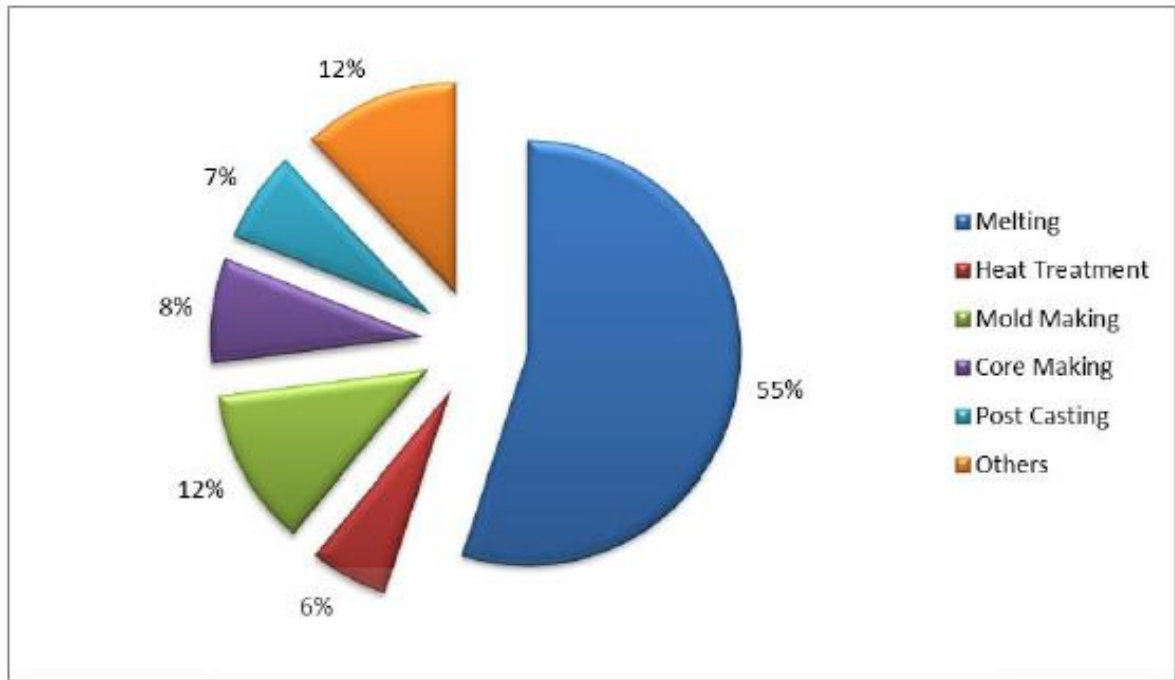


Figure 10: Energy distribution of foundry processes
Source: Mphasha (2016)

A big energy challenge for the foundry industry, apart from intermittent electricity due to load shedding, is the electricity price increase experienced in South Africa (Thiel, 2016). Although South Africa is not the most expensive in terms of electricity price, the rate of electricity increase is the highest in the world, as depicted by Figure 11 (NUS_Consulting_Group, 2014). The price of electricity increases, while employee skills decline and labour cost increases. The combination of the deteriorating education system and increased company overheads is causing the foundry industry in South Africa to become extinct.

2.4 The roll manufacturing foundry

The introduction of the roll manufacturing foundry is provided below since one of the main consumables purchased by the hot strip mill is casted rolls.

General foundries consist of more than 100 process parameters, each influencing the final casting quality produced (Ransing *et al.*, 2013). The roll manufacturing process is a subsection of the ferrous foundry section, as depicted in Figure 8 (b) (Madzivhandila, 2015). Rolls are utilised in the steel or stainless-steel industry as consumables that reduce a slab or billet from an initial large dimension to a thinner or reduced dimension, as depicted in Figure 12 (Belzunce *et al.*, 2004). Large multinational companies including, but not limited to ArcelorMittal, Nucor Steel, ThyssenKrupp, Evraz Steel and Acerinox are customers to the roll manufacturing industry.

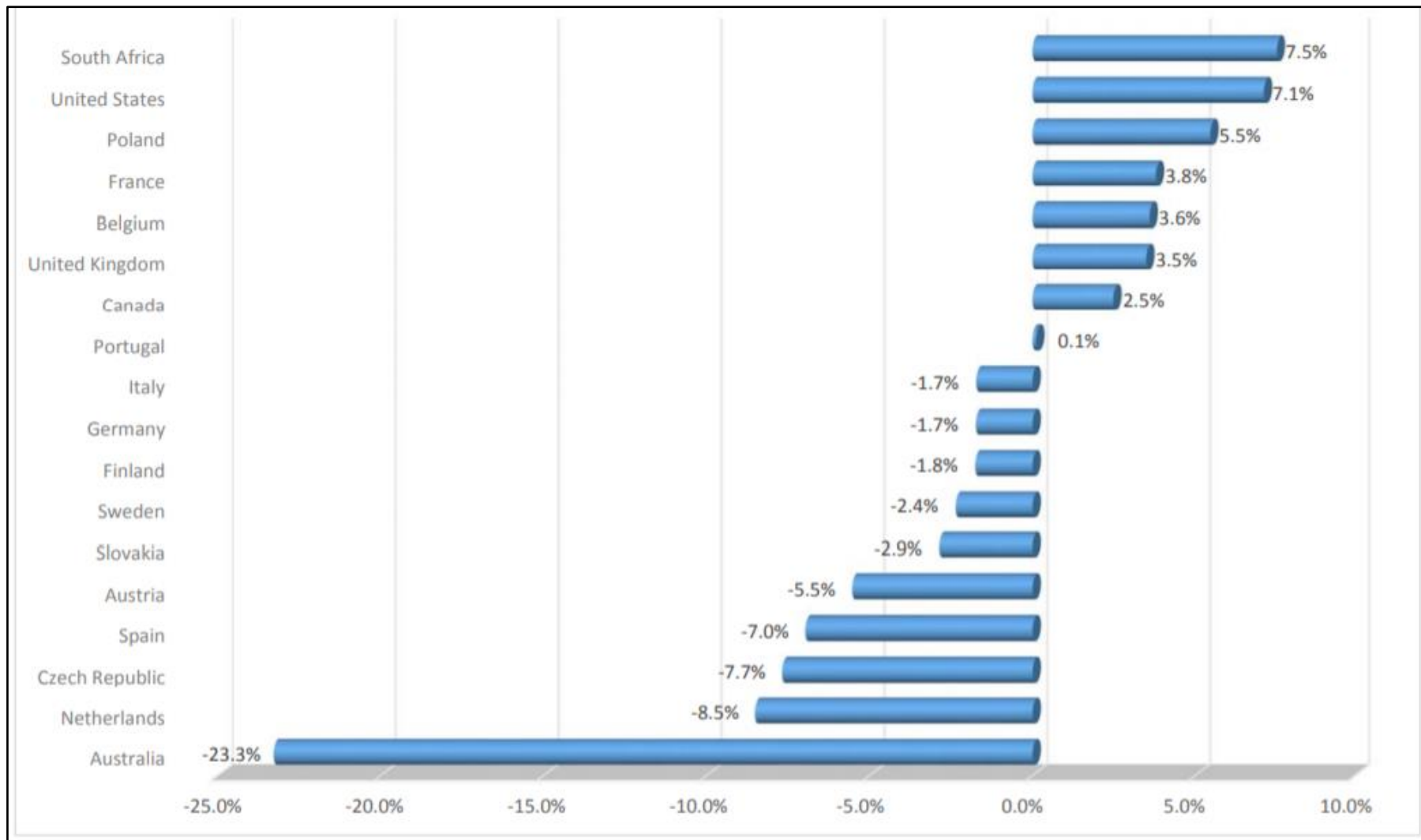


Figure 11: International electricity price survey showing the price difference from 2013 to 2014
 Source: NUS Consulting Group (2014)

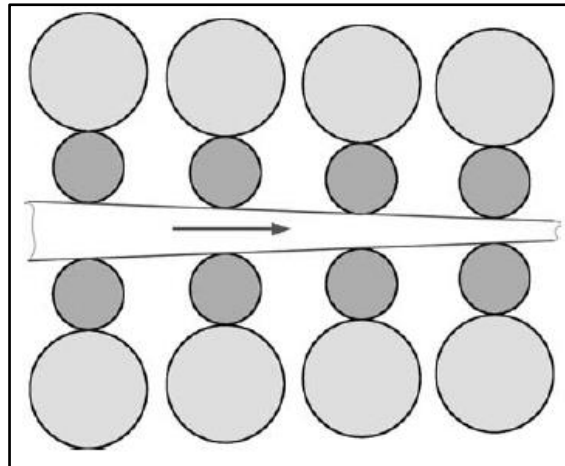


Figure 12: Reduction of steel slab in a continuous hot strip mill
 Source: Belzunce *et al.* (2004)

The type of roll produced (prescribed by customer process) determines the casting process used in the roll manufacturing foundry. A typical bi-metallic roll (consisting of a hard shell and ductile core) casting process is portrayed in Figure 13 (Song *et al.*, 2009). Hot metal is cast in a centrifugal spinning chill creating the initial outer shell layer shown in Figure 13(a), followed by vertical casting of a ductile iron core from the top shown in Figure 13(b). Other vertical static casting production methods are also utilised to cast larger rolls. Subsequent to machining and final quality inspection, rolls are dispatched through road transport to ports where they are shipped to the customers. Figure 14 (Kubota, 2022) shows the final machined rolls before being crated.

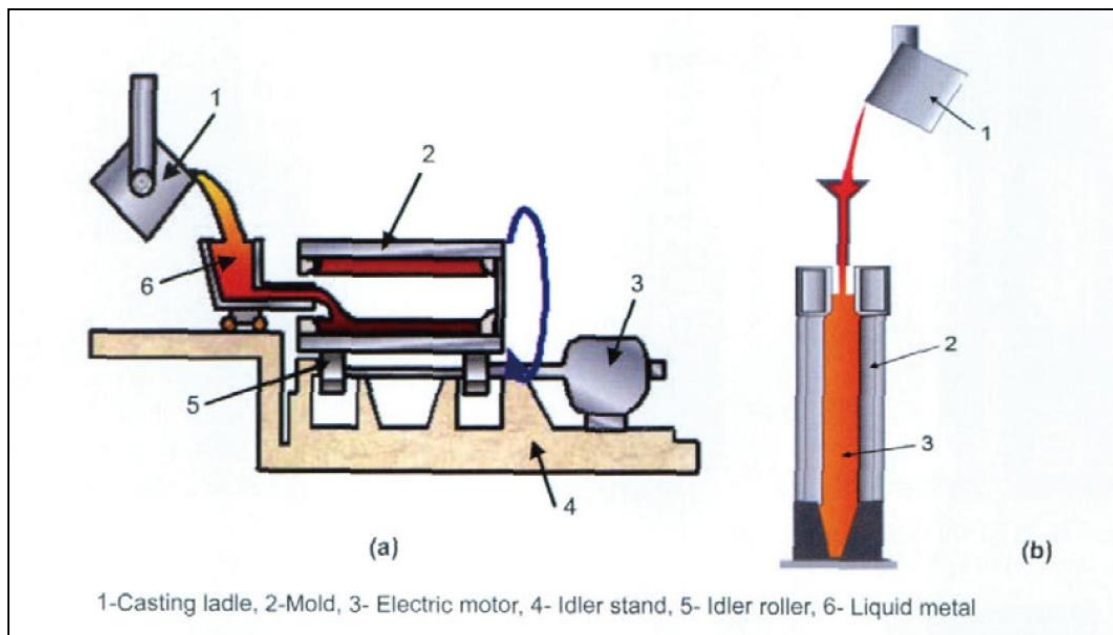


Figure 13: Typical roll manufacturing process. (a) Horizontal spin casting, and (b) vertical pouring of core material
 Source: Song *et al.* (2009)



Figure 14: Manufactured rolls for rolling mills
Source: Kubota (2022)

The roll manufacturing industry in South Africa exports to several countries in the Americas, Europe, Asia and Africa. Figure 15 depicts the increasing rand value of exported rolls over the past 30 years.

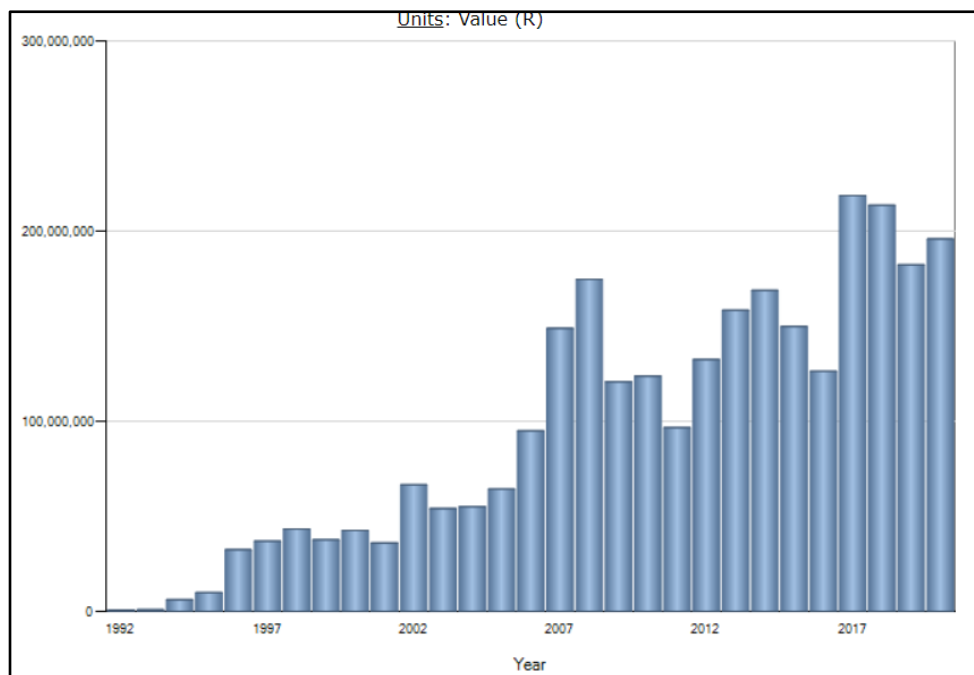


Figure 15: Rand value of rolls (H84553000) exported from South Africa since 1992
Source: dtic (2021)

2.5 The hot strip mill (HSM)

Steel can be manufactured by two well-known production processes. One process melts iron ore in a blast furnace, which is subsequently fed to the basic oxygen furnace as iron. The second process melts scrap to directly produce steel in an electric arc furnace. Melted and treated steel is subsequently cast through a continuous caster to produce billets, blooms or slabs. These semi-finished products are transformed to finished products (rods, bar, plates and coil) after a rolling process. Figure 16 (NewSteelConstruction, 2017) depicts the process flow of a typical iron and steel plant.

The HSM is a section in the rolling department of a steel company. The main aim of the HSM is to reduce semi-finished products using increased temperature and pressure applied by rolls to either finished products or products intended to be reduced further in the cold rolling mill (thinner and better surface finished coils). Finished products of a rolling department can either be in the form of a long or flat product, depending on the mill configuration and roll profile type installed (NewSteelConstruction, 2017).

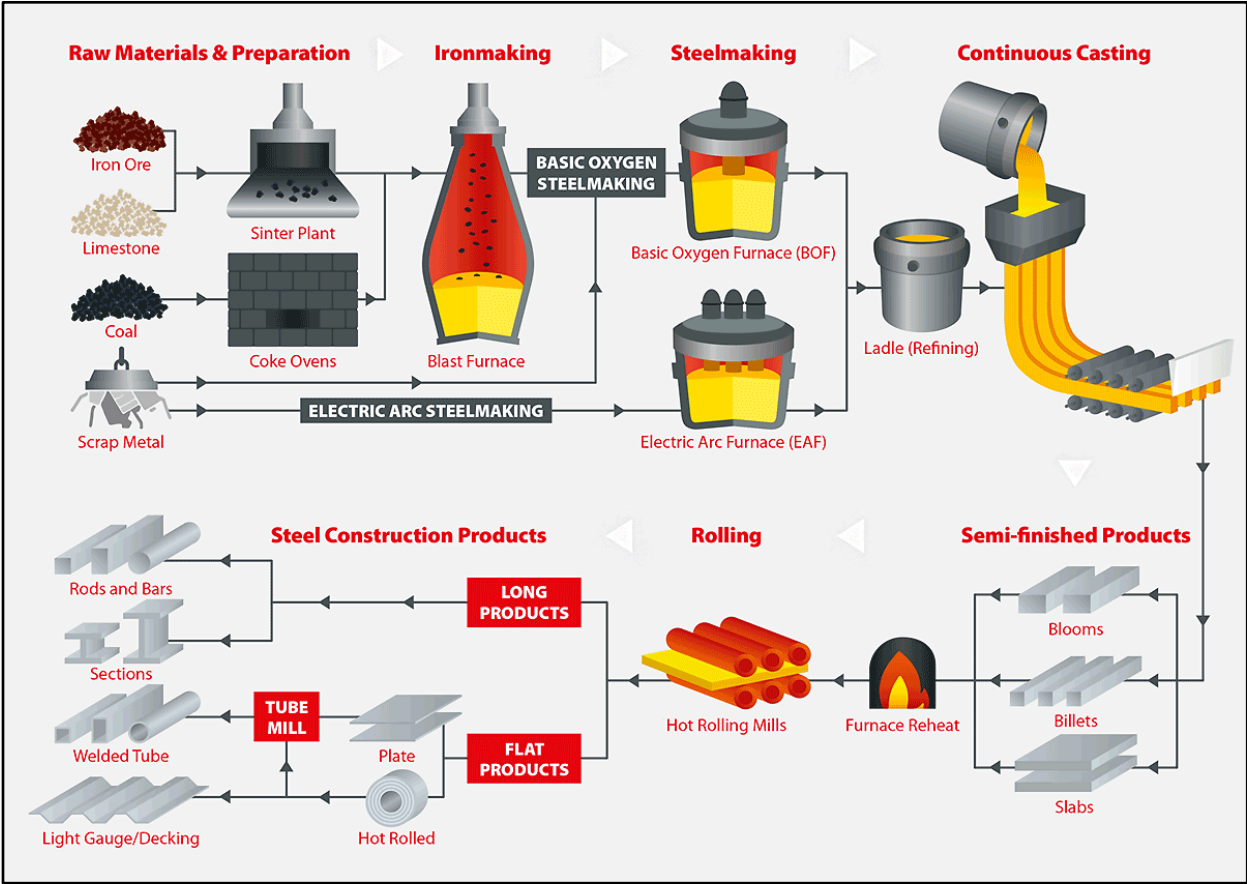


Figure 16: Iron and steelmaking process flow
Source: New Steel Construction (2017)

The typical HSM consists of furnaces (to reheat semi-finished products – 1 200°C), rolling stands (to reduce semi-finished products in dimension), descalers (to remove oxidation layers formed during reheating), and run-out table and coilers (to coil flat sheet). A typical layout is depicted in Figure 17 (Patel *et al.*, 2019).

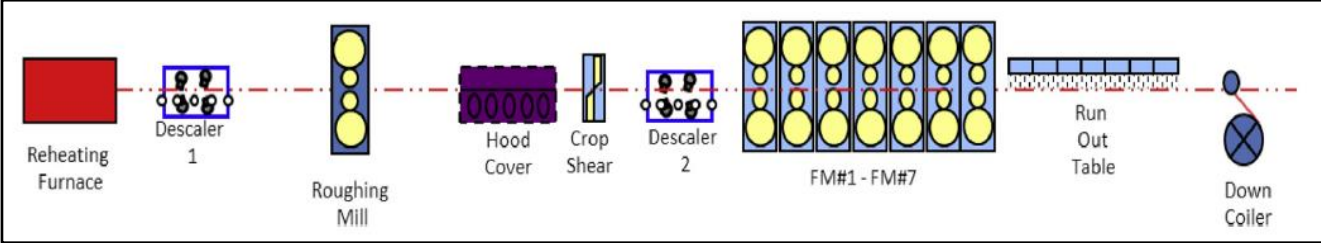


Figure 17: Layout of typical HSM
 Source: Patel *et al.* (2019)

Several cast consumables are used in the HSM as depicted in Figure 18 (Patel *et al.*, 2019), but the most significant consumable is work rolls.

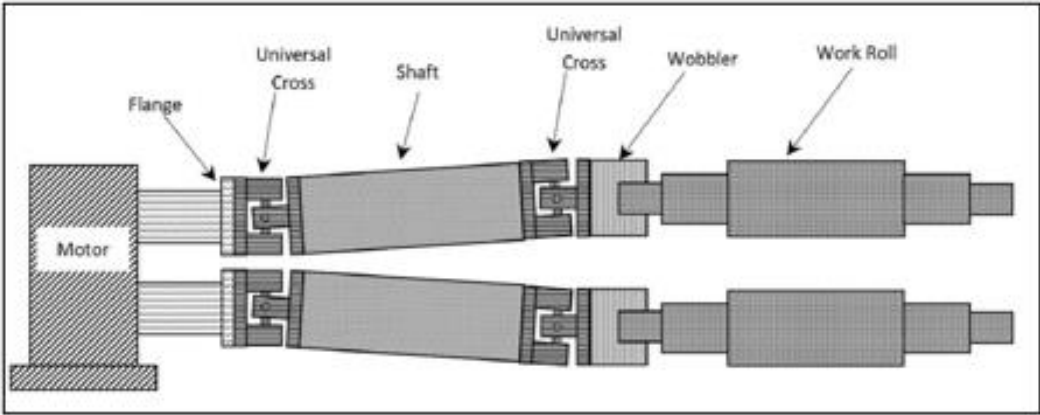


Figure 18: Typical construction of a mill stand in a finishing mill
 Source: Patel *et al.* (2019)

Customers of HSM products (automotive and construction industry) are continuously seeking improved product quality, thereby forcing the HSM process to become more efficient and less expensive. Figure 19 (Buchmayr *et al.*, 2018) depicts the technological improvements over the last 70 years applicable to the HSM. Steel quality improvement further cascades to HSM consumables, thereby enhancing competition within the consumable manufacturing sector. HSM rolls are continuously improved through research and development to yield longer rolling campaigns at a cheaper roll cost.

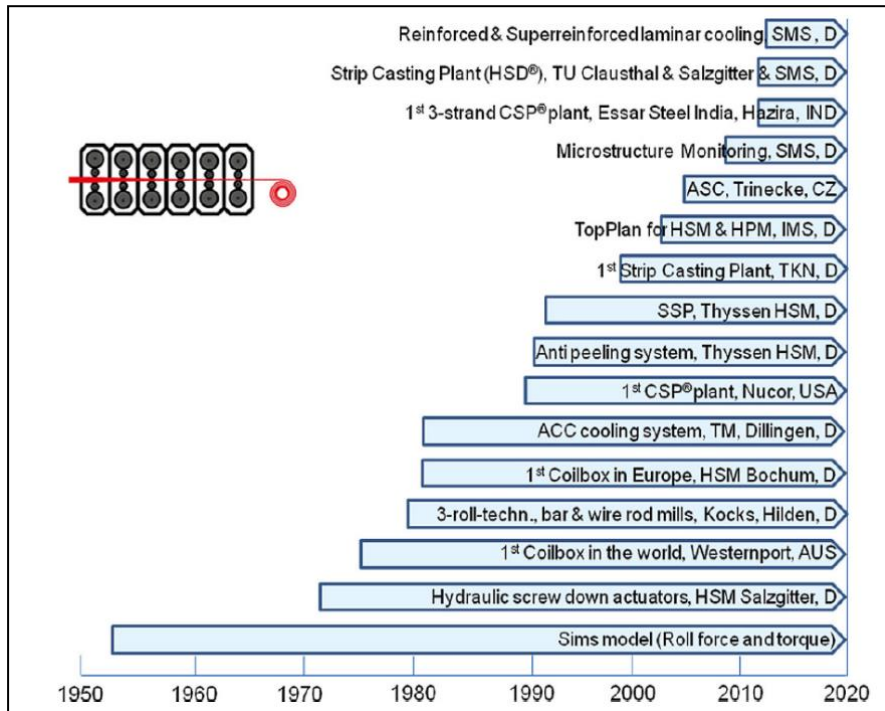


Figure 19: Major developments in HSM technology since 1950

Source: Buchmayr *et al.* (2018)

2.5.1 Total cost of ownership

Historically, TCO models were based on operator feeling, since no accurate data was available to rigorously evaluate different roll grades and suppliers. Roll decisions in the mill were based on subjective perception of the roll user, sometimes unfairly being rejected by a mill due to mill incidents (Webber, 2017).

Rolls in the HSM account for up to 15% of total HSM cost. Several factors can affect roll usage cost, including (Webber, 2017):

- Price of rolls,
- Performance of rolls (wear and resistance to failure),
- Roll changes leading to mill downtime,
- Cost of grinding rolls (time, electricity, labour and consumables), and
- Cost related to mill (maintenance, water, quality and availability).

Roll performance in an HSM is typically measured as tonne/mm (T/mm). Initial roll performance, for steel and iron rolls, was less than 3 000 T/mm. With the introduction of high chrome rolls (HiCr), the performance doubled. Additional roll performance enhancement was achieved with

the introduction of high speed steel (HSS) rolls into the mills (Kerr *et al.*, 2004). According to Kerr *et al.* (2004), the following factors led to increasing roll performance over the years:

- The roll wear of HSS rolls is better than HiCr and iron rolls.
- The HSS roll is less prone to peeling, and therefore the roll can be used in multiple roll campaigns.
- Mill condition improvements, thereby improving stability. Less roll grinding required.
- Due to improved grinding equipment, enhanced non-destructive testing is being performed, which prevents unnecessary grinding.

Figure 20 depicts the average roll performance and performance gap for each mill stand at the ArcelorMittal Dofasco (Kerr *et al.*, 2004). This HSM has been driving roll performance in the steel industry, but several performance gaps are still evident from stand F4 to F7.

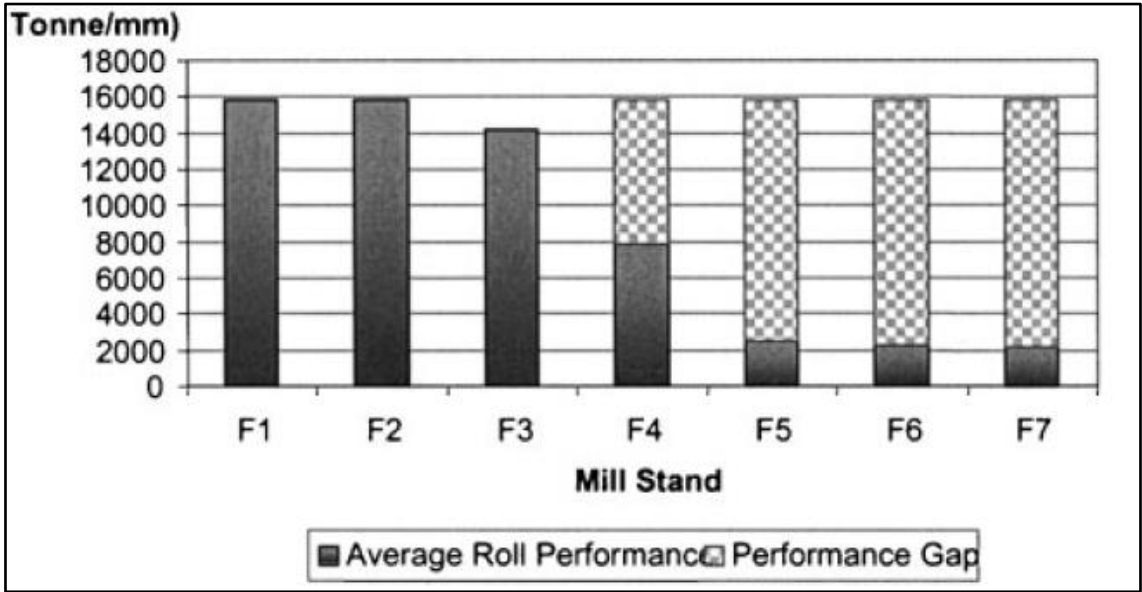


Figure 20: Average performance (tonne/mm) of the seven stands in ArcelorMittal Dofasco. (HSS rolls and ICDP rolls)

Source: Kerr *et al.* (2004)

2.6 Consumer perception of manufactured products

Consumer decision-making and behaviour are influenced through several individual as well as social factors. Perception, motivation, values, attitudes and learning are all individual factors affecting the behaviour of consumer buying (Lamb *et al.*, 2019:98-102).

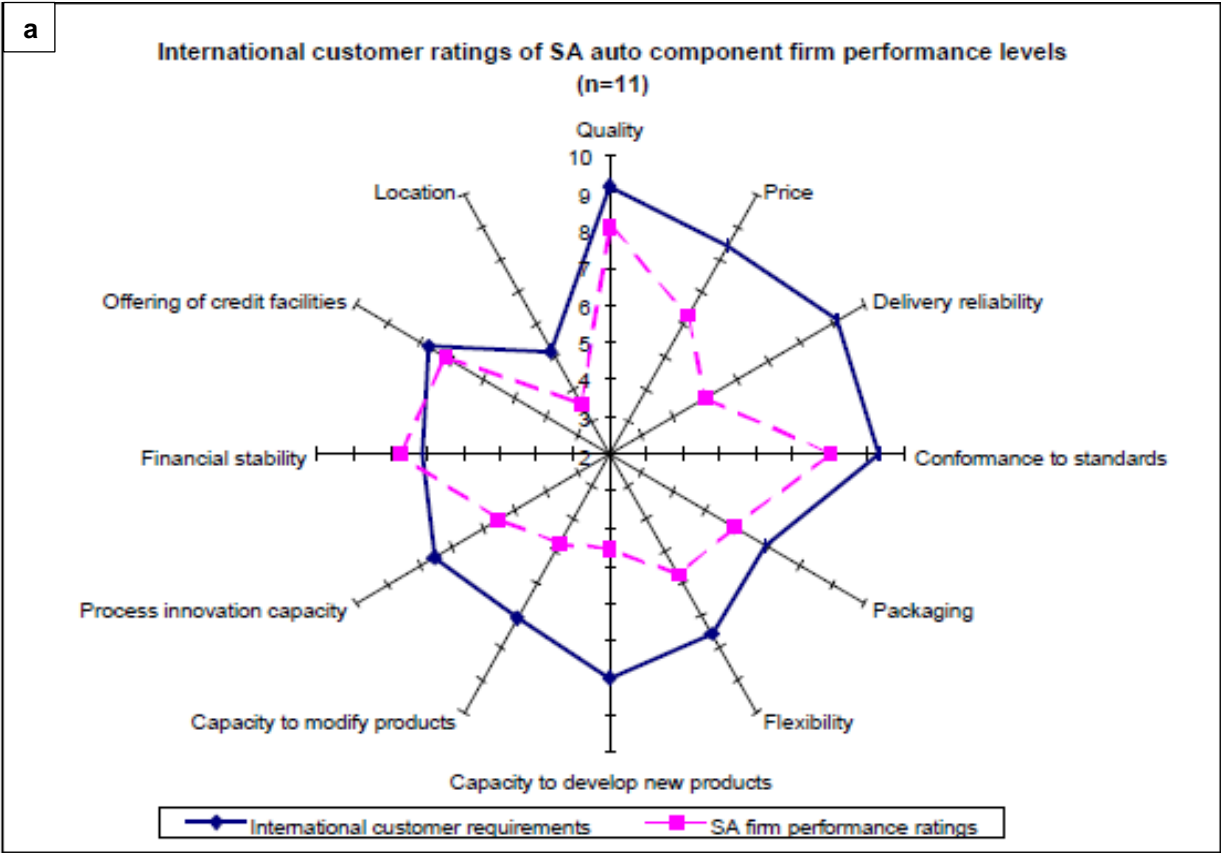
The perception of product quality, linked to the product's brand name, is called quality reputation (Li *et al.*, 2011). The association between a reputable brand and good quality will be made by rational consumers; bad quality will similarly be associated with an ill-reputable brand. Brand reputation has more impact than warranty and price on quality perception; although, for non-expert consumers, where the brand is unknown, warranty is more likely to be used for the formation of quality perceptions (Li *et al.*, 2019). A consumer's decision to perform a future purchase will be negatively affected should there be a product failure, even with the product being under warranty. Once a product failure occurs, negative quality perception will lead to consumers not willing to pay for the product (Li *et al.*, 2019). The purchasing decision of a consumer might also be influenced by bad experiences towards the product experienced by other purchasers (Li *et al.*, 2019).

Another factor to consider upon analysing consumer perception towards a product is the significance of country-of-origin (COO) image (Kaynak *et al.*, 2000). Research performed by McDonald (1995) indicated that Chinese consumers heavily weigh a product's COO and perceive imported products as strong positive stimulus while making the decision to select and purchase. Positive brand or product perception regarding COO is made for developed nations (Europe and North America), while negative perceptions are made for lesser developed nations (Kaynak *et al.*, 2000). Consumers will be willing to pay an extra premium should the product originate from a developed COO, as the COO in this case is seen as insurance of the product's quality and performance (Kaynak *et al.*, 2000). If a consumer is unsure of the product brand and performance, generally, the COO will be examined upon product quality perception (Eroglu & Machleit, 1989; Han, 1990); a consumer might make the decision to reject a product even with good marketing techniques such as promotion and incentives (Kaynak & Cavusgil, 1983).

Consumer behaviour is also affected by customer satisfaction and the effect of perceived fairness of price (Bolton & Lemon, 1999; Woodruff, 1997). Verhoef *et al.* (2002) postulate that, although consumers are often attracted to low prices, price reductions have a short-run effect on market share that quickly diminishes. Similarly, the effect of improving price perception with reduced prices will only be effective in the short run. The author further states that the strategy to improve customer satisfaction is better than enhancing price perceptions.

As South Africa is seen as a developing nation, international market infiltration from South African foundries is challenging, due to consumer perceptions as alluded to in the previous paragraph. An example of this can be seen in Figure 21 (Barnes, 2002), where the international customer perception was examined for an automotive component company. The research study was performed through the University of Natal (Barnes, 2002). It should be noted that the sample size for the research undertaken was small, with 11 international customer replies to the posed

questionnaire. This research remains important as a suggestive indication of the overall perception of international firms concerning the ability of South African exporters. The study indicates that international customers require performance in several aspects, but the top four requirements identified are conformance to standards, quality, delivery reliability and price. Geographical location was identified to be the least important criterion for international customers. The main aspects related to poor performance indicated by the international participating companies were the reliability of delivery terms as well as quality and conformance to specified performance. The most disappointing indications were that of poor levels of service and adherence to specified lead times (Barnes, 2002). Figure 21(a) represents the performance perceptions of South African companies compared to international requirements, while Figure 21(b) depicts the same requirements, but compared to international competition. It is noted that the overall performance of international competitors is perceived as superior when compared to their South African counterparts. Figure 21(c) shows the gap analysis between South African exporters compared to their international competition. Apart from credit facility offering, all South African perceptions are rated more negatively.



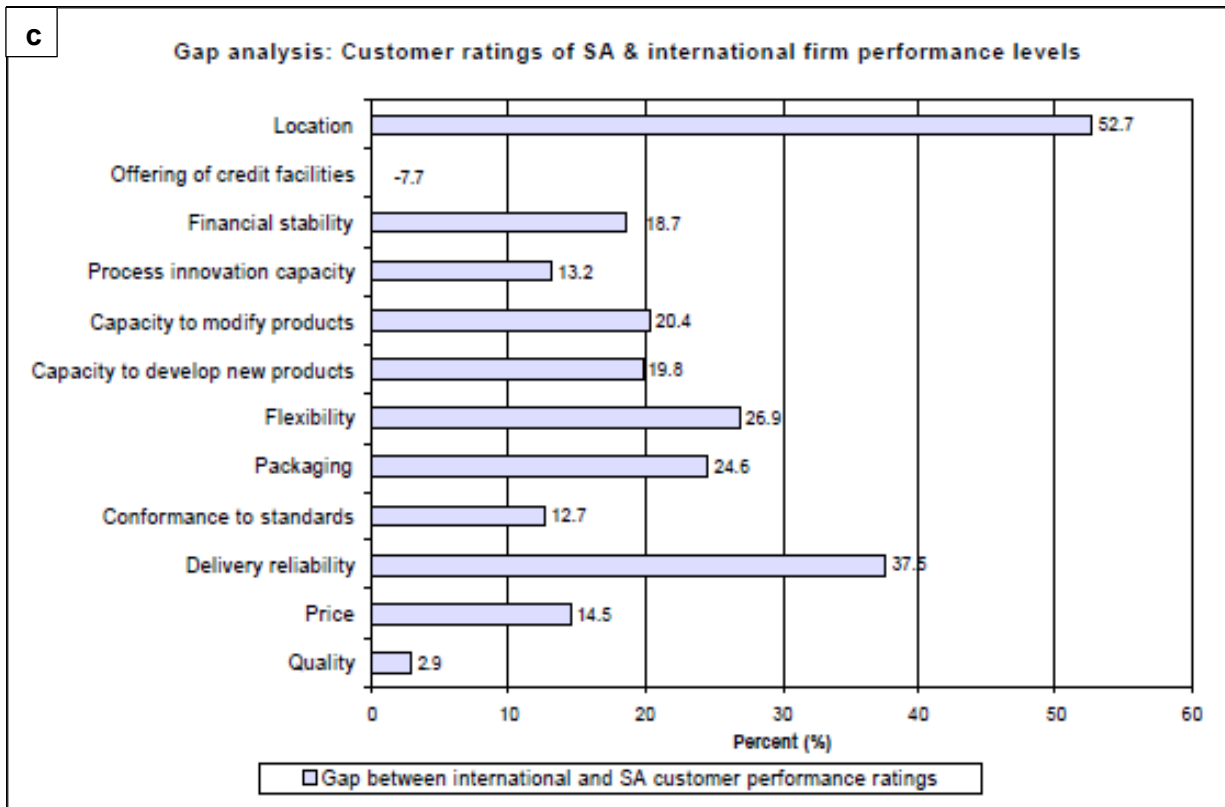
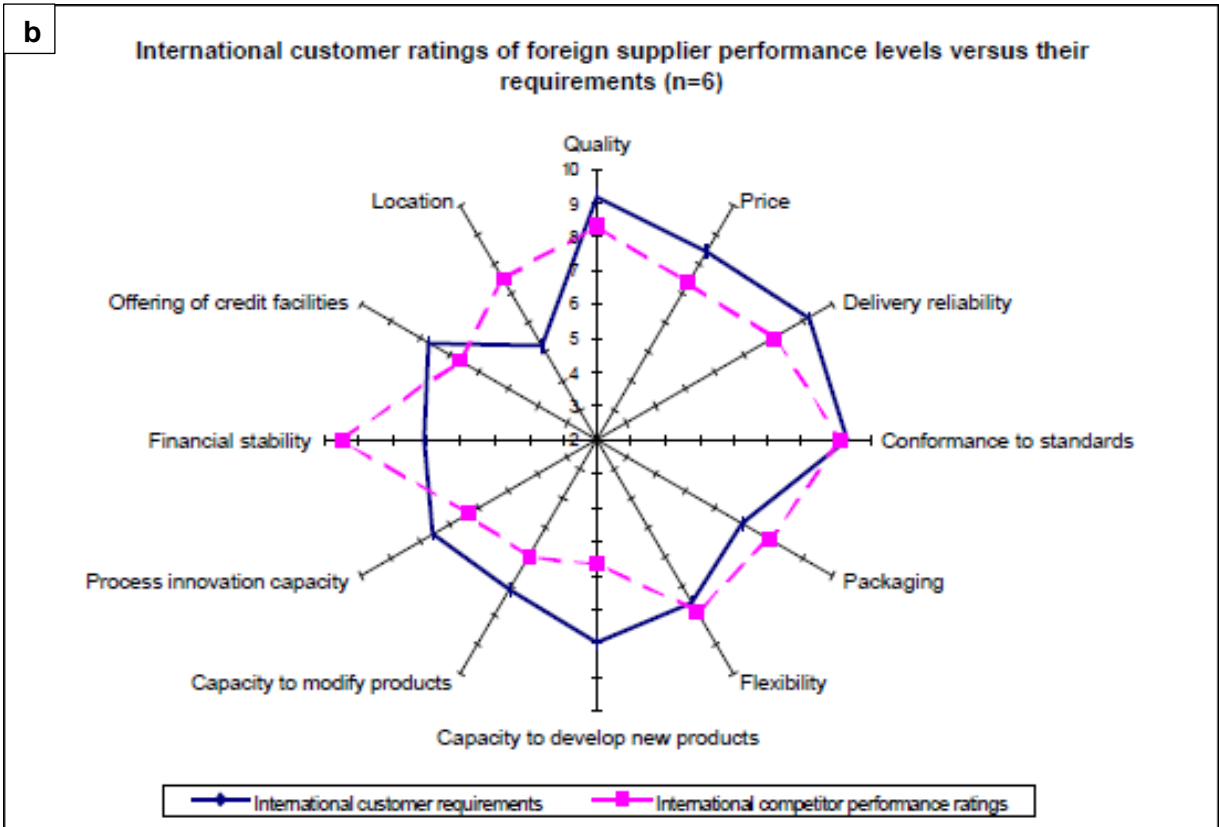


Figure 21: (a) International customer rating vs South African company performance rating, (b) international customer rating vs international competitor performance rating, and (c) gap analysis between South African vs international competitor firm

Source: Barnes (2002)

2.7 Altering perceptions

The theories of change management were reviewed to identify and utilise a model to change the consumer perception of South African foundry products, more specifically that of HSM operating plants across the globe. The main driving force behind decisions in an HSM is TCO. Alignment between TCO and the South African foundry industry should be made, specifically on aspects such as quality, price and delivery lead time. Section 0 briefly reviews change management theory obtained in literature, while section 0 provides a practical model of a selected change theory. This change model can be applied to the foundry industry through advancing of strategic growth and delivering of products that conform to customer specifications and positively influence consumer perception.

2.7.1 Theory of change management

Change management theory dates back more than 100 years, with the development of scientific management and the organisational dealing of employees by Frederick W Taylors in 1911 (Ratana *et al.*, 2020). The theory of change management can be divided into three distinct periods, including the pre-1990s planned change approach, the 1990s emerging change management theories and the post-1990s contemporary change management theories.

Although no definite mention is made in literature of the author of the term 'change management', scholars believe that Kurt Lewin (1951), with his three-step planned stage approach, is the creator (Ratana *et al.*, 2020). Lewin (1951) postulates that change must be projected by top management in a process of unfreezing, move and act, and refreezing. During the 1990s, Kanter *et al.* (1992) challenged Lewin's three-step model with the development of a 10-step change approach. Kotter (1996) also developed an eight-stage change approach, based in essence on Kanter's theory. The theory of Kotter (1996) will be further elaborated on in section 0, as this theory will be utilised as a change model in later chapters. Figure 22 (Ratana *et al.*, 2020) depicts the change management theories as a function of the management technique for the timeframe stretching across the three periods. Several change theories have been proposed, each associated with its own criticism. The post-1990 theories started to focus more on the human, technology and strategy change elements (Ratana *et al.*, 2020).

2.7.2 Applying change management model

Several authors agree that there is a disparity between theoretical and practical change management application (Appelbaum *et al.*, 2012; Buchanan, 1993; Saka, 2003). The eight stage process of Kotter (1996) is one of the most recognised and well-known change models regarding organisational behaviour (Pollack & Pollack, 2015), and will be studied further in this section. The

aim of exploring the change model of Kotter (1996) is to identify methods of shifting the industry towards becoming a world-class manufacturer of exported products. The change management model, as depicted by Kotter (1996), includes:

1. The establishment of urgency

This includes the creation of organisational awareness required to obtain employee cooperation. Effort is needed to motivate employees to invest in the concept of change.

2. The creation of a guiding coalition

Powerful leaders must be selected to effectively lead change. Groups consisting of top management down to technical advisors are vital to lead change effectively in the organisation.

3. Development of a vision and strategy

A vision and strategy relating to the required change must be formulated. This may include the need to ensure adequate knowledge transfer between employees and strategically developing the best practice to overcome this hurdle. The change identified in this point is typically related to culture and values.

4. Proper communication of the change strategy

The need for proper communication regarding the change vision is listed as the top two important aspects of Kotter's approach. There needs to be innovative presentation of change progress to all levels of the organisation.

5. Allowing for broad-based change

The removal of barriers that impede strategic thinking must be undertaken. There needs to be an environment created that encourages innovative ideas.

6. Creating instant wins

The highlighting of short-term wins will ensure that the change momentum be kept. Short-term wins must be clearly shown to indicate progress in the change programme.

7. Combining the gains achieved and generating additional change

8. Setting new approaches in culture

Both points are important and difficult to measure in the short term. It is necessary to keep the momentum when performing change until the change culture has shifted to a new equilibrium.

Several criticisms on the effectiveness of Kotter's change theory also exist in literature, mostly related to the lack of detail, lack of generalisation and lack of representation of organisation realities (Pollack & Pollack, 2015).

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

A qualitative research study was conducted through a non-probability sampling technique. The study deviated from the original research design as proposed in Chapter 1, due to various reasons explained below. The revised and applied research methodology is discussed in this chapter.

3.2 Qualitative empirical setting

Semi-structured interviews were conducted through online platforms, i.e. Microsoft Teams and Zoom. The interviews were set up through mail correspondence between the researcher and the respondent. The interview protocol was emailed to three participants due to language barriers experienced between the researcher and participant. The questions applicable to the interview protocol were replied via email for these instances.

3.3 Sampling

The study population selected for the study is based on global steel manufacturing plants, specifically with the capability of producing hot rolled coil. The units of analysis, as proposed in Table 2 in Chapter 1, were not successfully achieved due to the following:

- Global steel manufacturing plants are prohibited by top management from partaking in studies, especially due to competition between global foundries.
- The global steel manufacturing plants willing to partake in studies are running high tonnages and time is limited for discussion, ultimately preventing proper interviews to be conducted.
- Language barriers, especially in the Asian, Ukrainian and South American markets prohibit comprehensive interviews from being conducted.

As a result of the above-mentioned constraints, internationally-based agents representing South African foundry products were included as participants. These commercial agents know their represented steel market well and can provide insight into the same perception-based information required in the study.

The sampling method employed for the study was non-probability snowball sampling. The revised units of analysis are depicted in Table 4.

Table 4: Revised units of analysis applicable to the study

Geographical area	Country	Organisational level	Steel producer group	Plant location
European Union	Germany	Operational	ThyssenKrupp	Bochum
North America	USA	Agent	N/A	N/A
South America	Brazil	Agent	N/A	N/A
Asia	Taiwan	Agent	N/A	N/A
Asia	India	Commercial	Tata Group	Jamshedpur

3.4 Interview protocol

An interview protocol was developed to extract specific details from the selected participants. The following was first read/provided to the participant prior to conducting the semi-structured interview:

“You have completed and sent me the signed informed consent form. By continuing with this interview, you give consent that the information you share may be used for this study. You have the right to withdraw at any time and if you do not want to answer a specific question - you do not have to. Your identity will be kept anonymous in the study and you will only be referred to by a number. Confidentiality of your inputs is guaranteed. I would like to record the interview for the sake of accurately transcribing the discussion. Do you give me permission to record the interview?”

The participants subsequently replied to the questions as portrayed in Table 5.

3.5 Data collection

The following tools and methods were applied with regard to collection of the data from the selected participants.

3.5.1 Data recording

The interviews conducted with the non-agent participants, thus operational and commercial participants, were recorded using the built-in recording function supplied by Zoom. Zoom is a cloud-based video conferencing software used as a method to facilitate online communication. The recorded interviews were transcribed into text through the Otter.ia software application.

The interviews conducted with the agent participants were obtained through email; no transcribing was required as the data was received as text.

Table 5: Questions as per the interview protocol

Question number	Interview questions
Question 1.1	In which demographic area (continent and country) are you located?
Question 1.2	What is your experience on the related research topic?
Question 1.3	Are you currently employed in the operational or commercial environment?
Question 2	Are there currently any cast iron consumables imported from South Africa? Examples of castings include rolls utilised in the hot strip mill.
Question 3	Name some of the countries (if any) your company are currently importing from?
Question 4	What is your personal perception of South African casting prices compared to other countries?
Question 5	What is your personal perception of South African casting quality compared to other countries?
Question 6	What is your personal perception of logistical issues (delivery time, etc.) involved in South African casting compared to other countries?
Question 7	What would influence your perception positively with regards to South African imported castings?
Question 8	What would influence your perception negatively with regards to South African imported castings?
Question 9	Would you recommend South African castings to your affiliated sister branches (if applicable)?
Question 10	What is the most important aspect for your company, product price or quality?

3.5.2 Data analysis

Transcribed text interviews together with the obtained email interviews were categorised per question and entered into a qualitative software program called Atlas.ti. Codes, grouped into overarching group themes, were generated and analysed through the software.

3.5.3 Strategies employed to ensure quality data

The quality of data for the qualitative research study was attempted by upholding the internal validity, reliability and objectivity. The reliability and validity of the data are difficult to establish due to the sample size. The reliability and validity of the study could be improved upon a larger geographical sample of respondents across the operations as well as commercial business structures.

3.5.4 Reporting

The results of the study were scientifically reported in a formal and logical manner. The codes and group themes developed were compared to the available literature and clear conclusions and recommendations were proposed that meet the research objectives.

3.5.5 Ethical considerations

Four main ethical principles need to be adhered to upon conducting business research (Bryman & Bell, 2014):

- Eliminate harm to participants,
- Eliminate lack of informed consent,
- Eliminate invasion of privacy, and
- Eliminate deception that may be involved.

All principles as mentioned above were applied upon conducting of the semi-structured interviews. The informed consent form utilised in this study is depicted in Appendix 3. The following ethical clearance number was obtained: NWU-00040-21-A4.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

The qualitative results are portrayed in this chapter, accompanied by a detailed discussion on the analysis. Identified codes and associated code groupings are depicted in Appendix 4. The referenced quotations are also provided in Appendix 4.

The primary objective of the study was to study the international perception on selected South African foundry products. Hot strip mill consumable products were selected as the focal point for the study. The analyses of the semi-structured interviews are depicted in section 4.2.1, while the geographical analysis of South African foundry exports is performed in section 0. Section 4.2.3 evaluates the perceptions per organisational level, i.e. commercial, operational or sales agent.

The challenges identified in the literature study (Chapter 2) for the South African foundry industry are correlated to the perceptions of the interviewed international customers.

4.2 Qualitative results

Qualitative results, as analysed in Atlas.ti, were divided into three sub-divisions. The first analysis represents all codes associated per code group. Correlation of each code is also indicated. The second and third sections portray the geographical and organisational-level analysis, respectively.

4.2.1 Themes identified

In total, the study delivered 30 codes that were grouped into six distinctive themes. The grouped themes were correlated to each interview question.

Figure 23 represents the network diagram grouped under *Negative influence*. The codes selected were primarily related to question 8 of the interview protocol, linked to the actions from South African foundries that negatively influence the perception of exported foundry products. From this figure, it is shown that consistent pricing is sought after by international customers. In addition, poor TCO, which is caused by poor performance and quality, is not desired. Customer claims, typically caused by a defective casting that failed in the plant, are another undesired action for international customers.

In contrast, Figure 24 represents the network diagram under *Positive influence*. The codes selected were primarily related to question 7 of the interview protocol, linked to the actions from South African foundries that positively influence the perception of exported foundry products. The

figure shows that important aspects for international customers are related not only to having discussions with sales and marketing personnel, but also that technical discussions are important. Improved lead times as well as a reduction in cost remain of importance. Quality and brand importance, related to consistent delivered quality, are another desired action for international customers.

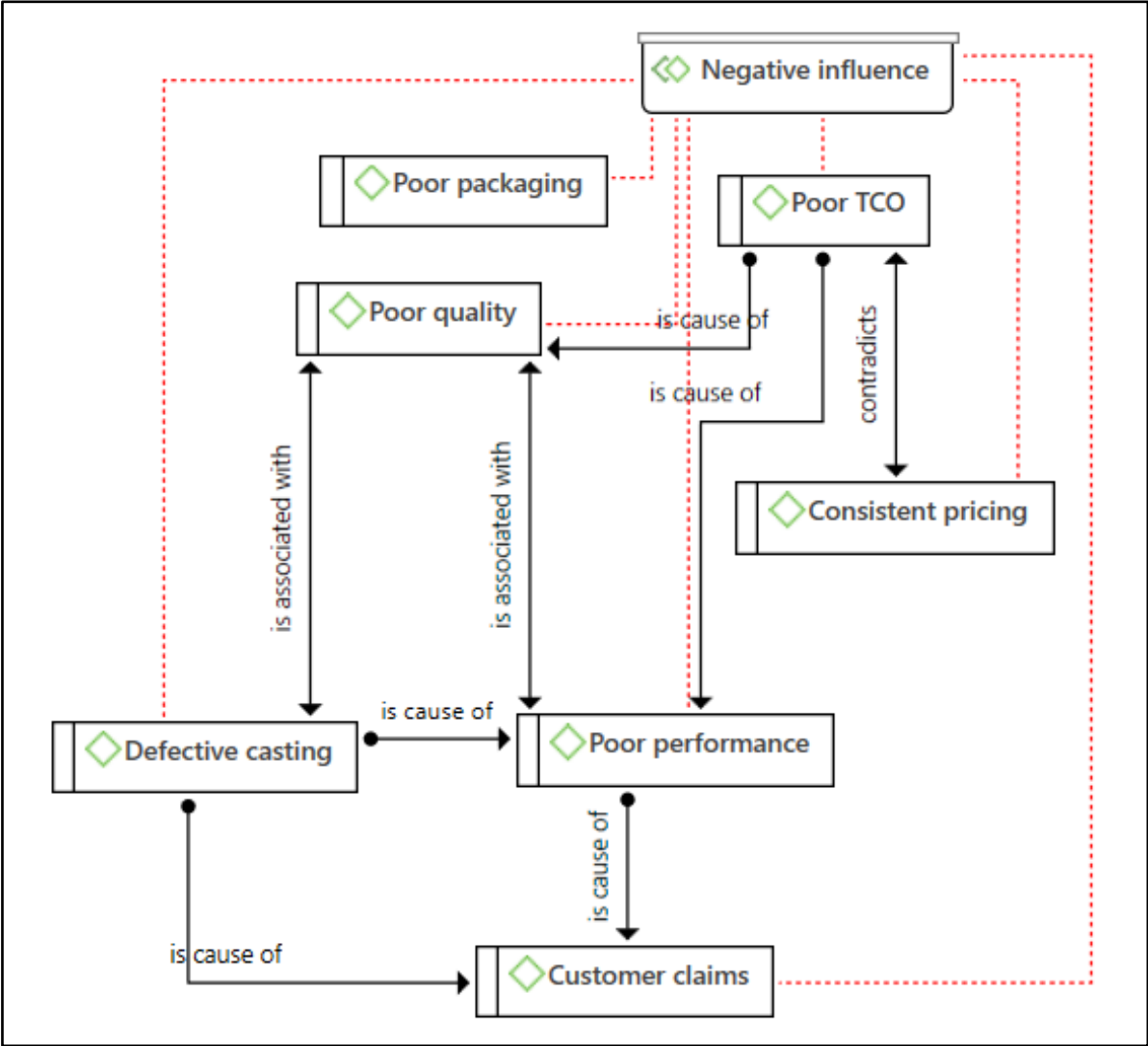


Figure 23: Qualitative analysis grouped theme: Negative influence

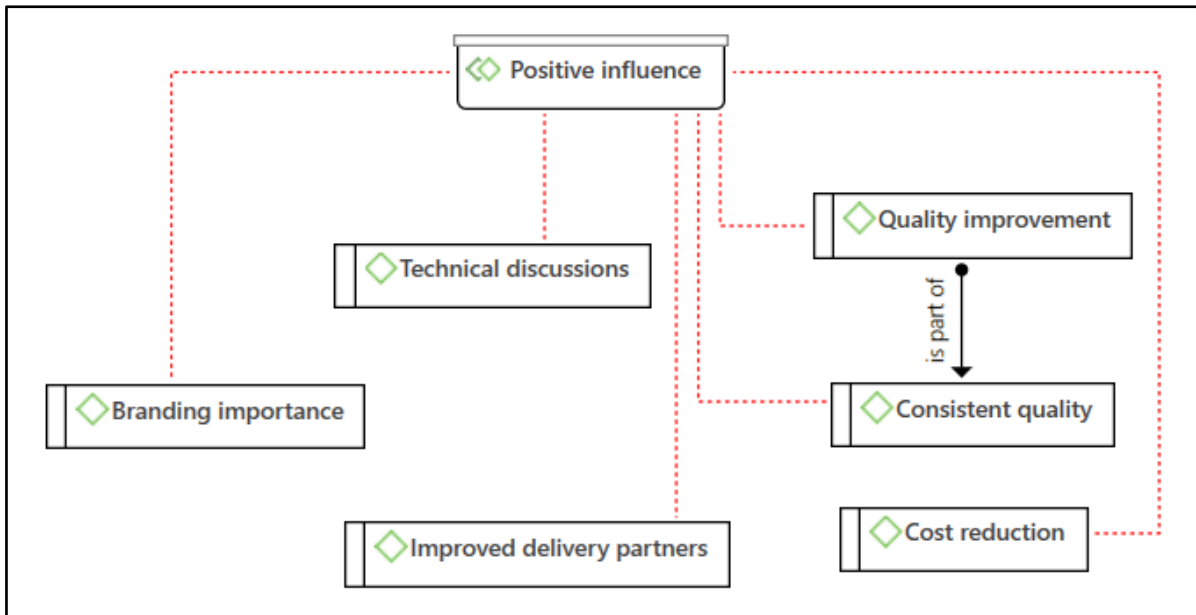


Figure 24: Qualitative analysis grouped theme: Positive influence

Figure 25 and Figure 26 represent the *Price perception* and *Quality perception*, respectively, of international customers on exported South African foundry products. The perception from international customers on price is related to question 4 of the interview protocol and is heavily correlated to the geographic market location of the customer. Both competitive as well as expensive perceptions were noted, which contradicts one another. Similarly, the perception of quality as obtained through question 5 depicts that the perceptions are linked to geographic market location, with good to average quality perceived. The link to the poor quality of South African exported foundry products was not perceived by any of the respondents.

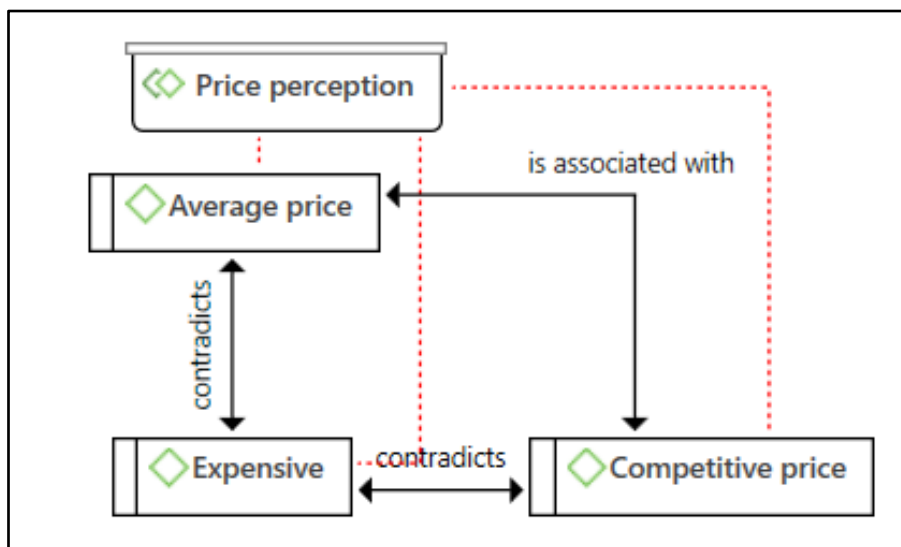


Figure 25: Qualitative analysis grouped theme: Price perception

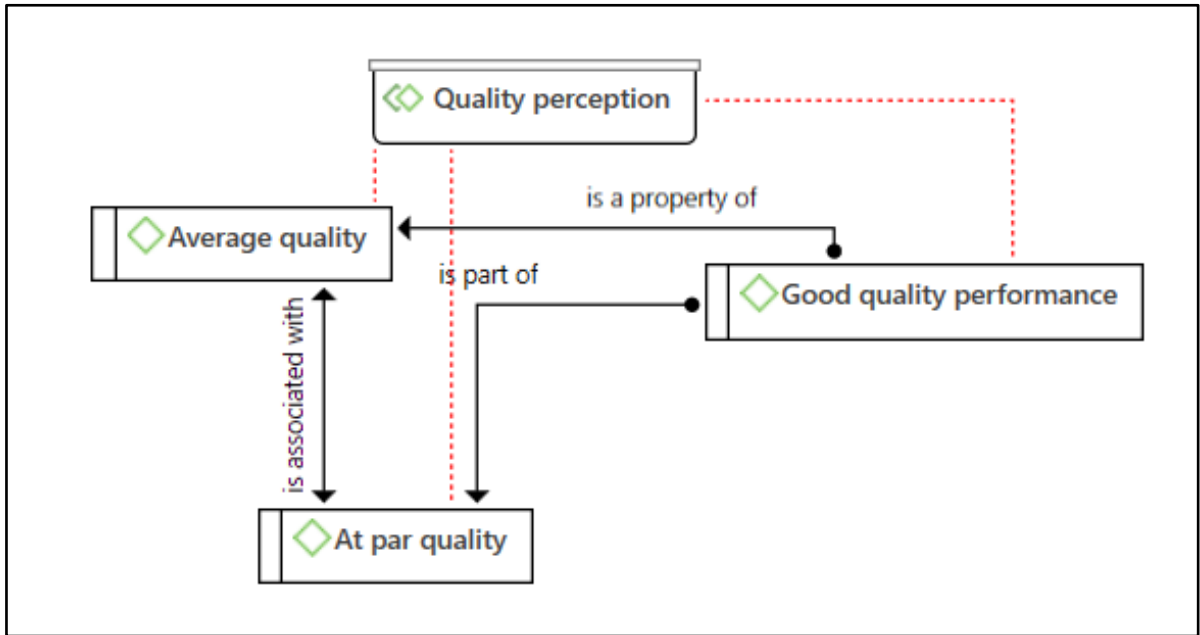


Figure 26: Qualitative analysis grouped theme: Quality perception

Valued elements, for international customers, as shown in Figure 27 and obtained through question 10 of the interview protocol, show the importance of associated quality to TCO. TCO remains the basis of measurement for most international hot rolling mills and is an important consideration for South African foundries to take note of.

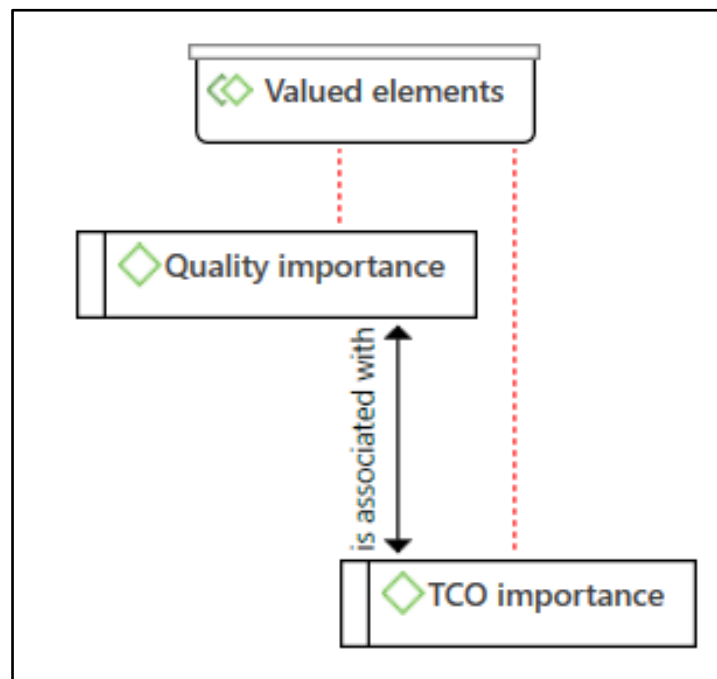


Figure 27: Qualitative analysis grouped theme: Valued elements

Figure 28 depicts the network diagram for the *Logistics* grouping as obtained through question 6 of the interview protocol. This grouping relates to the international customer logistical perception towards delivery lead times when importing from South African foundries. There are several contradicting factors closely correlated with the geographic market location.

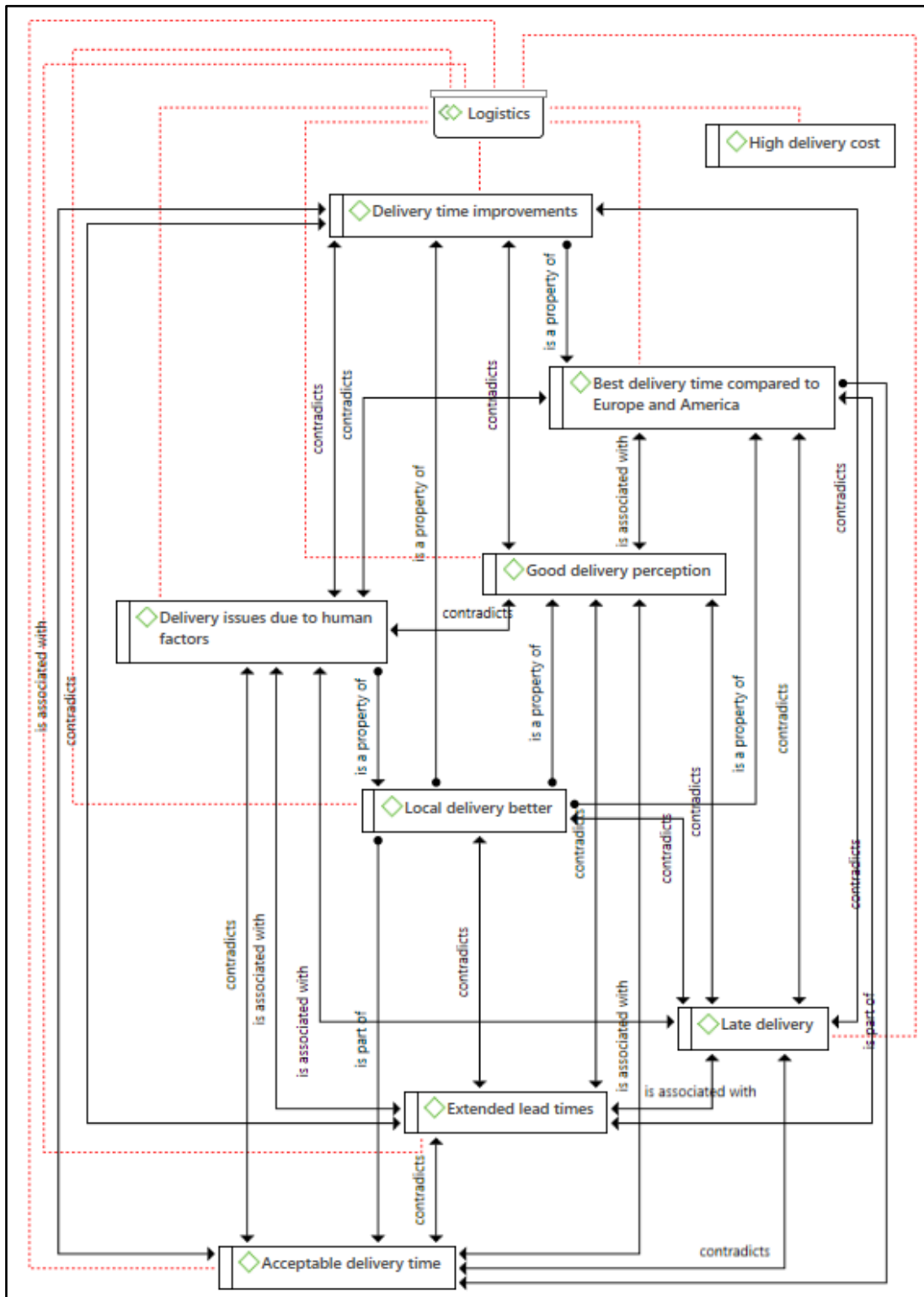


Figure 28: Qualitative analysis grouped theme: Logistics

4.2.2 Geographic analysis

South African foundry product perceptions from five geographic market regions were explored in the study. Figure 29 to Figure 33 depict the analyses of the results obtained from the various geographical markets. The results are portrayed with headings associated with the geographic location, code group and the code as allocated in the quoted text (Appendix 4). The numbering under the quotation heading corresponds with the numbering allocated in Appendix 4.

Figure 29 represents the perceptions from the South American region. This geographic market shows that quality is very important. South African foundry products are generally perceived as having good quality performance as well as being priced competitively. Although native South American foundries are perceived to have better delivery, the perception is that South African foundry products have a good delivery time when compared to European and American foundries.

Figure 30 represents the perceptions from the Asian region, specifically India. In contrast to the South American market, this market is very sensitive towards price. The perceptions are that South African foundry products are expensive with average to poor quality, especially when compared to the Asia-Pacific regions. Delivery costs are also perceived to be high and lead times long. Through general discussion with the India represented respondent, customer relationship was also identified as being important for this geographic market.

Figure 31 represents the perceptions from the North American region, specifically the United States of America and Canada. The perception of this market towards South African foundry products is that delivery lead times are problematic – especially human-related errors are perceived to limit on-time delivery. Overall, South African foundry product quality is perceived to be good compared to competitor prices. Packaging and branding are also noted as important aspects for this geographic market region.

Figure 32 represents the perceptions from the European region, specifically Germany. Technical discussions with South African foundry product suppliers are noted as being very important to the European market. The perception towards quality as well as price is that South African foundry product exports are average. Delivery times are perceived to be good. Late deliveries and defective castings are factors closely monitored in this geographical region.

Figure 33 represents the perceptions from another Asian region, specifically Taiwan. This geographic market has a perception that South African foundry products are expensive. Quality is also perceived to be average. The delivery time from South African foundries is perceived to be acceptable. Important considerations for this market are foundry products of consistent quality at the lowest possible cost.

TCO is of importance to mainly all regions interviewed. The concept of TCO is especially of importance for the HSM upon making decisions towards roll selection. The considerations of TCO and roll selection practices are further elaborated on in 4.3.

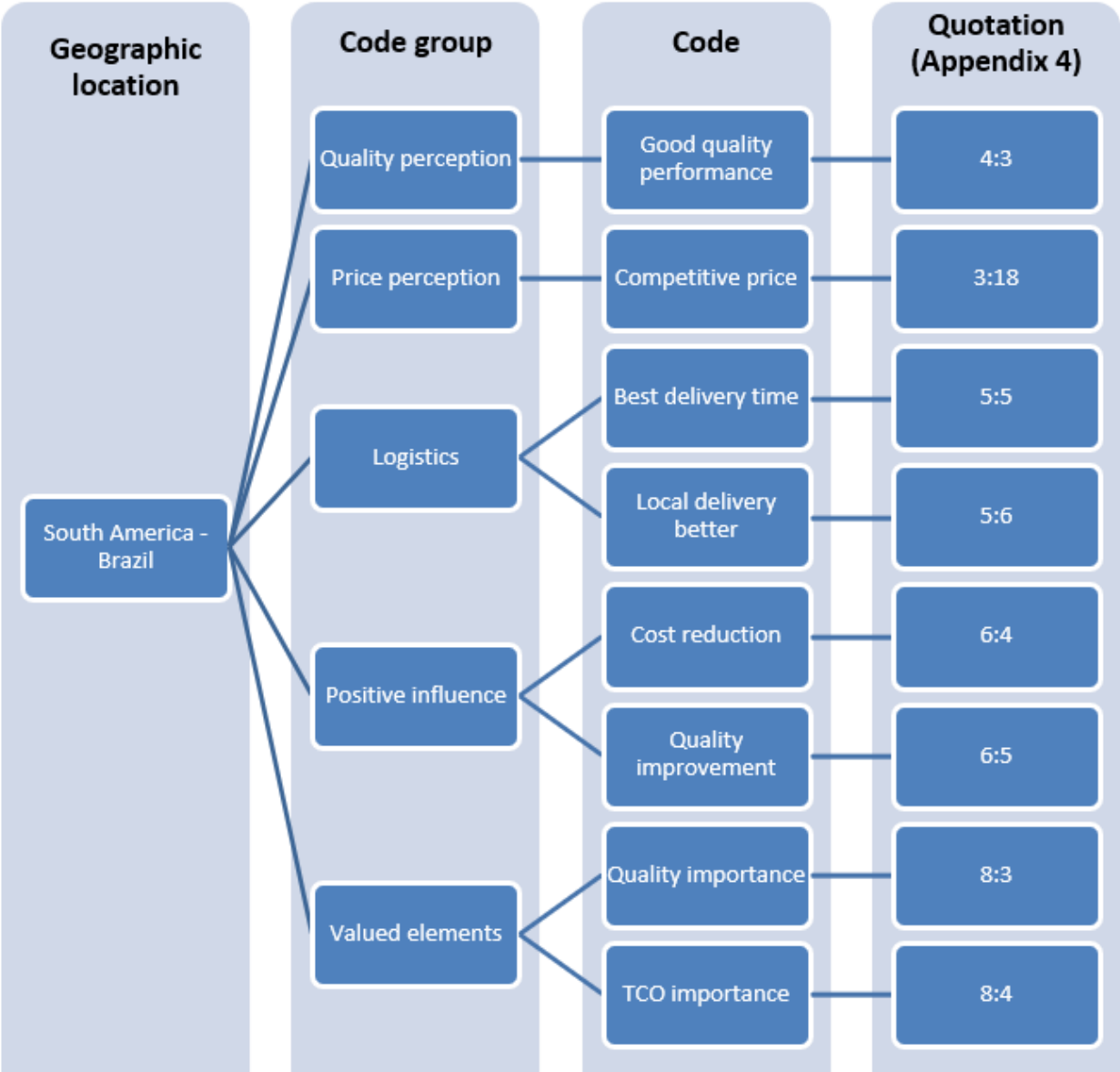


Figure 29: Geographic perception: South America, Brazil

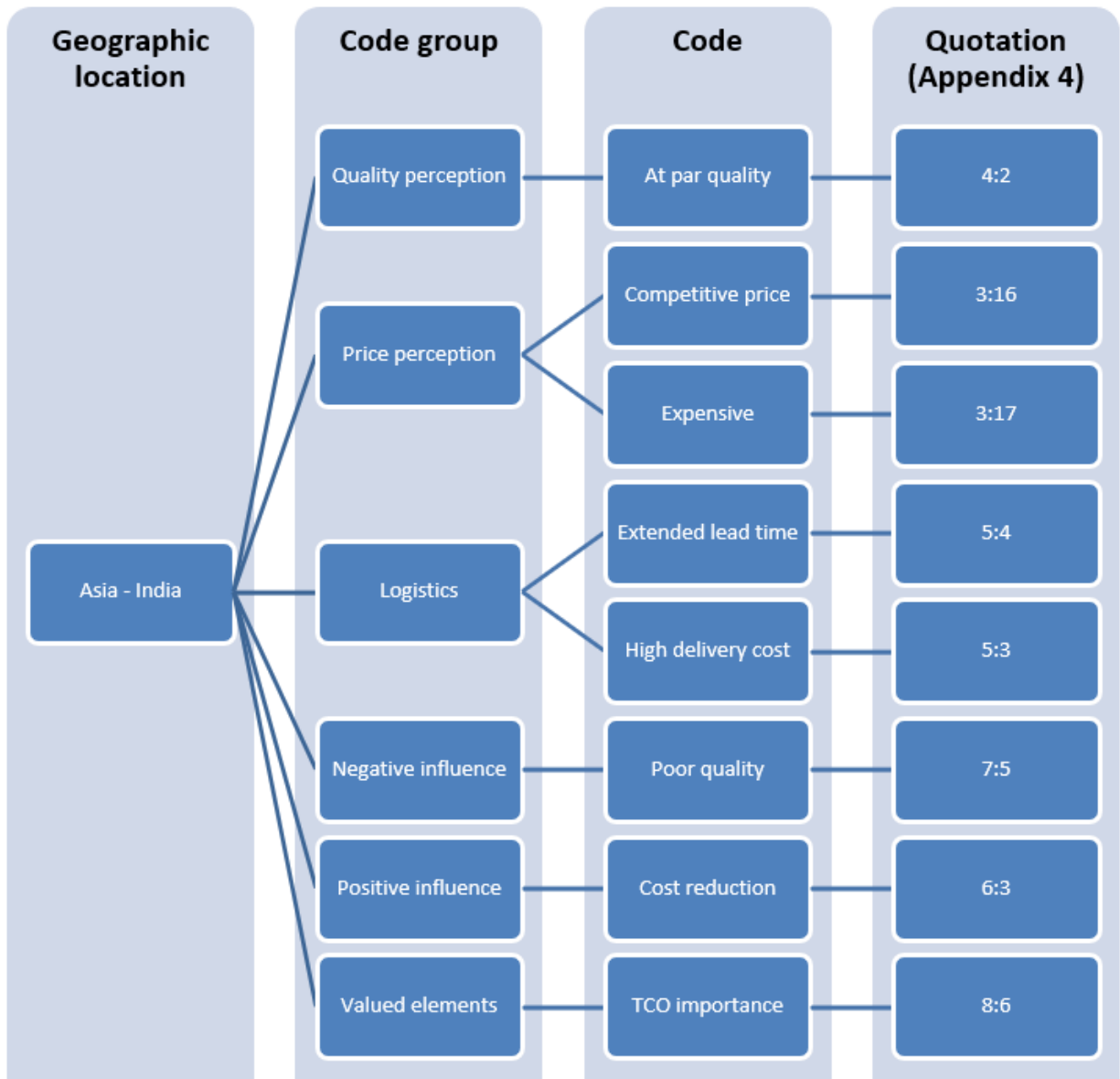


Figure 30:Geographic perception: Asia, India

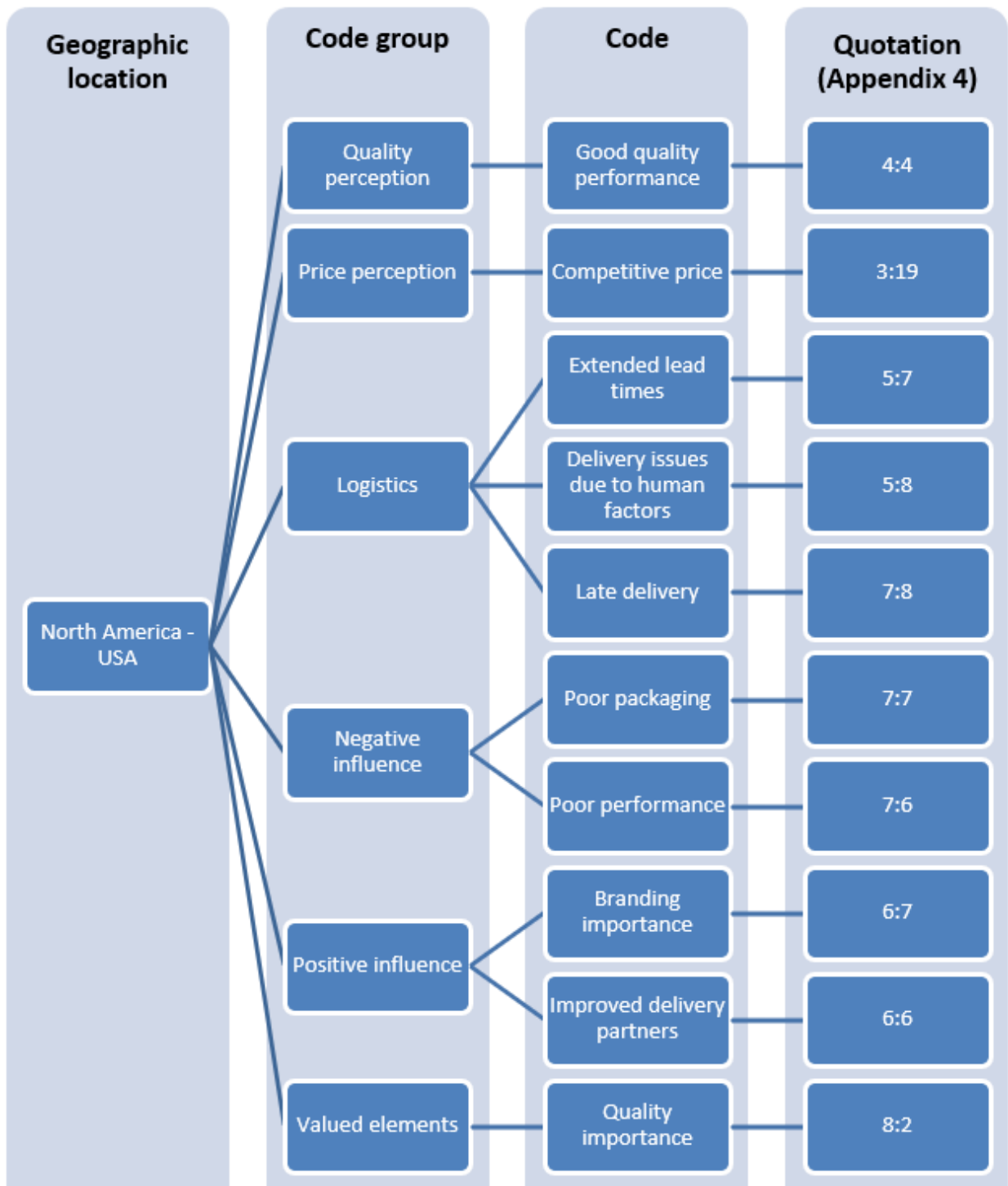


Figure 31: Geographic perception: North America, USA

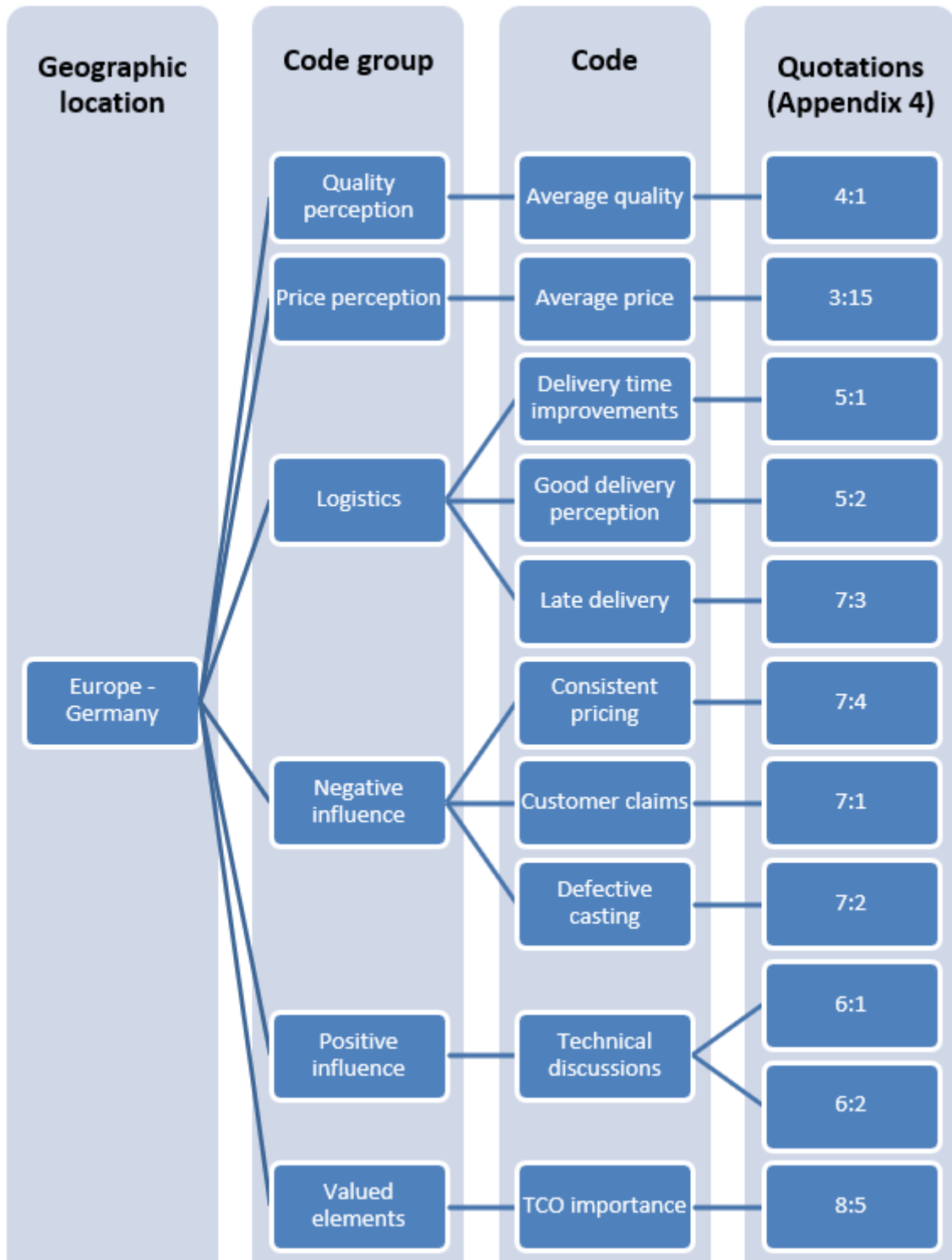


Figure 32: Geographic perception: Europe, Germany

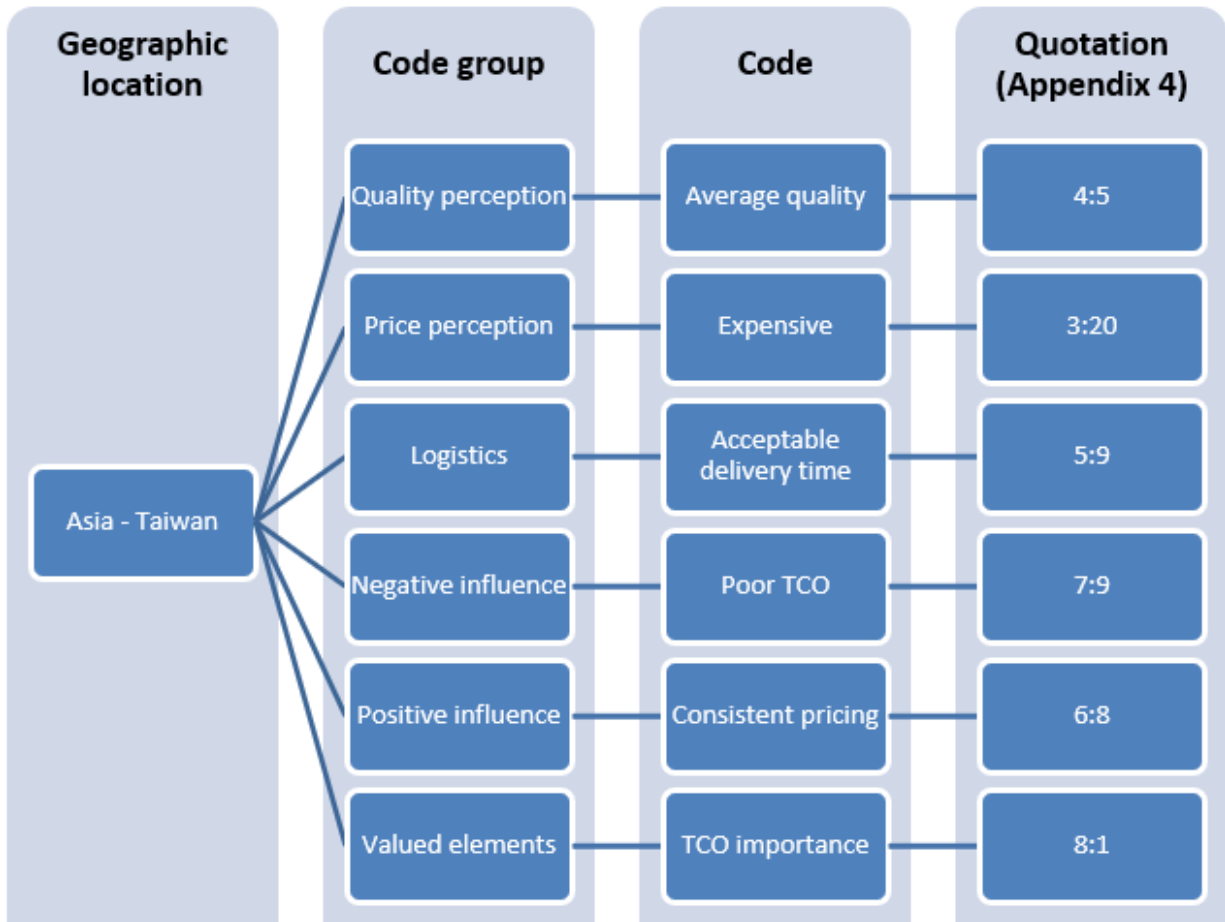


Figure 33: Geographic perception: Asia, Taiwan

4.2.3 Organisational section analysis

Three organisational functions were analysed in the study, including operations, commercial and the agents representing the South African foundries within their respective geographic location. Due to the limited sample size as portrayed in 3.3, the Indian geographical market also represents the perceptions of the commercial function. Similarly, the German geographical market represents the perceptions of the operational function. The perceptions of foundry agents represent the Brazilian, Taiwanese and North American markets.

4.3 Customer behaviour

Work rolls are purchased as required by the HSM department of the steel manufacturing facility. Depending on the organisational buying policy of the customer, buying of work rolls can either be purchased through a central buying department or through the HSM of the steel facility. Typically, the HSM technical needs are identified by the plant and requests are made to the buying department of the company (either local or centralised). Orders are provided to the roll

manufacturer by means of a tendering process, which enables the roll manufacturer to provide quotations prior to ordering from the steel manufacturer. Once all prices and historical performance figures are evaluated, an order on work rolls is placed. Commercial agents in each geographic market are contracted by roll suppliers to obtain new customers, follow up on orders and coordinate delivery aspects.

As confirmed by Webber (2002), work roll consumers base their purchases on a concept called TCO. This entails the selection of rolls based not only on low price, but also on the best quality and performance for their specific HSM. Figure 34 (Webber, 2002:302) depicts the roll selection process undertaken at the HSM. Depending on the corporate goals and mill requirements of the customer, the objectives in terms of order quantities and risk reduction are performed.

A criterion is required for each mill and is correlated to the importance of TCO perceived in the above results. Most of the respondents indicated that poor TCO, quality and elevated price would negatively influence their perception to buy. It is therefore critical for a roll manufacturer to be able to prove the roll performance (TCO) as well as best offered delivery date (reduced lead time) to be able to be selected as a supplier. Rolls are selected based on benchmarked information as well as roll supplier advice, indicating that the frequent communication of the roll supplier with the mill is of importance. The European market specifically indicated that a positive reflection is perceived when roll suppliers are not only available for technical discussions, but also upon frequent visits to the HSM plants. Depending on the geographical market, customers of work rolls perceive the value of price versus performance differently. Asian markets, e.g. India, make decisions primarily on price. The North American market typically requires a combination of improved performance at a low cost, although for this market customer relationship is deemed important and rolls at a higher cost will be purchased upon intimate supplier involvement. The European markets are mainly TCO driven, focusing primarily on high performance rolls (i.e. low TCO). Factors affecting the perception negatively include defective castings, customer claims and poor packaging.

Steel producers typically purchase work rolls, based on their demand for steel, a year or two in advance. The main reason for this is due to the extended delivery lead time from the roll supplier, typically three to six months. A certain level of roll stock is therefore maintained in the HSM. To gain sales traction as a roll supplier in an HSM is extremely slow and tedious. Trials should firstly prove the required TCO is minimised; should this not be possible, the next trials and evaluation iterations are required. Only once the roll performance is established in the HSM will frequent orders be realised, although price will always be under pressure and may lead to an established roll supplier to be replaced with another supplier.

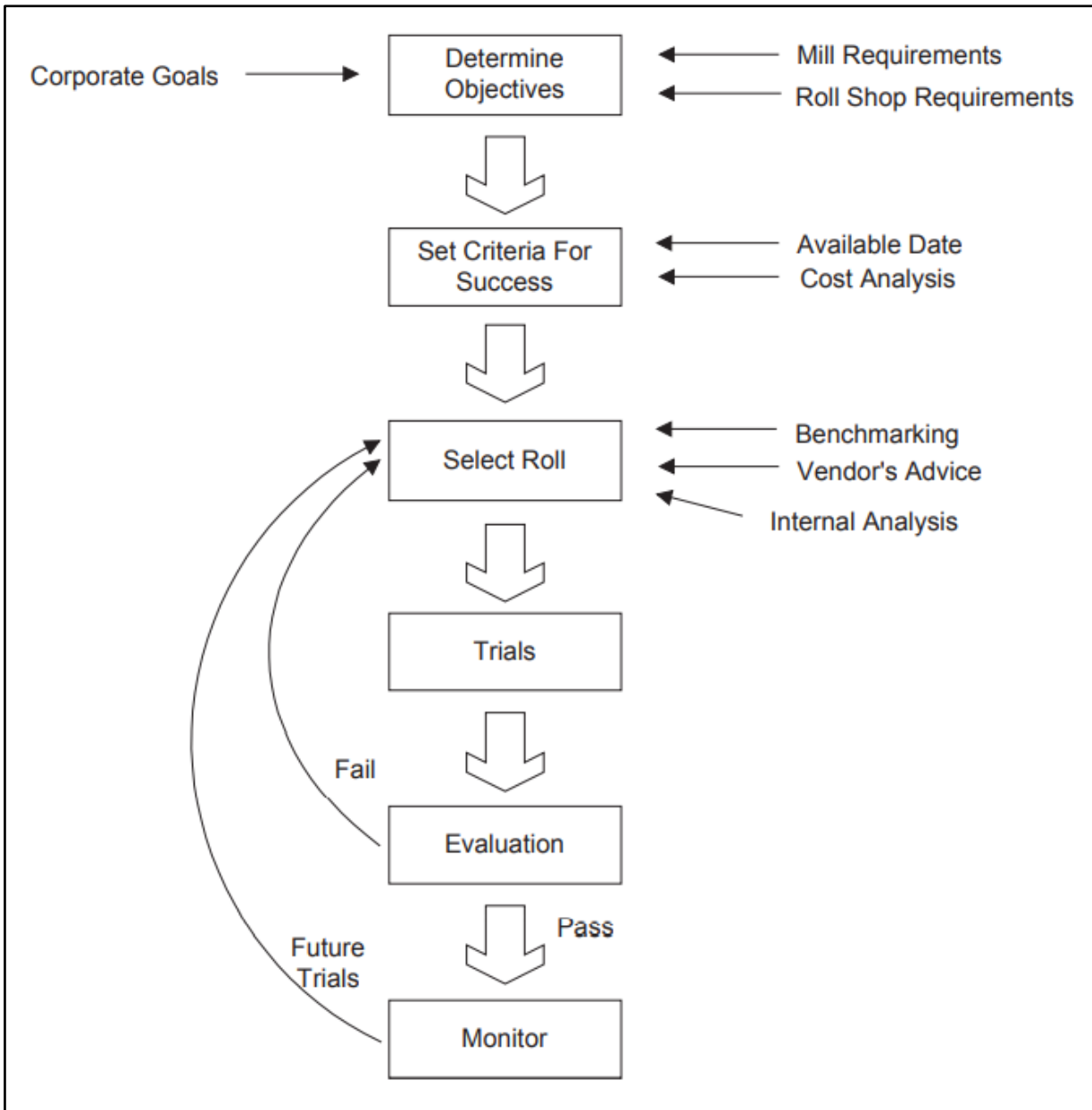


Figure 34: Roll selection process
 Source: Webber (2002:302)

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Concluding remarks towards the results and discussions made in Chapter 4 are provided. Recommendations towards targeting the international market, as well as proposed operational changes for the South African foundry industry are made. These recommendations attempt to improve the overall perception towards quality and price for the international foundry product importer.

5.2 Recommendations

5.2.1 Improvements in targeting the customer market

The product markets for HSM rolls are geographic locations across the globe. These geographic markets are linked to the physical location of crude steel producers. Figure 35 (WorldSteel, 2021b) depicts the distribution of crude steel produced across the globe.

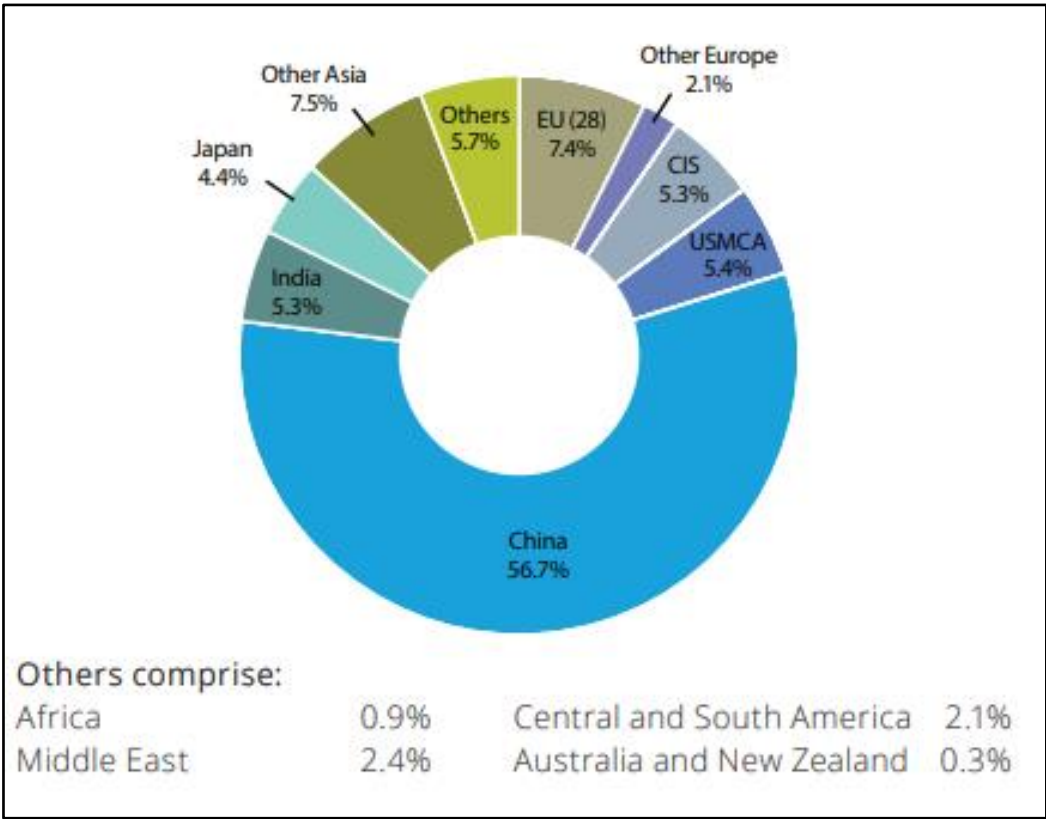


Figure 35: Crude steel production per geographic distribution (2020)

Source: WorldSteel (2021b)

The Chinese market is the largest, with 56.7%, compared to Australia and New Zealand with a crude steel production of 0.3%. The total global crude steel production for 2020 was 1 878 million tons (WorldSteel, 2021b). The steel demand figures for 2020 as well as the forecasted figures are depicted in Table 6 (WorldSteel, 2021a). The values provided are based on year-on-year growth rates (%). Apart for the Chinese steel demand, the Covid-19 pandemic affected the global demand for steel significantly during 2020. It is forecasted that China will have a declining growth of -1.1% in 2021. Major demand growth is expected in Central and South America (23.2%). Developing economies are therefore suggested to be targeted by the roll manufacturer during the next two-year period.

As the roll supply industry produces a niche product, the best way to target the customer market is to understand the needs of the customer. Most roll suppliers export to international markets and challenges in terms of language and culture will always remain an obstacle. The following improvements are suggested to target the customer market more effectively:

- Segment the buyers into segmented markets. Therefore, for the roll industry, this will typically not only be geographic segmentation (Tanner & Raymond, 2010), but also buying preference (importance of price versus performance). The roll supplier should segment and understand the markets based on a (Tanner & Raymond, 2010):
 - 1) priced-focused segment,
 - 2) quality and brand-focused segment,
 - 3) service-focused segment, and
 - 4) partnership-focused segment.
- Concentrated marketing techniques are required in this niche roll buying market. Although risky, this buying market is very specific and very few roll alternatives exist in the roll market. Refer to Figure 36 (Tanner & Raymond, 2010) for the strategies to target global markets.
- Focusing on emerging geographic markets (India and Brazil) will lead to enhanced future sales, but challenges in terms of cost competitiveness should be considered as these emerging markets typically represent the price-focused segment.
- Product differentiation in terms of roll uniqueness is challenging, as the required grade/quality per position in the HSM is relatively standard and known across the industry. Differentiation in the roll industry should be performed based on service, customer intimacy and technical assistance offered with the work rolls. This means that the roll supplier should have extensive knowledge of the steel manufacturer's rolling processes and rolled products.

Table 6: Steel demand forecast per geographic region

Regions	2020	2021 (f)	2022 (f)
European Union (27) & UK ¹	-11.2	12.7	5.5
Other Europe	9.4	16.4	7.1
CIS	-0.3	3.1	3.0
USMCA	-15.8	13.7	5.4
Central & South America	-7.2	23.2	0.9
Africa	-9.7	10.4	7.5
Middle East	-4.4	2.0	4.9
Asia and Oceania	3.7	1.9	1.1
World	0.1	4.5	2.2
World excl. China	-9.5	11.5	4.7
Developed Economies	-12.7	12.2	4.3
China	9.1	-1.0	0.0
Em. and Dev. Economies excl. China	-6.8	11.0	5.0
ASEAN (5) ²	-10.1	6.6	5.4
MENA	-6.4	3.6	6.5
f = forecast			
¹ European Union (27) + United Kingdom			
² Indonesia, Malaysia, Philippines, Thailand, Vietnam			

Source: WorldSteel (2021a)



Figure 36: Targeting strategies employed in global markets

Source: Tanner & Raymond (2010)

5.3 Implementation plan

A strategic marketing plan is required to ensure management remains accountable for the strategic growth of the foundry. Figure 37 shows the typical iterating nature of a strategic marketing plan, indicating that after the monitoring step, the strategy is adjusted to fit into the changing business environment. To execute the marketing plan effectively, the following steps are proposed (Kwach, 2018):

- Establish the correct expectations,
- Build the marketing team and secure resources,
- Communicate the strategy,
- Establish timelines and activities,
- Establish measures to success,
- Monitor,
- Be flexible and adapt to changes, and
- Communicate results.



Figure 37: The marketing strategy implementation process

Source: Kwach (2018)

Table 7 depicts the proposed strategic implementation plan for South African foundries. A summary of the strategic recommendations is linked through the strategic horizon, or timeline, to typical strategic objectives.

To facilitate the change required to excel the South African foundry industry towards excellence and sustainability, Kotter's (1996) model was applied as a potential implementation guidance tool.

5.3.1 Change management

Change management, as proposed by Kotter (1996) in 2.7.2, can guide the foundry industry to overcome some of the challenging obstacles when operating in the South African environment and exporting foundry products to the international market. The steps as proposed by Kotter (1996) are applied below.

The establishment of urgency

The aim is to reduce complacency within the workforce. Properly developed strategic objectives linked to the company threats and opportunities could assist in establishing the urgency required towards change. One of the biggest challenges currently experienced in the foundry industry (as per 2.3) is the ageing workforce, making the urgency to develop new skills as well as to retain current skills critical. Opportunities that can potentially elevate the foundry industry, such as renewable energy initiatives, effective management of cost drivers and expansion of geographic markets must be well understood and communicated. The proposal is to employ a change leader,

to effectively drive the change management process with the implementation of Kotter's eight-step model. Awareness programmes detailing the company's strategy and benefits towards change are crucial. Providing feedback to employees on the perceived poor quality and price in specifically the Asian market will propel them to initiate the proposed cost saving initiatives as well as attempt to reduce unwanted waste.

Table 7: Proposed strategic implementation plan for South African foundries

Marketing perspective	Strategic objective	Strategic horizon	Strategic recommendation
Strategic focus	Strengthen commercial relations with existing customers	Short term	<ul style="list-style-type: none"> • Increase marketing research to understand market gaps. • Focus on growing Indian and South American markets. • Increase technical and commercial visits. • Intense agent deployment into mills. • Increase marketing spending to 2% of company revenue
Strategic focus	Grow geographical markets	Long term	
Strategic focus	Become part of the European supplier mix	Long term	
Strategic focus	Understanding customer needs	Short/medium term	<ul style="list-style-type: none"> • Continuous improvement of current products • Research and development partnerships to develop new grades
Cost	Reduced transportation cost and ensuring dependable transportation	Medium term	<ul style="list-style-type: none"> • Benchmark transporters against each other. • Investigate alternative ports to export from.
Cost	Sustainable electricity supply	Medium term	<ul style="list-style-type: none"> • Investigate alternative energy sources (gas/solar power) • Optimise melting operations to decrease electricity demand

The creation of a guiding coalition

A team with sufficient power should be created to lead the change. Typically, the coalition is championed by the CEO of the company. Several advisory teams, grouped into management and technical advisors, are essential for the creation of a guiding coalition. Technical visits to customers should be reviewed and guidance towards proposed improvements should be made a priority.

Development of a vision and strategy

The development of a clear strategic vision towards the change in culture and values is necessary to achieve the required change management outcomes. Specifically, the focus on skills transfer through the implementation of knowledge sharing projects, including mentoring programmes and graduate programmes, should be executed. Another strategy could be the implementation of lean manufacturing programmes to achieve the goals set in terms of strategic KPIs. Understanding customers is important to guide the company strategy, as proper understanding of customer requirements is linked to improved TCO in all respondents interviewed.

The non-European manufacturers typically are perceived as commodity producers, implying that foundry products are treated like coal or iron ore. The performance of foundry products is typically perceived as average to acceptable, with prices controlled by the market. In contrast, European and Japanese competitors are typically perceived as foundry product manufacturers with differentiated product offerings. These competitors are actively involved with innovation and technological advances, leading to excellent performance and low TCO. The foundry product manufacturers in this spectrum are typically price-makers, as their products are highly sought-after. The South African foundry products are currently positioned to a large extent on the commodity product side, although through strategic intervention, the aim is to transfer to the differentiated product spectrum. The aim is not to fully transfer to the differentiated product spectrum, but rather to be positioned in between the two spectrums. This is due to the differentiated product spectrum being sensitive to economic instability, causing good foundry product manufacturers to close. Being positioned in between the two spectrums can lead to the production of foundry products at the best possible TCO with excellent technical relationships with customers.

Proper communication of the change strategy

Properly communicating the change vision is of utmost importance, as a lack in communication causes loss of interest and subsequently a failing change. Communication should start from the CEO, and senior leaders should follow suit. Every event should be utilised to discuss the change

vision. If the company consists of a communications department, the change leader should be in frequent discussions with the department to enable the broadcasting of positive progress to all employees.

Allowing for broad-based change

Barriers to change should be removed to enable strategic and innovative thinking. Within the manufacturing environment of the foundry, several conflicting circumstances may lead to deteriorating motivation and willingness to change. Some of these challenges were discussed in the previous chapters (0). The management team plays a vital role in enabling broad-based change, and it is important for employees to be aware of the support from management regarding the drive towards innovation that may change the way business is currently done. Empowering of the selected change leaders to intervene and remove obstacles is recommended.

Creating instant wins

Capitalising on short-term wins allows for the change momentum to be kept. These wins should be visible to employees and related to the change program. Proper communication of these instant wins should also be performed to prevent perceived dilution. Instant wins in the foundry industry may include the achievement of strategic KPIs, successful implementation of project milestones and recognition of employee skill transfer.

Combining the gains achieved and generating additional change

Proper document control and data visualisation could assist in combining, storing and representing the achievements. Additional change ideas should be noted and developed further through correctly structured forums.

Setting new approaches in culture

The final step is difficult to place a deadline on, as changes in culture may take years to achieve. Cultural changes towards being prone to change management systems in the organisation take patience and dedication. Once this step is successfully implemented, future change becomes easier.

5.4 Conclusion

The perceptions from the international HSM steel market towards exported South African foundry products were tested through a qualitative research approach. The results obtained from respondents based in various geographical markets were coded, analysed and discussed. The need to understand international consumer perceptions is necessary as this information enables South African foundries to properly target the customer market.

Research analyses performed on the geographical market showed that customer location plays a critical role in selecting the correct targeting strategy. The European markets tend to perceive the quality as well as price of South African foundry products as average. Technical discussions and improved TCO are important dimensions for this market. The North American market showed that, although South African foundry products are perceived to be price competitive, poor perceptions regarding on-time delivery are experienced. This market deems TCO as important, and therefore good product quality combined with reliable delivery is key. Asian markets typically perceive South African foundry products as expensive and on the price level of a European exporter. This market is close to competitive foundries in the Asian region, which allows for shorter delivery times. South American markets similarly perceive South African foundry products as competitive with good quality. The delivery lead time, apart from locally supplied foundry products, is perceived to be the best compared to international exporting competitors. TCO is again seen as important, similar to most of the other geographical regions analysed.

Although South African foundries are experiencing challenges in producing optimally and efficiently, international steel companies still overall perceive South African foundry products as a competitive product, with average quality and price. The distance to the market can be seen as a limiting factor for the South African foundry industry, which forces organisations to think more critically on process improvements and rework. It is for this reason that the change management process of Kotter (1996) was selected and applied to the foundry industry within this study as part of the implementation plan proposed to the South African foundry industry.

5.5 Limitations of the study

The original units of analysis, as proposed in the study, were not successfully achieved due to the following:

- Global steel manufacturing plants were prohibited by top management to partake in studies, especially due to competition between global foundries.
- The global steel manufacturing plants willing to partake in studies were running high tonnages and time was limited for discussion, ultimately preventing proper interviews to be conducted.

- Language barriers, especially in the Asian, Ukraine and South American markets prohibited comprehensive interviews to be conducted.

As a result of the above-mentioned constraints, internationally-based agents representing South African foundry products were included as participants. These commercial agents know their represented steel market well and could provide insight into the same perception-based information required in the study.

5.6 Further research

Due to the limitations mentioned in 5.5, causing the originally planned sample size to decrease from 15 to five, larger sample sizes will add enhanced insight towards different regions within the selected geographical markets. Approaches to overcome the obstacles mentioned may include a translator, building of networks within the international customer organisation and setting up face-to-face meetings.

One of the limitations of the samples selected was the type of customer manufacturing process. Further enrichment of knowledge can be obtained with sample diversification, including long steel product customers, stainless steel customers and mining customers importing castings from South Africa.

REFERENCES

- Appelbaum, S., Habashy, S., Malo, J. & Shafiq, H. 2012. Back to the future: Revisiting Kotter's 1996 change model. *Journal of Management Development*, 31:764-782.
- Barnes, J. 2002. International customer perceptions of South African automotive component manufacturer performance levels: University of Natal CSDS.
- Bean, R., du Preez, W. & Pain, A. 2006. Product development within the framework of a National Casting Technology Centre. *Journal for New Generation Sciences*, 4(1):57-63.
- Belzunce, F., Ziadi, A. & Rodriguez, C. 2004. Structural integrity of hot strip mill rolling rolls. *Engineering Failure Analysis*, 11(5):789-797.
- Bolton, R. & Lemon, K.N. 1999. A dynamic model of customers' usage of services: Usage as an antecedent and consequence of satisfaction. *Journal of Marketing Research*, 36(2):171-186.
- Bryman, A. & Bell, E. 2014. Research methodology: Business and management contexts: Oxford University Press Southern Africa.
- Buchanan, D. 1993. Review of 'a strategy of change: Concepts and controversies in the management of change'. *Journal of Management Studies*, 30(6):684-686.
- Buchmayr, B., Degner, M. & Palkowski, H. 2018. Future challenges in the steel industry and consequences for rolling plant technologies. *BHM Berg- und Hüttenmännische Monatshefte*, 163(3):76-83.
- Büchner, H.-J. 2019. Forecast 2025 for the global foundry industry.
- dtic. 2021. Trade data. <http://tradestats.thedti.gov.za/> Date of access: 26 October 2021.
- Eroglu, S. & Machleit, K.A. 1989. Effect of individual and product-specific variables on utilizing country-of-origin as a product quality cue. *International Marketing Review*, 6(6):27-41.
- Han, C.M. 1990. Testing the role of country image in consumer choice behavior. *European Journal of Marketing*, 24(6):24-40.
- IDC. 2020. Performance of the primary and secondary sectors of the South African economy. <https://www.idc.co.za/wp-content/uploads/2020/04/IDC-RI-publication-Sector-Trends-released-on-15-April-2020.pdf> Date of access.
- IDC. 2021. Economic trends: Key trends in the South African economy, 31 March 2021. <https://www.idc.co.za/wp-content/uploads/2021/04/IDC-RI-publication-Key-Trends-in-the-South-African-Economy-31-March-2021-FINAL.pdf> Date of access: 26 October 2021.
- ITA. 2021. Understanding HS codes and the Schedule B. <https://www.trade.gov/harmonized-system-hs-codes> Date of access: 20 January 2021.
- Kanter, R.M., Stein, B.A. & Jick, T.D. 1992. The challenges of execution: Roles and tasks in the change process. *The Challenge of Organizational Change*:369-394.
- Kaynak, E. & Cavusgil, S.T. 1983. Consumer attitudes towards products of foreign origin: Do they vary across product classes? *International Journal of Advertising*, 2(May):147-157.

- Kaynak, E., Kucukemiroglu, O. & Hyder, A.S. 2000. Consumers' country-of-origin (COO) perceptions of imported products in a homogenous less-developed country. *European Journal of Marketing*.
- Kerr, E., Webber, R. & McCaw, D. 2004. Roll performance—technical overview and future outlook. *Ironmaking and Steelmaking*, 31(4):295-299.
- Kotter, J. 1996. *Leading change*. Boston: Harvard Business School Press.
- Kubota. 2022. Kubota's Rolling Mill Rolls Support the World Steel Industry. www.kubota.com/products/materials/products/roll/index.html Date of access: 5 February 2022.
- Kwach, J. 2018. Strategy implementation process: Meaning and components <https://www.tuko.co.ke/286159-strategy-implementation-process-meaning-components.html> Date of access: 11 November 2021.
- Lamb, C.W., Hair, J.F., Jr., McDaniel, C., Jr., Boshoff, C., Terblanché, N.S., Elliott, R. & Klopper, H.B. 2019. *Marketing*. 6th ed.: Oxford University Press Southern Africa (Pty) Limited.
- Lewin, K. 1951. *Field theory in social science*. New York: Harper.
- Li, K., Geng, Q. & Shao, B. 2011. Warranty designs and brand reputation analysis in a duopoly. *California Journal of Operations Management*, 9(1):34-42.
- Li, K., Wang, L., Chhajed, D. & Mallik, S. 2019. The impact of quality perception and consumer valuation change on manufacturer's optimal warranty, pricing, and market coverage strategies. *Decision Sciences*, 50(2):311-339.
- Madzivhandila, T. 2015. Present status and future trends. Presented to the V BRICS Foundry Forum.
- McDonald, J. 1995. Chinese prefer to buy from their own/Foreign companies must fight low-cost rivals for part of huge market. *Associated Press* 20 February.
- Mphasha, M.C. 2016. *An analysis of the South African foundry industry: Competitiveness compared to international Foundries*. University of Johannesburg.
- NewSteelConstruction. 2017. An introduction to steelmaking. <https://www.newsteelconstruction.com/wp/an-introduction-to-steelmaking/> Date of access: 8 October 2020.
- NUS_Consulting_Group. 2014. International Electricity & Natural Gas Report & Price Survey. [https://www.bizcommunity.com/f/1411/NUS_Energy_Market_Survey_-_Report_2014_\(Final\).pdf](https://www.bizcommunity.com/f/1411/NUS_Energy_Market_Survey_-_Report_2014_(Final).pdf) Date of access: 8 October 2020.
- Patel, S.N., Palit, P., Mishra, A., Mathur, J. & Bhattacharyya, S. 2019. A comprehensive analysis of failure of cross bearing of universal spindle in Hot Strip Mill. *Engineering Failure Analysis*, 98:1-9.
- Pollack, J. & Pollack, R. 2015. Using Kotter's eight stage process to manage an organisational change program: Presentation and practice. *Systemic Practice & Action Research*, 28(1):51-66.
- Ransing, R.S., Giannetti, C., Ransing, M.R. & James, M. 2013. A coupled penalty matrix approach and principal component based co-linearity index technique to discover product

specific foundry process knowledge from in-process data in order to reduce defects. *Computers in Industry*, 64(5):514-523.

Ratana, S., Raksmeay, C. & Danut, D. 2020. Conceptualizing a framework: A critical review of the development of change management theories *Studies in Business & Economics*, 15(2):205-214.

SAIF. 2015. Tough times ahead for foundries (Vol. 8.). South African Institute of Foundrymen.

Saka, A. 2003. Internal change agents' view of the management of change problem. *Journal of Organizational Change Management*, 16:480-496.

Song, N., Luan, Y., Bai, Y., Kang, X., Xia, L. & Li, D. 2009. Computer simulation of core filling process of cast high speed steel roll. *China Foundry*, 6(4):314-318.

Tanner & Raymond. 2010. Principles of marketing. Minnesota: University of Minnesota.

Thiel, D. 2016. Reducing industrial energy costs through energy efficiency measures in the South African foundry industry-evaluation and opportunities of a South African foundry. University of Cape Town.

Verhoef, P.C., Franses, P.H. & Donkers, B. 2002. Changing perceptions and changing behavior in customer relationships. *Marketing Letters*, 13(2):121-134.

Webber, R. 2002. Preferred roll specification for rolling ferrous materials in hot strip mills. (In Lee, G.E., ed. Rolls for the metalworking industries. Warrendale, PA: Iron & Steel Society.

Webber, R. 2017. Total cost of ownership models. (In. 54th Seminário de Laminação e Conformação de Metais organised by São Paulo, Brazil.

Woodruff, R.B. 1997. Customer value: The next source for competitive advantage. *Journal of the Academy of Marketing Science*, 25(2):139-153.

WorldSteel. 2018. Production of hot rolled products. https://www.worldsteel.org/steel-by-topic/statistics/steel-data-viewer/P2_hr_products_total/CHN/IND Date of access: 1 August 2020.

WorldSteel. 2019. Steel statistical yearbook 2019. <https://www.worldsteel.org/steel-by-topic/statistics/steel-statistical-yearbook.html> Date of access: 1 August 2020.

WorldSteel. 2020. Top steel-producing companies 2019. <https://www.worldsteel.org/steel-by-topic/statistics/top-producers.html> Date of access: 1 August 2020.

WorldSteel. 2021a. Short range outlook. <https://www.worldsteel.org/steel-by-topic/statistics/short-range-outlook.html> Date of access: 18 October 2021.

WorldSteel. 2021b. World steel in figures. <https://www.worldsteel.org/en/dam/jcr:976723ed-74b3-47b4-92f6-81b6a452b86e/World%2520Steel%2520in%2520Figures%25202021.pdf> Date of access: 28 August 2021.

APPENDIX 1

(Thousand tons)

Production of Hot Rolled Products

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Austria	5 394	6 619	6 875	6 900	7 377	7 148	7 601	7 594	7 999	7 495
Belgium	7 172	9 649	10 012	8 917	8 293	8 392	8 938	8 735	9 292	10 260
Bulgaria	947	896	1 115	818	875	935	840	921	911	1 131
Croatia	76	81	69	15	18	17	16	17	15	13
Czech Republic	3 955	4 625	4 616	4 276	4 416	4 375	4 459	4 657	4 053	4 458
Denmark (e)	313	470	540	360	480	490	575	615	590	655 e
Germany	29 990	38 103	39 286	37 843	37 687	37 713	37 562	37 602	37 539	36 584
Finland (e)	2 537	3 380	3 380	3 355	3 195	3 440	3 560	3 660	3 700	3 770 e
France	3 336	3 388	3 486	13 529	14 716	15 464	14 994	14 319	15 103	14 738
Greece (e)	1 855	1 635	1 790	1 155	985	965	875	1 020	1 140	1 200 e
Hungary	1 452	1 594	1 765	1 928	1 936	1 823	1 714	1 593	1 972	2 086
Italy	20 743	25 359	27 978	26 309	23 553	23 150	21 730	23 205	23 227	23 533
Latvia (e)	692	650	570	810	814	150	200			
Luxembourg	2 418	2 737	2 220	2 136	2 015	2 124	2 034	2 056	2 055	2 166
Netherlands	4 997	6 274	6 401	6 418	6 370	6 657	6 814	6 465	6 589	6 971
Poland	6 358	7 050	7 844	7 789	7 514	7 650	7 953	8 229	9 039	9 105
Portugal (e)	1 483	1 330	1 765	1 870	1 910	1 860	1 835	1 750	1 700	1 900 e
Romania (e)	2 862	3 580	3 860	3 080	2 750	2 945	3 200	3 120	3 100	3 200 e
Slovak Republic (e)	3 395	3 726	3 468	3 600	3 660	4 607	4 300	4 300	4 350	4 380 e
Slovenia (e)	355	492	530	580	555	555	555	570	605	610 e
Spain	14 406	15 511	15 251	13 166	12 954	13 529	13 781	13 181	13 589	13 777 e
Sweden (e)	2 956	4 100	4 125	3 420	3 500	3 800	3 950	4 120	4 200	4 020 e
United Kingdom	7 135	8 415	7 993	7 054	8 053	8 148	7 988	6 680	6 330	6 529
European Union (28)	124 826	149 663	154 939	155 329	153 625	155 935	155 472	154 410	157 097	158 583
Albania (e)	280	236	295	355	480	435	475	100		
Bosnia-Herzegovina	435	475	548	565	592	605	650	690	690	685
Montenegro (e)	120	120	125	110	65	135	140	100	100	100 e
Norway (e)	470	405	450	465	450	475	480	500	460	465 e
Serbia	950	1 120	1 180	340	390	550	860	1 050	1 310	1 690 e
Turkey (e)	25 133	26 300	31 943	34 286	36 405	36 093	36 939	36 882	39 154	39 510 e
Other Europe	27 388	28 655	34 541	36 121	38 382	38 294	39 544	39 321	41 714	42 450
Belarus	2 296	1 567	1 685	1 898	1 818	1 855	1 878	1 878	1 891	2 009
Kazakhstan	3 098	3 033	3 355	2 689	2 803	3 173	3 474	3 669	4 261	3 818
Moldova	441	231	307	360	180	333	421	120	446	472 e
Russia	50 840	42 959	45 351	46 653	46 966	48 653	48 106	48 079	48 640	49 201
Ukraine	14 900	17 799	19 807	18 577	17 594	14 942	12 370	13 147	12 781	18 361
Uzbekistan	700	700	720	725	735	785	850	860	850	850 e
C.I.S.	72 275	66 289	71 224	70 902	70 096	69 741	67 099	67 753	68 869	74 711
Canada	8 685	12 365	12 080	12 321	12 192	11 984	11 954	11 977	11 860	13 718
Costa Rica	280	267	308	372	447	460	474	382	378	393
Cuba	120	108	118	126	150	105	126	130	114	117
Dominican Republic	268	273	272	395	406	516	425	385	471	523
El Salvador	69	78	97	78	81	83	85	97	90	92
Guatemala	288	345	376	449	557	574	591	474	454	463
Mexico	12 994	14 809	15 793	16 269	16 357	17 742	17 573	18 697	18 694	18 872
Trinidad and Tobago	238	361	427	398	297	300	413	25		
United States	56 396	75 699	83 339	87 043	86 567	89 130	78 514	78 502	82 451	86 436
North America	79 338	104 325	112 811	117 452	117 053	120 894	110 156	110 668	114 512	120 614

Production of Hot Rolled Products

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Argentina	3 749	5 046	5 386	4 952	5 144	5 021	4 572	3 984	4 595	4 763
Brazil	20 223	25 401	25 240	25 696	26 263	24 916	31 789	30 555	32 670	33 611
Chile	1 279	1 473	1 514	1 594	1 289	1 017	1 035	1 081	1 062	1 131
Colombia	1 466	1 621	1 780	1 726	1 651	1 795	1 860	1 772	1 895	1 647
Ecuador	442	546	489	559	691	707	761	682	710	738
Paraguay	42	44	27	22	23	23	24	19	21	22
Peru	871	1 046	913	1 205	1 358	1 434	1 335	1 417	1 517	1 505
Uruguay	55	59	72	74	76	79	81	75	66	68
Venezuela	3 204	2 054	2 658	2 065	1 948	1 357	1 261	530	404	131
South America	31 329	37 291	38 077	37 893	38 442	36 349	42 717	40 115	42 941	43 619
Algeria (e)	510	560	470	470	400	520	1 050	1 100	1 950	2 850 e
Egypt	6 352	7 939	6 588	7 265	7 438	8 137	7 676	8 001	8 059	9 598
Libya (e)	1 370	945	65	310	690	650	440	430	410	650 e
Morocco (e)	963	1 035	1 090	855	1 035	970	1 200	1 200	950	1 000 e
South Africa (e)	5 550	5 820	5 850	5 400	5 800	5 583	5 700	5 450	5 600	5 650 e
Tunisia (e)	400	500	395	370	440	440	490	400	500	500 e
Africa	15 145	16 799	14 458	14 670	15 803	16 300	16 556	16 581	17 469	20 248
Iran	9 880	15 395	16 813	17 261	16 656	16 482	15 133	15 473	15 920	17 212
Qatar	1 468	1 550	1 580	1 650	1 696	1 709	1 784	1 894	1 745	1 847
Saudi Arabia (e)	4 130	4 420	4 650	4 600	4 900	5 000	5 500	5 000	4 500	5 000 e
United Arab Emirates	1 170	1 580	1 950	2 156	2 549	2 765	2 959	3 126	3 246	3 167
Middle East	16 648	22 945	24 993	25 666	25 801	25 956	25 376	25 494	25 410	27 225
China (3)	693 405	802 014	885 195	950 641	1 086 926	1 125 131	1 034 684	1 048 135	1 046 421	1 105 517
China (4)	578 836	655 160	717 670	768 026	859 521	872 637	849 485	814 556	814 085	855 403 e
India (5)	59 355	66 120	74 521	80 198	85 277	92 470	89 927	99 312	119 892	100 574
Indonesia	5 092	5 212	5 448	5 418	5 116	6 475	6 168	6 552	7 866	10 045
Japan	76 686	97 765	94 832	94 807	96 965	97 882	93 020	92 636	92 441	92 440
South Korea	51 057	59 031	66 473	66 317	64 541	68 905	67 756	67 131	69 557	69 785
Malaysia	5 103	4 967	5 111	4 954	4 980	4 759	4 226	3 782	3 772	3 801
Philippines	1 977	2 133	2 420	2 653	3 020	3 273	4 013	4 346	4 300	4 864
Singapore	689	716	750	705	429	540	501	528	596	584
Taiwan, China	18 385	23 493	24 578	24 277	24 845	25 472	25 019	26 639	27 664	28 513
Thailand	6 955	7 483	6 936	6 721	7 070	8 710	3 841	9 542	9 318	9 032
Viet Nam	4 723	5 659	5 470	5 049	5 123	5 657	7 199	8 657	11 302	14 532
Asia	808 857	927 737	1 004 209	1 059 125	1 156 888	1 186 779	1 151 154	1 133 682	1 160 793	1 189 573
Australia	4 789	6 327	6 082	5 078	4 400	4 092	4 307	4 693	4 606	4 680
New Zealand (e)	710	810	800	845	830	780	735	650	740	735 e
Oceania	5 499	7 137	6 882	5 923	5 230	4 872	5 042	5 343	5 346	5 415
World	1 181 305	1 360 842	1 462 135	1 523 082	1 621 320	1 655 119	1 613 115	1 593 366	1 634 152	1 682 437

(3) - rolled steel products, not included in totals.

(4) - total hot rolled steel products derived from the sum of individual products.

(5) - finished steel products for sale.

APPENDIX 2

(in million metric tonnes crude steel production)

Companies	HQ	Tonnage 2019	Tonnage 2018	Tonnage 2017	Tonnage 2016	2019 Ranking
ArcelorMittal (1)	Luxembourg	97.31	96.42	97.03	95.45	1
China Baowu Group (2)	China	95.47	67.43	65.39	63.81	2
Nippon Steel Corporation (3)	Japan	51.68	49.22	47.36	44.65	3
HBIS Group (4)	China	46.56	46.80	45.56	46.18	4
POSCO	South Korea	43.12	42.86	42.19	41.80	5
Shagang Group	China	41.10	40.66	38.35	33.25	6
Ansteel Group	China	39.20	37.36	35.76	33.19	7
Jianlong Group	China	31.19	27.88	20.26	16.45	8
Tata Steel Group (5)	India	30.15	27.27	25.11	24.49	9
Shougang Group	China	29.34	27.34	27.63	26.80	10
Shandong Steel Group	China	27.58	23.21	21.68	23.02	11
JFE Steel Corporation	Japan	27.35	29.15	30.15	30.29	12
Valin Group	China	24.31	23.01	20.15	15.48	13
Nucor Corporation	USA	23.09	25.49	24.39	21.95	14
HYUNDAI Steel Company	South Korea	21.56	21.88	21.23	19.86	15
IMIDRO (6)	Iran	16.79	16.79	15.60	14.02	16
JSW Steel Limited	India	16.26	16.83	16.06	14.91	17
Steel Authority of India Ltd. (SAIL)	India	16.18	15.93	14.80	14.38	18
Benxi Steel	China	16.18	15.90	15.77	14.40	19
Fangda Steel	China	15.66	15.51	15.11	13.68	20
Novolipetsk Steel (NLMK)	Russia	15.61	17.39	17.08	16.64	21
Baotou Iron & Steel (Group) Co., Ltd.	China	15.46	15.25	14.20	12.30	22
China Steel Corporation	Taiwan, China	15.23	15.88	15.33	15.52	23
Techint Group (7)	Argentina	14.44	15.38	11.75	7.98	24
Liuzhou Steel	China	14.40	13.53	12.30	11.05	25
Rizhao Steel	China	14.20	14.95	14.98	13.86	26
United States Steel Corporation	USA	13.89	15.37	14.43	14.22	27
EVRAZ	Russia	13.81	13.02	14.03	13.53	28
CITIC Pacific	China	13.55	12.55	8.77	8.40	29
Gerdau S.A.	Brazil	13.13	15.80	16.50	15.95	30
Jingye Steel	China	12.58	11.25	10.41	11.01	31
Magnitogorsk Iron & Steel Works (MMK)	Russia	12.46	12.66	12.86	12.54	32
Shaanxi Steel	China	12.45	11.38	10.24	7.30	33
Sanming Steel	China	12.40	11.68	11.19	10.39	34
thyssenkrupp	Germany	12.25	12.58	13.22	17.24	35
Zenith Steel	China	11.93	8.70	10.36	9.24	36
Severstal	Russia	11.85	12.04	11.65	11.63	37
Tsingshan Stainless Steel	China	(e) 11.40	9.29	N.A.	N.A.	38
Nanjing Steel	China	10.97	10.05	9.85	9.01	39
Taiyuan Steel	China	10.86	10.70	10.50	10.28	40
Anyang Steel	China	10.54	10.97	10.06	10.48	41
Metinvest Holding LLC	Ukraine	9.58	9.37	9.59	10.34	42
Xinyu Steel	China	9.47	9.36	8.90	8.57	43
Donghai Special Steel	China	8.90	7.61	7.43	N.A.	44
Jinxi Steel (also known as China Oriental)	China	8.73	10.33	11.72	11.05	45
ERDEMIR Group	Turkey	8.61	9.14	9.20	9.18	46
Steel Dynamics, Inc.	USA	8.59	8.92	8.27	N.A.	47
Kunming Steel	China	7.73	7.27	6.36	6.40	48
SSAB	Sweden	7.62	8.03	8.00	7.99	49
Jiuquan Steel	China	7.48	7.02	5.17	5.50	50
voestalpine Group	Austria	7.26	6.94	8.15	7.47	51
Yingkou Plate	China	7.01	6.36	6.09	5.78	52
Salzgitter AG Stahl und Technologie	Germany	6.90	7.04	7.31	6.80	53
CELSA Steel Group	Spain	6.90	7.10	7.02	6.94	54
Kobe Steel, Ltd.	Japan	6.89	6.88	7.74	7.26	55
Puyang Steel	China	6.36	5.32	5.93	4.96	56
Jindal Steel and Power Ltd (JSPL)	India	(p) 6.30	4.02	3.48	3.48	57
Ruifeng Steel	China	6.25	5.73	5.97	6.26	58
Binxin Special Steel	China	5.91	5.99	5.98	6.06	59
Lingyuan Steel	China	5.90	5.53	5.05	4.88	60
BlueScope Steel Limited	Australia	5.86	5.91	5.91	5.63	61
RIVA Group	Luxembourg	5.55	6.02	5.87	5.47	62
Liberty Steel Group	Australia/UK	5.41	2.35	2.05	2.10	63
ISD (Industrial Union of Donbass)	Ukraine	5.40	(r) 5.32	(e) 3.41	4.61	64
AK Steel Corporation	USA	5.32	5.71	5.67	5.05	65
Ganglu Steel	China	5.20	5.39	3.07	3.07	66

(in million metric tonnes crude steel production)

Companies	HQ	Tonnage 2019	Tonnage 2018	Tonnage 2017	Tonnage 2016	2019 Ranking
Yuanli Group	China	4.97	4.91	4.67	4.39	67
Hongxing Steel	China	4.92	5.10	4.84	5.10	68
Saudi Iron & Steel Co. (Hadeed, an affiliate of SABIC)	KSA	4.87	5.26	4.27	5.27	69
Metalloinvest Management Company	Russia	4.87	5.05	4.76	4.66	70
Rashtriya Ispat Nigam Ltd (VIZAG Steel)	India	4.84	5.26	4.41	3.82	71
Tian Tie	China	4.79	2.63			72
Ezz Steel	Egypt	4.68	4.88	4.52	3.66	73
Tianzhu Steel	China	4.68	4.03	3.51	3.49	74
Usinas Siderúrgicas de Minas Gerais S.A. (USIMINAS)	Brazil	4.57	4.47	4.38	4.06	75
Huttenwerke Krupp Mannesmann	Germany	(e) 4.39	4.39	5.90	4.78	76
Donghua Steel	China	4.37	2.58			77
Ningbo Steel	China	4.33	4.55	4.57	4.55	78
Habaş	Turkey	4.29	3.77	3.51	3.21	79
Shiheng Special Steel	China	4.16	3.75	3.41	3.54	80
Xinxing Ductile	China	4.05	3.89	4.58	3.48	81
Yukun Steel	China	3.99	3.99	2.69	3.99	82
Jiyuan Steel	China	3.98	3.85	3.82	3.60	83
Tosyalı Holding	Turkey	3.91	3.34	2.77	2.64	84
Rockcheck Steel	China	3.85	3.69	3.48	3.51	85
Mechel	Russia	3.60	3.88	4.27	4.19	86
Sanbao Steel	China	3.60	3.53	3.30	3.53	87
Dongkuk Steel Mill Co., Ltd.	South Korea	3.56	3.77	3.73	3.29	88
Zhongyang Steel	China	3.55	3.13			89
Altos Hornos de México, S.A.B. de C.V. (AHMSA)	Mexico	3.52	4.52	4.39	4.65	90
Lianxin Steel	China	3.49	3.09	3.23	2.98	91
Yuhua Steel	China	3.48	4.80	4.50	5.42	92
Delong Steel	China	3.46	3.18	2.59	3.18	93
Rongxin Steel	China	3.39	3.50			94
Taishan Steel	China	3.33	3.60	3.33	3.28	95
Emirates Steel	UAE	3.33	3.25	3.31	3.15	96
Acciaieria Arvedi SpA	Italy	3.27	3.35	3.19	2.95	97
Longteng Special Steel	China	3.18	3.00	3.01	2.87	98
Jianbang Group	China	3.17	2.99			99
TMK	Russia	3.12	3.31	3.24	2.74	100
İçdaş	Turkey	3.09	4.02	4.31	3.30	101
Xintai Steel	China	3.05	2.45			102
Companhia Siderúrgica Nacional (CSN)	Brazil	(e) 3.04	4.20	4.43	4.06	103
Lengshuijiang Steel	China	3.03	3.27	3.08	2.80	104

N.A. not available (e) estimated (r) revised (p) provisional

(1) Includes shares in AM/NS India

(2) Includes tonnage of Maanshan Steel and Chongqing Steel

(3) Includes tonnage of NIPPON STEEL Stainless Steel Corporation, Sanyo Special Steel, Ovako, as well as shares in USIMINAS and in AM/NS India

(4) Includes tonnage of Serbia Iron & Steel d.o.o. Beograd and MAKSTIL A.D. in Macedonia

(5) Includes tonnage of Bhushan Steel Ltd.

(6) Combined tonnage of Mobarrakeh Steel, Esfahan Steel, Khuzestan Steel and NISCO

(7) Includes shares in USIMINAS

Notes on company ownership and tonnage calculations:

Chinese companies, the official CISA tonnage publication was used, unless especially noted. Figures represent consolidated tonnage ending 31 December 2019, including interests in subsidiaries and joint ventures.

APPENDIX 3



Ethics informed consent **Ethics number: NWU-00040-21-A4**

Dear Participant

This **Informed Consent Statement** serves to confirm the following information as it relates to the officially approved research project at the North-West University on the international perception of foundry consumables imported from South Africa for consumption in the Hot Strip Mill. The title is "Investigating international perceptions on selected South African foundry products".

- The sole purpose of this study is to obtain information from role-players like yourself to determine the perception of South African exported foundry consumables through interviews. Each interview will take 30 minutes, unless you prefer to continue beyond that.
- Participation is completely voluntary and you may withdraw at any time. You may also decide not to answer specific questions.
- The procedure to be followed is a qualitative research design, which entails an online Zoom/Teams interview. Basic background information will be asked e.g. function and related experience to the topic.
- Confidentiality of the data is guaranteed and only the combined results will be used for research and publication purposes. All records of the interviews will be kept under lock for three years, after which it will be destroyed.
- The data gathered from the questionnaires will only be used for research purposes.
- Note that this study does not have a correct or incorrect answer to any of the questions. The study merely analyses perception towards imported consumables used in the Hot Strip Mill.
- The study intends to determine your personal viewpoint, and therefore it is not expected that your views represent that of the organisation where you work.
- You could have access to the results of the study upon request.

Please indicate your consent

I hereby give my consent after having read the above information that my data may be used as stated above.	YES	NO
I hereby give my consent that my demographic data may be used to develop a profile on customer perception.	YES	NO

You can contact myself at gerharddied@gmail.com or my supervisor, Dr Johan Jordaan at Jordaan.johan@nwu.ac.za

Thank you for your time.

Gerhard Diedericks

APPENDIX 4

Report created by Gerhard Diedericks from Atlas.ti

Quotation Report – Grouped by: Code Groups

All (43) quotations

Logistics

11 Quotations:

5:1 ¶ 3 in Q6 Logistics and delivery time

In the beginning, it was a big problem. So delivery times were very long and they never reached in time.

5:2 ¶ 3 in Q6 Logistics and delivery time

Compared to others, it's still good

5:3 ¶ 4 in Q6 Logistics and delivery time

CIF cost from South African suppliers then the costs are very, very high

5:4 ¶ 4 in Q6 Logistics and delivery time

And as far as the logistics timeline is concerned, so South African location obviously is a deterrent. So there's additional time involved, the logistics time is much, much less if I'm buying from other countries compared to South Africa. Typically, the cycle time would be around adding 50 to 55 days to India

5:5 ¶ 5 in Q6 Logistics and delivery time

Compared with Europeans and Americans, South Africa has the best delivery time

5:6 ¶ 5 in Q6 Logistics and delivery time

We have in Brazil domestic suppliers with very good delivery time

5:7 ¶ 6 in Q6 Logistics and delivery time

Much longer transit than other places

5:8 ¶ 6 in Q6 Logistics and delivery time

Many errors in human inputs of shipments – paperwork can be very confusing

5:9 ¶ 7 in Q6 Logistics and delivery time

In general okay

7:3 ¶ 3 in Q8 Influence negative perception

Delayed deliveries, you expect the role to be on site next week and wait and then the appointment is there and the role is not coming and then you hear the roll it coming only in three months

7:8 ¶ 6 in Q8 Influence negative perception

Poor delivery performance

Negative influence

7 Quotations:

7:1 ¶ 3 in Q8 Influence negative perception

Claims are always very bad

7:2 ¶ 3 in Q8 Influence negative perception

Mistake in the production or the roll was delivered with defects

7:4 ¶ 3 in Q8 Influence negative perception

New price for the next order and you see the prices doubled suddenly, then that makes it very difficult for us to say we want this type of roll. So we want a continuous price

7:5 ¶ 4 in Q8 Influence negative perception

Quality is important

7:6 ¶ 6 in Q8 Influence negative perception

Poor performance

7:7 ¶ 6 in Q8 Influence negative perception

Poor packaging

7:9 ¶ 7 in Q8 Influence negative perception

Cost/performance ratio not competitive

Positive influence

8 Quotations:

6:1 ¶ 3 in Q7 Influence positive perception

If I could get a chance to discuss technical problems with people from operational environment

6:2 ¶ 3 in Q7 Influence positive perception

But I never had a chance to talk to someone who is making rolls, they all want to sell rolls. That is a big difference

6:3 ¶ 4 in Q7 Influence positive perception

They can reduce the cost

6:4 ¶ 5 in Q7 Influence positive perception

Price

6:5 ¶ 5 in Q7 Influence positive perception

Quality

6:6 ¶ 6 in Q7 Influence positive perception

More professional delivery partners

6:7 ¶ 6 in Q7 Influence positive perception

South Africa branded packaging

6:8 ¶ 7 in Q7 Influence positive perception

Roll quality stable

Price perception

6 Quotations:

3:15 ¶ 3 in Q4 Price

It's not the cheapest, but we're not the most expensive, maybe lower middle class

3:16 ¶ 4 in Q4 Price

If you consider the European region and the US market, the South African players are competitive compared to them

3:17 ¶ 4 in Q4 Price

But if you see the Asia Pacific region, Japan, China, and even for that case, Russia and Turkey, then South Africa is very, very expensive

3:18 ¶ 5 in Q4 Price

They are very competitive

3:19 ¶ 6 in Q4 Price

Very competitive outside of China and India prices

3:20 ¶ 7 in Q4 Price

Above average, sometimes the highest

Quality perception

5 Quotations:

4:1 ¶ 3 in Q5 Quality

There are some really much better and also some worse, you cannot compare, for example, with Japanese rolls, that is for me is a top. Russian rolls is far the worst? And South Africa is somewhere in the middle

4:2 ¶ 4 in Q5 Quality

I think the quality is at par

4:3 ¶ 5 in Q5 Quality

South African rolls perform very well, always at first positions on performance ranking.

4:4 ¶ 6 in Q5 Quality

Generally, very good and reliable

4:5 ¶ 7 in Q5 Quality

Average

Valued elements

6 Quotations:

8:1 ¶ 7 in Q10 Quality or Price

C/P comparison

8:2 ¶ 6 in Q10 Quality or Price

Quality is key

8:3 ¶ 5 in Q10 Quality or Price

For my point of view, quality of course.

8:4 ¶ 5 in Q10 Quality or Price

But it must be attempted to the price as it is the first point checked by Purchase Dept.

8:5 ¶ 3 in Q10 Quality or Price

As it is really a good question, and they're very difficult to answer. Then we must say those in equal parts is it's the same. See, what we have is a computer application, what we call total cost of ownership. And you're given to the computer as a price. And let's say as a price is a response a purchasing department pays to the salesman let's say 50 000 euros a month or whatever, but turns out operational people tell me for some ways they Okay, this rolls from for example, South Africa can make 2000 tonnes per millimetre on the roll. So, how many tonnes per millimetre can I roll with this product, is a question of quality. And then we calculate the euros and the tons per millimetre and we know how many millimetres we have on the roll. And then we calculate how much 1 000 tons cost 10 euros when we buy this roll from South Africa for example, and there are some more details for example, when there is a claim and we increase the price by 5 000 euros and when we see that rolls are also delivered too late, then we put on 100 euro per days it is too late. And so the question of quality, tons per millimetre, delivery time and claims broken roles and service. Did any salesman show up or did you hear nothing? What is quality? The arguments are part of this calculation and in the end, the computer says this roll is worse. Let's say 60 000 euro, and then we compare that with the other 10 or 20 suppliers and the computer makes some proposal by 10 rolls here, 5 here and 2 there. But in the end I look at what the computer proposes and then I decide not to computer. So you cannot say yes or no or something like that. It is a very complicated issue. And with this app it is very good to see so many aspects, buying the most expensive roll is in the end the cheapest way to produce steel. For example, my very expensive roll in Japan, but roll makes 10,000 tonnes per millimetre or you buy a very cheap roll in India cost only 20,000 euros, but it makes over a 1000 tonnes per millimetre. So the question is, in the end, that is what we call the total cost of ownership. The most expensive role is maybe the cheapest to produce and is very difficult to discuss it with your boss or with the purchasing people. The good service is also important. If you have a claim and nobody is interested, what will you do with a roll like that. You will only have trouble and will never buy again. So it is not only the price? The price is so easy to say. Price is what salesmen get from the purchasing department. That is easy. But what is quality? Quality is difficult.

8:6 ¶ 4 in Q10 Quality or Price

It can never be one. It is always the coalition of both the factors, I think it's not just the right quality, it has to be the right quality at the right price. That is what matters at the end of the day. So it's

complete value in use that is what we really consider the total cost of ownership. So it includes quality, performance as well as the cost. So obviously, these things like the wear and the grinding amount, the unproductive grinding and the productive grinding, all these factors are considered to determine the final performance. And usually the performance for specifically rolls is measured in terms of the tonnes of steel roll per mm off roll consumed. That is the parameter, you can eliminate the unproductive grinding, the grinding which is because of our side issue in the mill, those is removed to actually determine the fair performance of the supplier? this year, all eggs in one basket is also not suitable because anything can go wrong with any market. So it's like we try to maximise our supplier base across different geographies. While obviously we will work towards having multiple suppliers, but also multiple suppliers from multiple geographies and not from one, because that's inherent risk, which we identify in our organisation. That is where I think South Africa plays a very crucial role for us, because you are one of the only suppliers from that segment or from that market. And it helps to achieve our objectives of risk mitigation. But then there is a fine balance we need to achieve between the overall cost which we have to pay for that risk mitigation. So it there is always a limitation to it. So, the other markets are gradually picking up. The Russian and Turkish markets are gradually coming into the market in India and they may have an upper edge in the future, so you have to be really cautious. Look for more ways to reduce your cost, look for alternative fuel, which can be cost effective. Apart from electricity, I think these things should be in your focus area to help improve the competitiveness in future, because we also believe in long term relationships. It's not the absolute cost, which we are talking about, since we are getting weightage to the total cost of ownership and the value in use. So, even the improvement in your product, which can outnumber the other suppliers in terms of the performance will also help you in the long run to command a premium in your price. So it is not only important that you reduce your absolute cost, but work towards the total cost. That is what I would like to pass on to you, because you are from foundry, so you will appreciate it more, the better the chemistry of the product developed. And the better performance I get, will actually reduce my final cost. And that is more important rather than the absolute cost I'm paying. Today, I am rolling around 30 000 tonnes, then if you can increase it to 40 000 tonnes, I can share a premium with you, since you are improving our mill productivity.

Price perception		Quality perception		Logistics	
ID	Codes	ID	Codes	ID	Codes
3:15	#Germany @Operations Average price	4:1	#Germany @Operations Average quality	5:1	#Germany @Operations Delivery time improvements
3:16	#India @Commercial Competative price	4:2	#India @Commercial At par quality	5:2	#Germany @Operations Good delivery perception
3:17	#India @Commercial Expensive	4:3	#Brazil @Agent Good quality performance	5:3	#India @Commercial High delivery cost
3:18	#Brazil @Agent Competative price	4:4	#North America @Agent Good quality performance	5:4	#India @Commercial Extended lead times
3:19	#North America @Agent Competative price	4:5	#Taiwan @Agent Average quality	5:5	#Brazil @Agent Best delivery time compared to Europe and America
3:20	#Taiwan @Agent Expensive			5:6	#Brazil @Agent Local delivery better
				5:7	#North America @Agent Extended lead times
				5:8	#North America @Agent Delivery issues due to human factors
				5:9	#Taiwan @Agent Acceptable delivery time

Positive influence		Negative influence		Valued elements	
ID	Codes	ID	Codes	ID	Codes
6:1	#Germany @Operations Technical discussions	7:1	#Germany @Operations Customer claims	8:1	#Taiwan @Agent TCO importance
6:2	#Germany @Operations Technical discussions	7:2	#Germany @Operations Defective casting	8:2	#North America @Agent Quality importance
6:3	#India @Commercial Cost reduction	7:3	#Germany @Operations Late delivery	8:3	#Brazil @Agent Quality importance
6:4	#Brazil @Agent Cost reduction	7:4	#Germany @Agent Consistant pricing	8:4	#Brazil @Agent TCO importance
6:5	#Brazil @Agent Quality improvement	7:5	#India @Commercial Poor quality	8:5	#Germany @Operations TCO importance
6:6	#North America @Agent Improved delivery partners	7:6	#North America @Agent Poor performance	8:6	#India @Commercial TCO importance
6:7	#North America @Agent Branding importance	7:7	#North America @Agent Poor packaging		
6:8	#Taiwan @Agent Consistant quality	7:8	#North America @Agent Late delivery		
		7:9	#Taiwan @Agent Poor TCO		