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The sustainability of the steel industry in South Africa

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The sustainability of the steel industry in South Africa

Tebogo Immaculate Raaleka

A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

Johannesburg, 2017

ABSTRACT

Undoubtedly the steel industry in South Africa remains one of the key strategic industries within the manufacturing sector and the South African economy overall. However, recent developments have led to the industry's decline, raising grim concerns and uncertainties about this key industry's viability, casting doubts about the future prosperity and sustainability of the industry; as various stakeholders contented to identify and mitigate a range of factors impacting the industry.

The purpose of this study was to identify factors that impact the steel industry in South Africa and to determine whether there are any key factors (or influential drivers) that have resulted in the recent decline in the industry. Moreover, the study aimed to develop an empirical model that represents the industry, allowing for simulations and plausible future scenarios to be tested to identify measures, interventions and outcomes required to ensure the sustainability of the industry

This research identified a multitude of factors that have resulted in the recent decline in the steel industry in South Africa, with particular reference to the key factors (or influential drivers) that are directly attributable and most influential to the industry's decline. Fuzzy Cognitive Mapping (FCM) was used as a methodology for analysis, wherein an empirical model of the steel industry was developed.

The study identified *increasing steel imports*, *Chinese steel overcapacity*, *increasing input costs*, *subdued economic growth*, *inadequate infrastructure investment* and *lack of government/institutional policy* as the most influential drivers. The research further identified and concluded that the growth and sustainability of the steel industry in South Africa is dependent not only on policy interventions aimed at controlling the influx of imports or promoting downstream beneficiation and localisation; but rather more prominently on measures that would act as precursors to stimulating or inducing demand for steel and steel consuming products.

Keywords: *Fuzzy cognitive mapping, manufacturing end users, downstream beneficiation*

DECLARATION

I, Tebogo Immaculate Raaleka, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

……

Tebogo Immaculate Raaleka

Signed at ……

On the ……day of …….. 2017

DEDICATION

The completion of this research report would not have been possible without the support of my beautiful wife, *Siyamanga Raaleka*. Many thanks for your sacrifices, encouragement and support throughout my MBA degree.

This report is further dedicated to my daughters, *Kamogelo* and *Yamasa*. Many thanks for giving me an excuse to break away from my studies to have a few relaxing moments. Your happiness and well-being continue to drive me ever forward.

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Special thanks to the following individuals for their professional guidance, sacrifices and support:

- My supervisor, Prof. Eric Schaling; for knowledge sharing and guidance throughout the research process;
- Prof. Anthony Stacey; for assisting with the modelling and simulations using fuzzy cognitive mapping and for the insightful knowledge that you imparted to me during my research period;
- All steel industry leaders and subject matter experts; for giving their time to be interviewed and for giving paramount input into the steel industry. Your contributions were the cornerstone of this research;
- Lastly, to God, the almighty. You were with me and you kept me wherever I went!

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ABBREVIATIONS

AMSA	ArcelorMittal South Africa
BCCS	Best-Cost County Sourcing
BCI	Business Consumer Index
BRICS	Brazil, Russia, India, China and South Africa
EAF	Electric Arc Furnace
EBIT	Earnings before Interest and Tax
FOCAC	Forum of Africa-China Cooperation
FCM	Fuzzy Cognitive Mapping
FDI	Foreign Direct Investment
FOB	Free On Board
GDP	Gross Domestic Product
GJ	Gigajoule (equivalent to 1 billion joules)
GFCF	Gross Fixed Capital Formation
IPAP	Industrial Policy Action Plan
ISCOR	South African Iron and Steel Corporation
ISI	Import Substitution Industrialisation
ISF	International Steel Fabricators
ITAC	International Trade Administration Commission of South Africa
NDP	National Development Plan

NGP	New Growth Path
NUMSA	National Union of Metalworkers of South Africa
OBF	Oxygen Blast Furnace
OHF	Open Hearth Furnace
PRASA	Passenger Rail Association of South Africa
PPPFA	Preferential Procurement Policy Framework Act
SACCI	South African Chamber of Commerce and Industry
SAISC	Southern African Institute of Steel Construction
SAISI	South African Iron and Steel Institute
SME	Subject Matter Experts
SOE	State Owned Enterprises
USCO	Union Steel Corporation of South Africa Ltd
WTO	World Trade Organisation

CHAPTER 1. INTRODUCTION

1.1 Purpose of the study

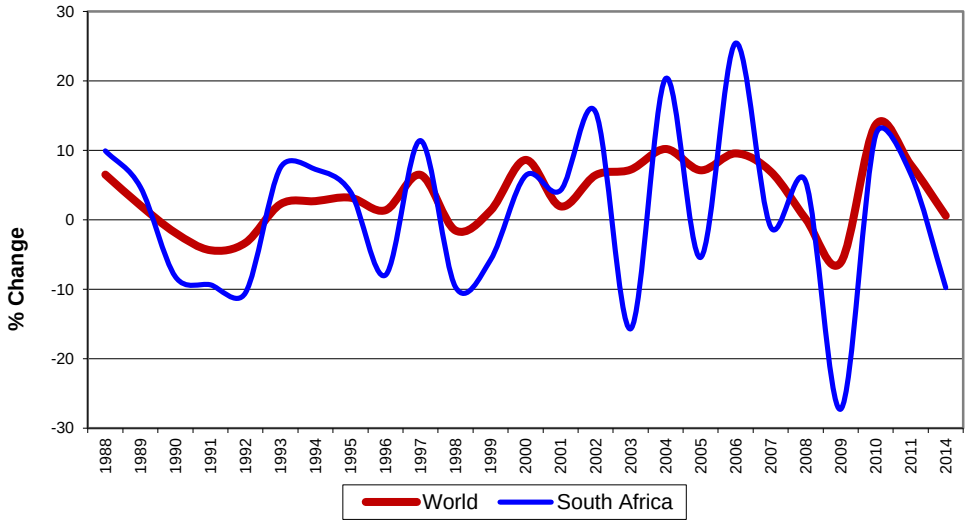
The purpose of this study is to identify factors that impact the steel industry in South Africa and to determine whether there are any key factors (or influential drivers) that have resulted in the recent decline in the industry. Moreover, this study aims to develop an empirical model that represents the industry, allowing for simulations and plausible future scenarios to be tested to identify measures, interventions and outcomes required to ensure the sustainability of the industry.

1.2 Context of the study

South Africa is at a high risk of losing its domestic steel producing capabilities as a result of a series of exogenous economic “shocks” (Davies, 2015). Coupled with a series of domestic macroeconomic factors relating largely to constrained and expensive electricity supply and high input prices, these factors have resulted in an adverse impact to the economic growth, industrial development and creation of jobs for the domestic economy (Davies, 2015). The factors have over the past few years led to an industry that is uncompetitive against other international steel producing countries, enabling easy access and an opportunistic response by international mill producers to export into the South African market at highly competitive prices. In addition to the above, the subdued state of the steel industry has also been exacerbated by the decline in local demand due to the lack of sustained investment in infrastructure projects, by both the private and public sectors.

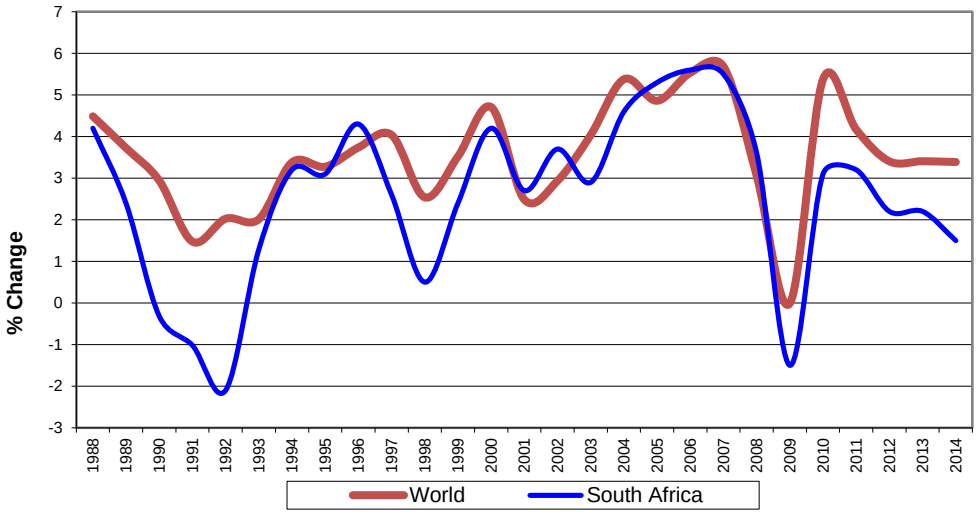
Steel is one of the most widely used metals in existence. Its applications extend across a diverse range of industries; from the construction of bridges, multi-storey buildings, mining structures, to the automotive sector for the manufacturing of motor vehicles; to packaging, agriculture, defence, appliance manufacturing, telecommunication, machinery and equipment manufacturing, including many other diverse applications. Steel is attributed to the development of industrialisation and regarded as the key input to the evolution of modern economies.

As a result of the close link between per capita steel consumption within an economy and growth rates, steel consumption is often considered to be a barometer indicating economic growth and industrial development within an economy (Huh, 2011). Figures 1 and 2 illustrate the correlation between apparent consumption of finished steel and economic growth rates.



(Source SAISI, 2016)

Figure 1: Apparent Consumption of finished steel



(Source SAISI, 2016)

Figure 2: Economic growth rate

The South African steel industry originated in 1927, following the inception of ISCOR, a state formed and operated steel mill (Schneider, 2000). ISCOR was formed to facilitate mining operations as an input product to many of the mining activities and also to establish capacity for domestic manufacturing. By the 1940s, ISCOR steel prices were competitively priced against internationally produced steel and by the 1960s, South Africa had a comparative advantage over other countries as prices were considerably lower than in leading iron and steel producing international mills (Schneider, 2000).

The iron and steel value chains consist of four stages across the value chain, spanning multiple industries; “exploration and extraction, mining beneficiation, metallurgical beneficiation and shaping, and lastly conversion/fabrication and manufacturing/and user industries” (Kumba Iron Ore, 2011b, p. 2). The value chain is illustrated in Figure 3:

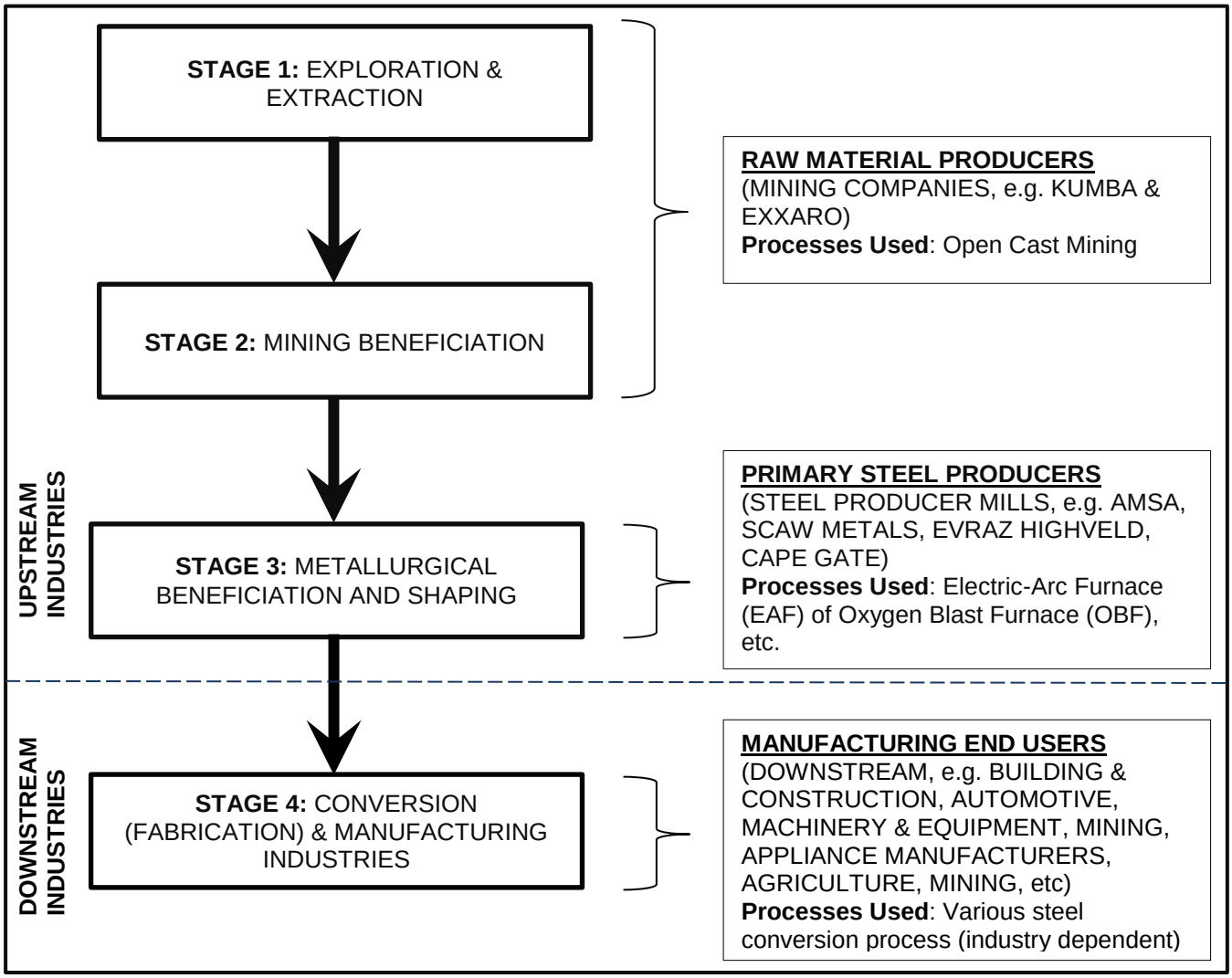


Figure 3: The steel value chain in South Africa

The **exploration and extraction** phase is performed by mining companies through an open cast operation, where iron ore is extracted by rock drilling and blasting. **Mining beneficiation** involves the beneficiation of the iron ore through the use of high capital equipment using dense medium separation methods at the main source mine site (Kumba Iron Ore, 2011b).

Metallurgical beneficiation and shaping is carried out by Primary Steel Producer Mills and the process typically involves the conversion of the raw iron ore to pig iron using either a blast furnace or electric arc furnace method, and then refining and rolling it into various steel products (Kumba Iron Ore, 2011b). Other input products used in the steelmaking process include scrap steel collected by metal waste reclaimers, manganese and coking coal. The electric arc furnace (EAF) method utilises relatively small amounts of raw iron ore, as the bulk of the iron ore is obtained from smelting recycled scrap metal using a relatively high electricity intensive process (Kumba Iron Ore, 2011b). South Africa has five Steel Producer Mills; ArcelorMittal SA, Cape Gate, Evraz Highveld, Scaw Metals and Columbus Stainless. They produced a combined 7.6 million tonnes of steel in 2015, up 16.3 percent from an output of 6.55 million tonnes in 2014, placing South Africa as the largest producer in Africa and the twenty-first largest producer in the world (Research Channel, 2016).

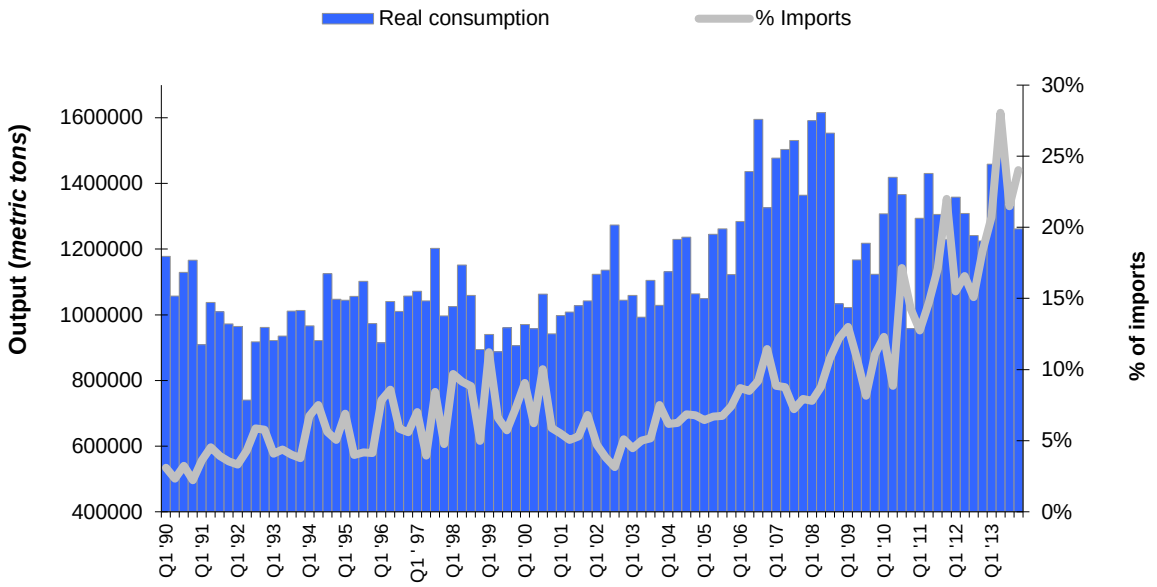
The final stage in the steel value chain consists of conversion (fabrication) and manufacturing (end use) industries (Kumba Iron Ore, 2011b). For this report, these end user industries are grouped together and referred to as "**Manufacturing End Users**". The manufacturing end users process and add value to standard steel products for application in various industries. Building and construction are the largest manufacturing end users consuming about 40 percent of steel produced locally, followed by the automotive sector at 11 percent, then machinery and equipment manufacturers at 7 percent, mining at 7 percent, packaging at 7 percent, appliance manufacturers and agriculture at 4 and 2 percent, respectively. A number of smaller end users make up the difference.

An intermediary group exists between metallurgical beneficiation and manufacturing end users. This group consists of traders and stockists (**steel merchants**), that stock standard steel products in bulk tonnages from Primary Steel Producer Mills (both local

and international) and supply directly to the manufacturing end users. The dominant players within this market are Macsteel and Aveng Steel (formerly Trident Steel).

The South African steel industry underwent a prolonged period of rapid growth from its inception in the late 1920s up until the 1980s. This growth was largely accelerated by the state's intense involvement in the economy, primarily through state-owned enterprises and infrastructure development (Lundall, 2008). The mining sector facilitated the creation of the manufacturing sector, which increased the demand and the consumption of steel and steel related products. The impact of expenditure on the military created another major demand for steel which contributed towards the development of the steel and engineering sectors of our economy (Lundall, 2008).

The growth rate stagnated from the early 1980s onwards, and following the global economic recession of 2008/2009, there has been a decline in both apparent domestic steel consumption and exports. The reasons for this decline have been attributed to a multitude of varying attributes which are discussed in more detail in this research, but chief amongst these attributes can be linked to highly competitive Chinese steel imports. Imports from the Far East Asian markets (mainly from China) have far exceeded the industry's exports and have reached levels where they constitute more than 25 percent of the steel consumed domestically. Figure 4 illustrates the rate of increasing steel imports steel as a percentage of domestic consumption from the 1st quarter of 1990 to till the end of 2013. The high composition of imported steel and the increasing import trend continue to pose a threat to prosperity and sustainability of the steel industry in South Africa.



(SAISI, 2016)

Figure 4: South Africa's steel consumption vs. import percentages

1.3 Problem statement

1.3.1 *Main problem*

To identify factors that have resulted in the recent decline in the steel industry in South Africa and to determine measures or interventions required to address these factors in order to ensure the growth and sustainability of the industry.

The main problem is further subdivided into the following sub-problems.

1.3.2 *Sub-problems*

The first sub-problem is to identify key factors (influential drivers) that are attributable to the recent decline in the steel industry in South Africa.

The second sub-problem is to determine which measures or interventions would be required to address the influential drivers in order to ensure the growth and sustainability of the steel industry.

1.4 Significance of the study

> "*Steel plays a crucial beneficiation role for the country's iron ore, adding R24.3 billion in value to its raw material base. It also underpins several other key industries such as agriculture, construction, automotive and mining, with these top five industries contributing 15 percent of South Africa's GDP and employing some eight million people. The sustainability of these sectors as well as the role of steel therein have far-reaching implications for our economy which behests our industry and government to sustain the partnership forged so far*" (Makwana, 2016)

Nell (2014) supports the above statement, by arguing that the production of local steel is highly beneficial to the domestic economy due to the added value through beneficiation rather than the exportation of the raw materials; creating direct and indirect employment, increasing the tax revenue pool and because of high local content supply, reducing high supply lead times which are associated with imported steel from international mill suppliers. The manufacturing end user industries are extremely labour intensive. Lundall, Maree and Godfrey (2008) found that there are 75 to 150 jobs per 1000 tons of steel output. The Southern African Institute of Steel Construction (SAISC) estimated this figure to be 100 jobs per 1000 tons of steel output (deBeer, 2013).

Although the steel industry has been a major contributor to economic growth and infrastructure development, very little academic research has been conducted on the impact of this industry within the South African context. In many cases, the industry has been grouped under the manufacturing sector and studied in conjunction with many other industries. This research isolates the steel industry and focuses exclusively on exogenous economic factors that impact the industry and their consequential impact on the prosperity of the industry.

The study provides guidance to policy makers, industry associations and steel dependent businesses by identifying influential drivers that are impacting the industry and proposing which measures or interventions to implement to ensure the growth, viability and the future sustainability of the industry.

1.5 Delimitations of the study

Although this research considers all three elements of sustainability, i.e. economic, social and environmental; “sustainability” within the scope of this research is used to refer to “economic sustainability”. Doane and MacGillivray (2001) interpret economic sustainability simply as the business of staying in business; hence this research is mainly concerned with the macro-economic factors that influence the viability of the steel industry in South Africa to continue as a going concern over a foreseeable period into the future. The research does, however, take cognisance of the fact that economic sustainability cannot be studied in isolation without the other elements of the triple-bottom-line; hence various facets such as employment creation, skills improvement and operating efficiency are also discussed in the study, as inherently, they tend to be intertwined with economic sustainability.

In addition to the above, the research is also narrowed down mainly to the metallurgical beneficiation and the manufacturing end user industries only. As illustrated in Figure 3, the steel industry value chain extends from “exploration and extraction, to mining beneficiation, metallurgical beneficiation and shaping, and lastly conversion/fabrication and manufacturing/end users” (Kumba Iron Ore, 2011b, p. 2), however this research is limited only to the metallurgical beneficiation and the manufacturing end user industries. The *exploration and extraction*, and *mining beneficiation sectors* are excluded, mainly based on the fact that they are not extensively impacted by exogenous economic factors that affect the metallurgical beneficiation and manufacturing end user sectors. Furthermore, Kumba Iron Ore (2011a) posits that sustainability and long term viability of downstream manufacturing industries are not dependent on the country’s abundance of mineral reserve, but rather by the structural competitive advantages across downstream manufacturing industries, which further justifies their exclusion from the scope of this research.

1.6 Definition of terms

- **Dumping** - Dumping occurs where foreign producers are exporting their goods into South Africa at prices (called the “export price”) lower than what they charge

for the same product in their own country (called the “normal value”). Thus if the export price is lower than the normal value, dumping occurs (ITAC, 2015)

- **Overcapacity** – a situation in which an industry or business cannot sell as much as it produces (Collins, 2016)
- **Imports** – Spending by individuals, firms and governments for goods and services produced in foreign nations (van Rensburg, 2011)
- **Exports** – Goods and services produced in a nation and sold to buyers in other nations (van Rensburg, 2011)
- **Tariffs** – custom duties on merchandise imported. Tariffs give a price advantage to locally produced goods over similar imported goods (WTO, 2016)
- **Gross Fixed Capital Formation –** “Investments in land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways and the like, including commercial and industrial buildings, offices, schools, hospitals and private residential dwellings” (Krkoska, 2002, p. 5)
- **Iron Ore** – The key ingredient in the steelmaking process. Rock or lumps of rock which contain the iron mineral.
- **Coking Coal** – One of the key ingredients in the steelmaking process. Also known as metallurgical coal, coking coal is heated in a coke oven which forces out impurities to produce coke, an almost pure carbon (West Cambria Mining, 2016)
- **Flat steel products** – A class or grouping of steel products that include slabs, hot-rolled and cold-rolled coils, coated steel products, tin plates and heavy plates (ArcelorMittal, 2016)
- **Regional overland market** - predominantly some parts of Sub-Saharan Africa where excess domestically produced steel is mostly exported (Kumba Iron Ore, 2011b)
- **Import Substitution Industrialisation** – An economic strategy aimed at encouraging national industrial growth so as to reduce imports of manufactured goods (Encyclopedia, 2016)
- **Trade protectionism** – Measures used by countries to limit unfair competition (surge of imports) from foreign industries (The Balance, 2016)

- **Long steel products** - A class or grouping of steel products that include billets, blooms, reinforcing steel, wire rods, sections, rails, sheet piles and drawn wire (ArcelorMittal, 2016).

1.7 Assumptions

The following assumptions were made during the research:

- **Assumption 1**: The steel industry is dynamic in nature, and fundamentally regional/country dependent; however, an assumption is made in this research that it is stable enough to ensure that it can be modelled;

- **Assumption 2**: Scenarios and simulations are based on plausible events and any unforeseeable events such as natural disasters are not considered;

- **Assumption 3**: The causality coefficients (causal weightings) between the interval “-1” to “+1” in increments of 0.25, are assumed to be sufficient enough to allow for the experts interviewed to descriptively express their expert views about causal relationships between two concepts;

- **Assumption 4**: The data sourced from relevant sources is assumed to be accurate; however careful attention is given towards ensuring the validity and reliability of the data sourced.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

Davies (2015) attributes the decline in domestic steel producing capability to “a series of exogenous economic shocks”. These factors have resulted in a progressive decline in the South African steel industry and continue to pose a risk and uncertainty over the future existence of this key strategic industry.

The literature review deliberates on the structure of the steel industry in South Africa from its inception, to its transition and its current state; highlighting key issues pertaining to global influence, production, consumption and other factors that have an influential impact of the dynamics of the industry. The following topics are discussed in detail through the literature review section:

- The global steel industry
- China’s influence on the global steel market
- Increasing trade with China
- Impact of imports on the domestic steel industry
- Infrastructure investment
- Pricing issues
- Government and Institutional policy interventions, and
- Outlook on South Africa’s economy

Figure 5 is the schematic representation of the structure and flow of the literature review section which illustrates two main sections from which the above mentioned topics are discussed in more detail. The first sections focuses on factors, both domestic and global, which have an influence on the steel industry in South Africa and the second section deliberates on interventions, current and proposed, which have been instituted or proposed to address the key challenges, as detailed in the first section.

The literature review section ultimately concludes by making two proposition statements based on the literature appraisal.

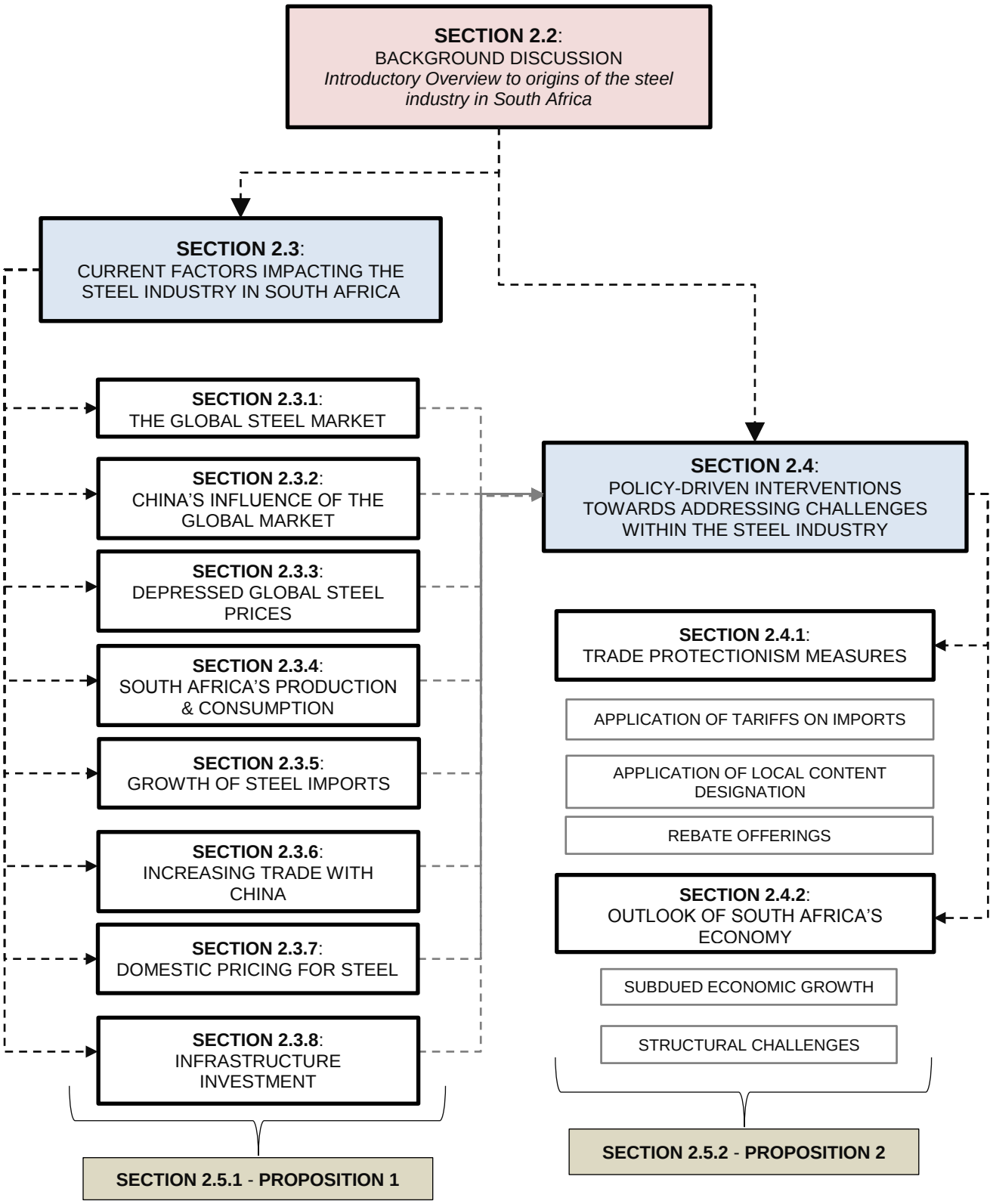
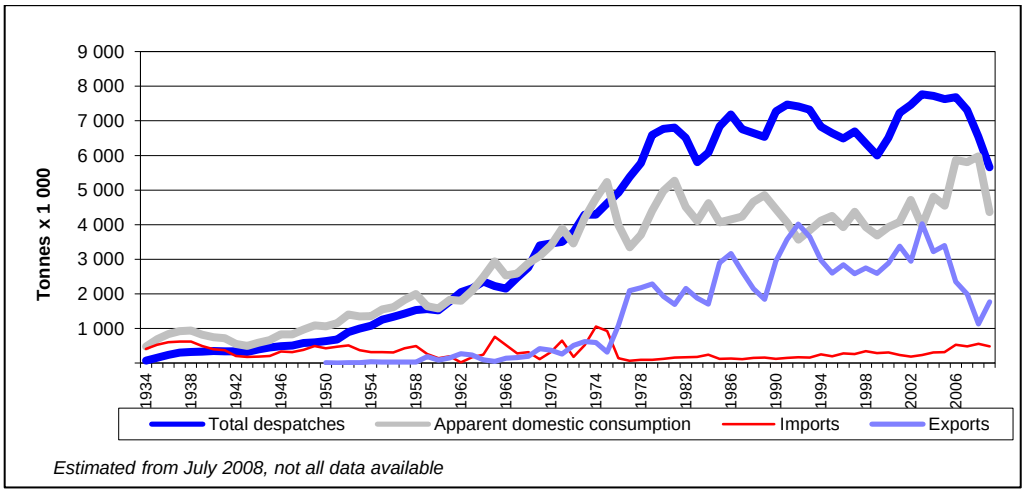


Figure 5: Schematic overview of the structure of the literature review

2.2 Background discussion

The origin of the steel industry in South Africa can be traced back to 1912 when the Union Steel Cooperation of South Africa (USCO) Ltd was formed (ArcelorMittalSA, 2004). Owing to a decline in the financial performance of USCO, South African Iron and Steel Corporation (Iscor) was "established as a state owned company in terms of the Iron and Steel Industry Act, No.11 of 1928" to produce iron and steel required for industrial growth and to create employment (ArcelorMittalSA, 2004). Production at Iscor's Pretoria steel mill commenced in 1934, 6 years after its establishment, and on the 4th of April 1934, the first steel was produced from the open-hearth furnace (OHF) at the Pretoria mill (ArcelorMittalSA, 2004). Increased demand within local manufacturing and warfare prompted the need for expansion of the industry by building new mills (ArcelorMittalSA, 2004). The period from 1934 to 1980, was a period of rapid growth and expansion in both primary steel production and domestic consumption as illustrated in Figure 6.



(Source SAISI, 2016)

Figure 6: Growth in South Africa's primary carbon steel market

During the growth period a number of firms were established, which included - Cape Gate Fence and Wire Works (Pty) Ltd during the early 1930s; Highveld Development Company Ltd in 1960; Cape Gate (Pty) Ltd in 1962; Southern Cross Steel (Pty) Ltd in 1964 and Cape Town Iron and Steel Works (Pty) Ltd (CISCO) in 1965 (SAISI, 2013).

The global recession of the early 1980s resulted in a decline in domestic consumption owing to weakened local demand. There was a global oversupply in the steel market and export prices declined to “uneconomical levels” (ArcelorMittalSA, 2004). In 1988, the South African government “unveiled plans to privatise several state controlled industries" (McKenzie, 2013, p. 4). Iscor was privatised in 1989 and was listed in the Johannesburg Stock Exchange (JSE) in November of the same year (ArcelorMittalSA, 2004).

The dawn of the new democracy came about with further transition promulgated by mergers and acquisitions, and the establishment of joint ventures. The most notable include – Highveld Steel’s acquisition of vanadium producer, Transvaal Alloys (Pty) Ltd in 1994; CISCO and Reinforcing Steel Contractors’ joint venture in 1995; Iscor and the Industrial Development Corporation’s joint venture for the construction of Saldanha Steel plant in 1996; Iscor’s transfer of its mining stakes to Kumba Resources Ltd in 2001; Highveld Steel’s acquisition of a fifty percent stake in South Africa Japan Vanadium (Pty) Ltd in 2003 and the renaming of Iscor to Mittal Steel South Africa in 2005 (SAISI, 2013).

Further transition occurred between 2004 and 2007 following the merger of international firms Arcelor and Mittal Steel, and locally, the acquisition of Highveld Steel by Evraz. In 2006, Mittal Steel South Africa became ArcelorMittal Steel South Africa (AMSA) following the global merger between Arcelor and the Indian-owned Mittal Steel. In July 2006, Evraz Steel, a Russian based “vertically integrated steel, mining and vanadium business” and one of the leading global steel producers acquired a 29.4 percent ownership interest in Highveld Steel from Anglo American, and by the end of December 2007, its stake within Highveld had increased to 80.92 percent as a result of a number of share acquisitions (Evraz, 2007). By July 2010, the company was officially operating under the name, Evraz Highveld Steel and Vanadium (SAISI, 2013).

By 2016, the steel industry in South Africa had grown to become an integral part of the economy, fundamental to the beneficiation of key mineral resources; whist providing direct employment to 190,000 people within the iron-ore, steelmaking and fabrication industries (Department of Trade and Industry, 2016a). Top steel consuming industries, i.e. mining, construction, structural steel, autos and cables, contribute approximately R600 billion to South Africa’s GDP (about 15 percent) and employ approximately 8 million people, direct and indirectly (Department of Trade and Industry, 2016a).

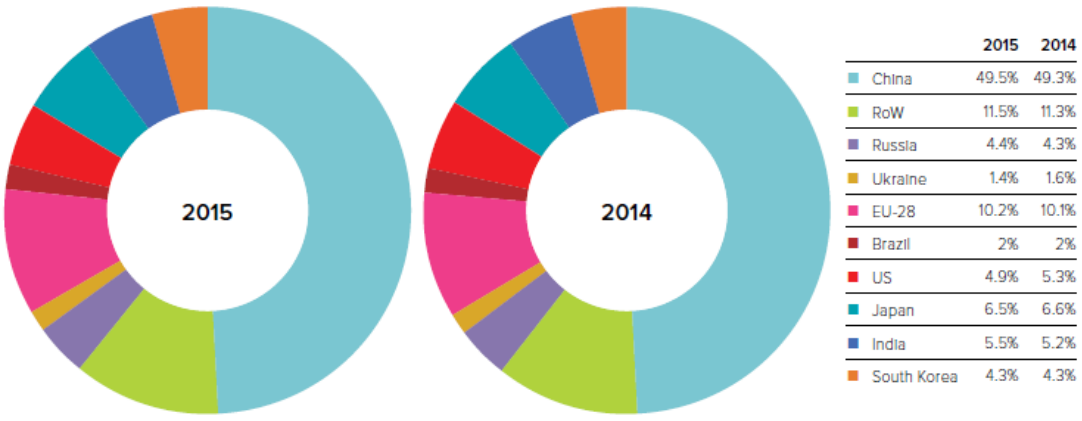
2.3 Current factors impacting the steel industry in South Africa

2.3.1 *The global steel market*

Steel is one of the most extensively used metals across the world (Ramos, 2015). It is widely considered to be a critical product within any developing or modernised economy and its consumption is often used as an indicator for industrial development and economic growth (Huh, 2011).

According to WorldSteel (2016), global crude steel production reached 1,621 million tonnes for the year 2015 with China accounting for nearly 50 percent of global production. World steel production grew year-on-year from 1,239 million tonnes in 2009 to 1,670 million tonnes in 2014, but declined to 1,621 million tonnes in 2015, attributable to weakening demand within the Chinese economy (Research Channel, 2016).

China has not only grown to become the world's largest producer of steel but also the largest consumer by volume. In 2015, China's share of the world's crude steel production was just under 50 percent of total global production (Research Channel, 2016). Figure 7 shows China's share of world crude steel production in comparison to other producing countries.



(Source ResearchChannel, 2016)

Figure 7: Share of world crude steel production

Although China's share of world crude steel production increased from 49.3 percent in 2014 to 49.5 percent in 2015, its domestic production declined for the first time in three

decades to 803.83 million tonnes, a drop of 2.3 percent (or 18.92 million tonnes) compared to 2014 (Research Channel, 2016). This is in response to slowing economic growth and measures instituted to reduce overcapacity. The rest of the top 10 crude steel producing countries also reported declines in production varying between 0.5 to 15.6 percent, with the exception of India, which reported an increase of 2.6 percent year-on-year; as illustrated in Table 1.

Table 1: Top 10 steel-producing countries

Top ten steel-producing countries					
Rank	**Country**	**2014 (Mt)**	**2015 (Mt)**	**Difference**	**% difference**
1	China	822,75	803,83	-18,92	-2,4
2	Japan	110,67	105,15	-5,52	-5,2
3	India	87,29	89,58	2,29	2,6
4	United States	88,17	78,92	-9,25	-11,7
5	Russia	71,46	71,11	-0,35	-0,5
6	South Korea	71,54	69,67	-1,87	-2,7
7	Germany	42,94	42,68	-0,26	-0,6
8	Brazil	33,9	33,25	-0,65	-2,0
9	Turkey	34,04	31,52	-2,52	-8,0
10	Ukraine	27,17	22,93	-4,24	-18,5
Total (*top 10 countries*)		**1389,93**	**1348,64**	**-41,29**	
Mt - million tonnes. 2015 Figures for Russia and Ukraine are estimates based on first 11 months production					

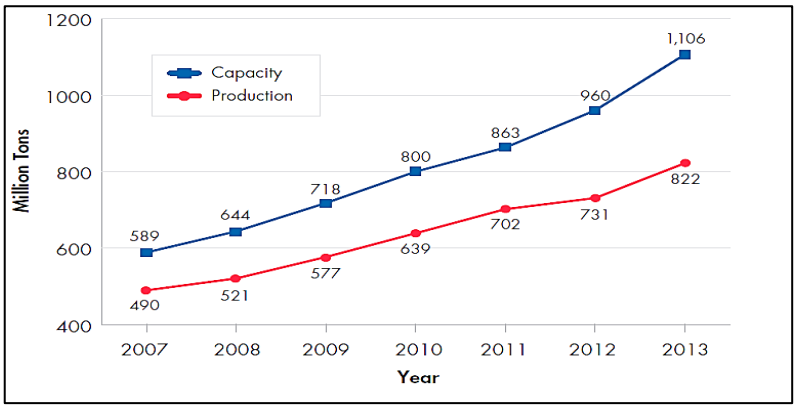
(Adapted from Research Channel, 2016)

2.3.2 *China's influence on the global steel market*

The growth of China's steel industry can be attributed to large scale industrialisation and urbanisation since the introduction of market-based economic reforms in 1978 and market liberalisation within the steel industry (Holloway, Roberts, & Rush, 2010). Privatisation of steel companies in the early 1980s allowed Chinese steel producer firms to gain some independence from the state, allowing them to invest surplus funds towards facilities improvements, increases in production capacity and an investment in advanced technologies (Holloway et al., 2010). This created an industry that is highly modernised with advanced steelmaking capabilities.

China’s rapid economic growth and a growth in urbanisation drove the demand for steel production and consumption, increasing the demand for raw materials such as iron ore and coking coal. By 2008, there were more than 660 companies producing crude steel in China, with many other smaller smelters and steel mills producing various steel related products (Holloway et al., 2010). The growth was not only within the Chinese domestic economy, but also aggressively fuelled by international trade and exports. Defever and Riaño (2012) report that between the periods 2000 to 2006 more than a third of Chinese exporters sold in excess of 90 percent of their products to export markets. The authors attribute this to “pure exporter subsidies” which they refer to as “a wide range of policies which favour firms producing almost exclusively for the foreign market” (Defever & Riaño, 2012, p. 1)

China’s steel production increased from 90 million tonnes in 2003 to 822.75 million in 2014 but contracted by 2.3 percent to 803.83 million tonnes in 2015, its first decline in over three decades (Research Channel, 2016). This decline was in line with the country’s deceleration in economic growth to 6.8 percent in 2015 (down 7.3 percent in 2014), the lowest growth the country has experienced in 25 years (WSJ, 2016). The slowing economic growth created a decline in demand as a result of a high abundance and availability of housing and factory capacity, which prompted a contraction in the construction sector and decline in manufacturing (Research Channel, 2016). As a result of the slowdown, China’s steel consumption reduced, creating overcapacity in the global steel market. USW (2016) reported that in 2014, China accounted for more than 400 million tonnes of excess global capacity of steel. In the same year, the country exported more than 94 million tonnes of steel and over 100 million tonnes in the first 11 months of 2015 (Research Channel, 2016). Figure 8 illustrates the widening gap between China’s production and capacity over the period 2007 to 2013.

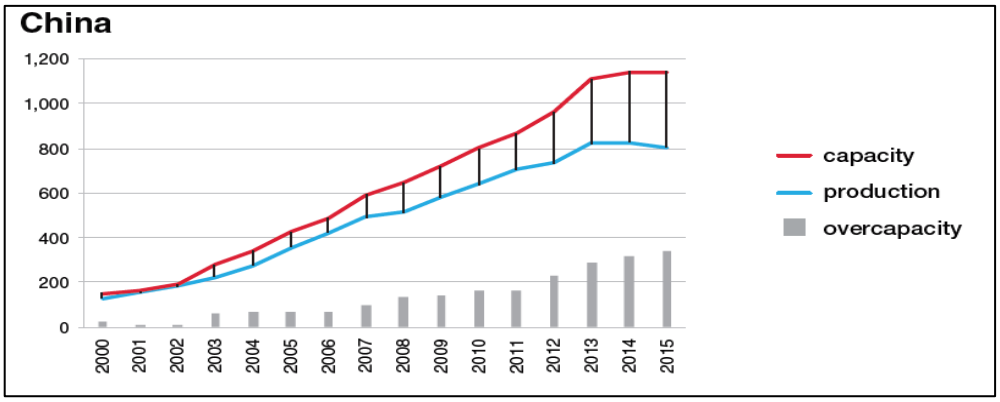


(Source USW, 2016)

Figure 8: China's steelmaking production and capacity

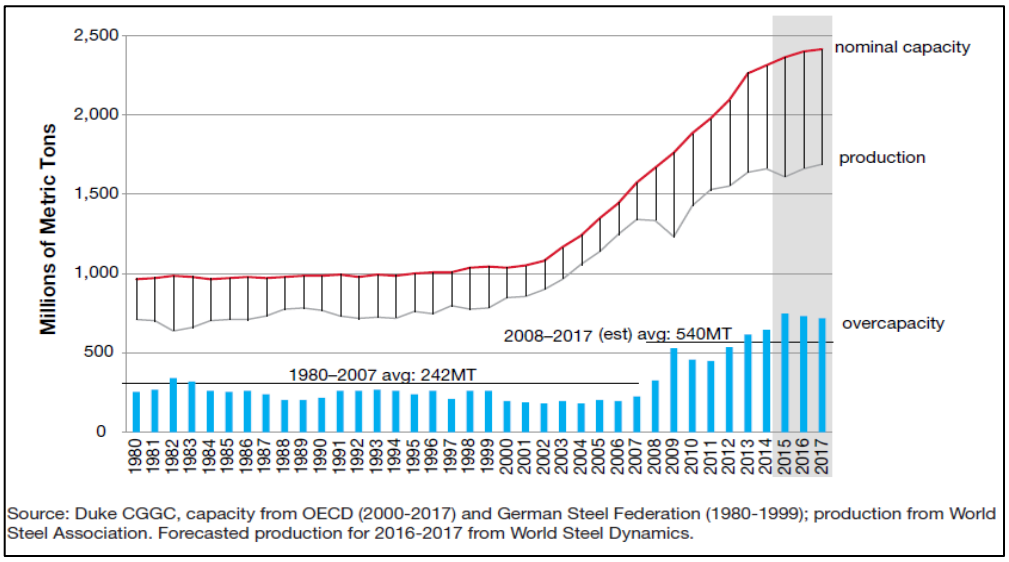
China's overcapacity widened from 99 million tonnes in 2007 to 284 million tonnes by 2013, as illustrated in Figure 8. The Chinese government and policy makers have made several commitments over the past few years that they would cut back on production and would implement capacity reduction measures, but USW (2016) reports that none of the commitments were ever met.

The overcapacity within Chinese mills has had a far reaching impact on the global steel industry, as illustrated in Figure 9 and 10 below.



(Source Brun, 2016)

Figure 9: China's production, capacity and overcapacity for crude steel



(Source Brun, 2016)

Figure 10: Global production, capacity and overcapacity for crude steel

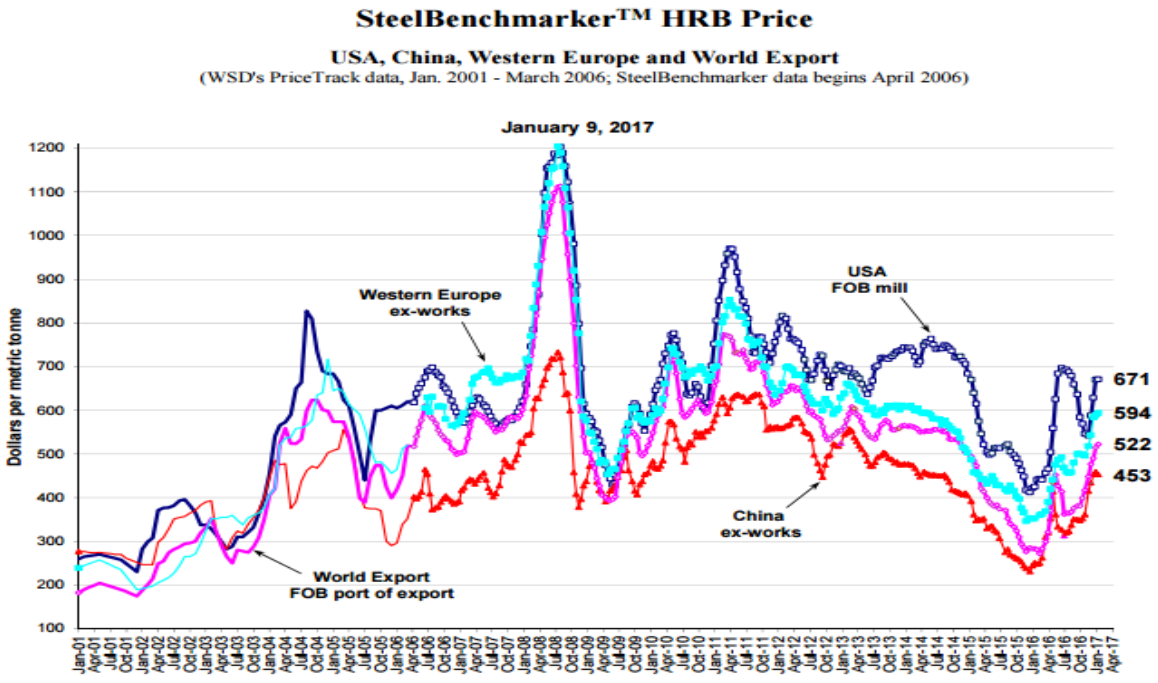
By the end of 2015, China's share of global overcapacity was 46 percent (336.2 million tonnes). The rapid development in steelmaking capacity in China can be observed from Figure 9, where it is remarkable to note that the Chinese steelmaking overcapacity grew from zero base from the year 2000 to over 336 million tonnes by the end of 2015 (Brun, 2016).

China continued to produce in a global environment where there was reduced demand, declining steel prices and oversupply, and as a consequence, resulting in the closure of many steel mills across the world. In an effort to curb an influx of imports from China, the US Commerce Department imposed duties of up to 450 percent on steel products from China (EngineeringNews, 2016).

The impact of the Chinese overcapacity had equally far reaching impact on the steel industry in South Africa as well. In April 2015, Evraz Highveld Steel, the country's second largest mill producer filed for voluntary business rescue, sighting declining demand and an influx in cheap steel from China as the major cause. By July 2015, ArcelorMittalSA announced that it was considering the possibility of closing its 100-year old Vereeniging steel works (Talkin, 2016).

2.3.3 *Depressed global steel prices*

The global steel oversupply and overcapacity as discussed in section 2.3.2 are attributed to the declining global steel prices over the past few years (2011 to 2015), as observed in Figure 11. Richardson (1998) proposes that surplus capacity (overcapacity) causes steel prices to remain depressed even under conditions of strengthening demand. Prior to the 2007/2008 global financial crises, global steel prices were trending upwards; but during the global recession, global prices (World Export FOB price) declined from a peak of over US$1100 per ton to just below US$400 per ton within a period of less than 12 months, as illustrated in Figure 11.



(Source SteelBenchmarker, 2017)

Figure 11: Global steel prices (in US$ per metric tonne)

Global steel prices recovered post the recession, primarily as a result of the Chinese government policy stimulus and increasing infrastructure spend, which resulted in the increase in prices of iron ore and coking coal (Caputo, Robinson, & Wang, 2013). The price of iron ore and coking coal, and many other commodities, trended downwards from 2010 onwards and with this decline; global steel prices fell from an average of US$800

per ton to below US$500 per ton, as illustrated in Figure 11. The decline in global steel prices resulted in a rapid influx of low-priced steel to the local market, with a consequential loss in the domestic industry's market share and reductions in capacity utilisation by local producer mills (ITAC, 2016).

In addition to overcapacity and the forces of demand and supply, other steel market variables that influence the pricing of steel include; inventories, cost structure, technology, price leadership, exchange rates, non-tariff barriers to trade and state aid (Richardson, 1998).

2.3.4 *South Africa's steel production and consumption*

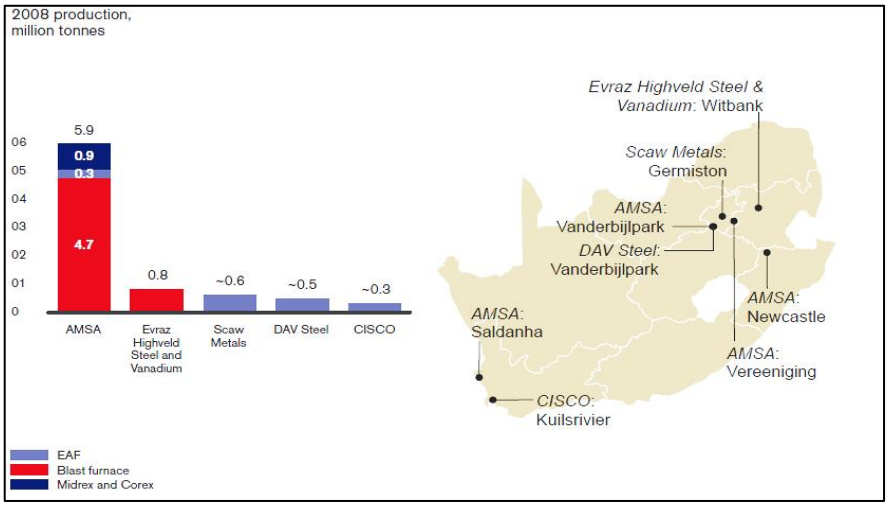
South Africa is the largest producer of steel in Africa and is one of only 65 countries in the world with the capabilities of primary steelmaking (Research Channel, 2016). Fine (1997) posits that direct access to raw materials and an abundant supply of most material required for steelmaking gives South Africa a considerable advantage amongst other steelmaking countries. Notwithstanding our considerable access to high-grade iron ore, South Africa unfortunately does not have an abundant access to high quality coking coal reserves. To make up for the supply deficit, in the past AMSA (formerly Iscor) used to blend high-quality coals with the limited quality coking coals, however this had the disadvantage of creating a high ash content and did not compare favourably with other steel producing countries (Coetze & Gebhard, 1971).

South Africa's geographical location also presents another competitive disadvantage against other steel producing countries as a result of our limited logistical access to global export markets where there is much higher consumption per capita. Kumba Iron Ore (2011b) segments the markets for South African steel into three categories; "the domestic market", "the regional overland market" and "the seaborne export market".

Steel production within *the domestic market* for 2015 was 7.6 million tonnes, an increase of 16.3% as compared to 2014 (Research Channel, 2016), with ArcelorMittal South Africa (AMSA) accounting for most of the output. As at March 2016, AMSA was the largest steel producer in both South Africa and Africa, with an installed annual production capacity of 6.5 million tonnes (Research Channel, 2016). AMSA operates five plants

located in Gauteng (Pretoria, Vereeniging and Vanderbijlpark), KwaZulu-Natal (Newcastle) and the Western Cape (Saldanha), producing a wide range of mainly flat and long steel products for both local and export markets (ArcelorMittalSA, 2016).

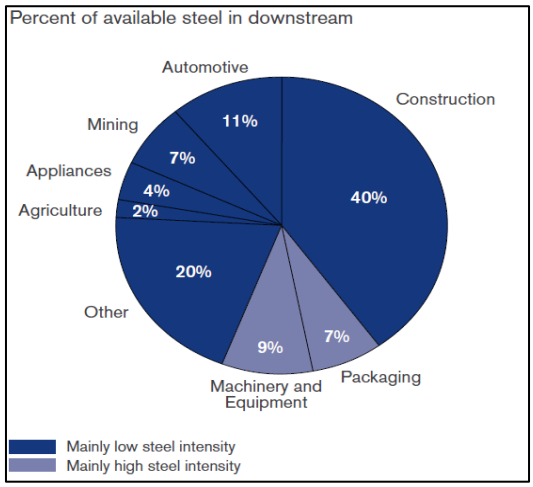
Evraz Highveld Steel is the second largest producer, with a production output of 0.8 million tonnes of crude steel in 2008 (Kumba Iron Ore, 2011b). The company is a vertically integrated steel and vanadium producer and uses an Oxygen Blast Furnace (OBF) at its steelmaking operations. Its produces mainly long sections; such as beam, columns, channels, etc.; predominantly used in the construction of steel structures. Other smaller producers include; CISCO, Scaw Metals and Cape Gate which produced approximately a combined 1.4 million tonnes of steel in 2008, using an Electric Arc Furnace (EAF) process (Kumba Iron Ore, 2011b). Figure 12 represents the geographical distribution of steel producer mills in South Africa and tonnes produced in 2008.



(Source Kumba, 2011)

Figure 12: Steel producers in South Africa

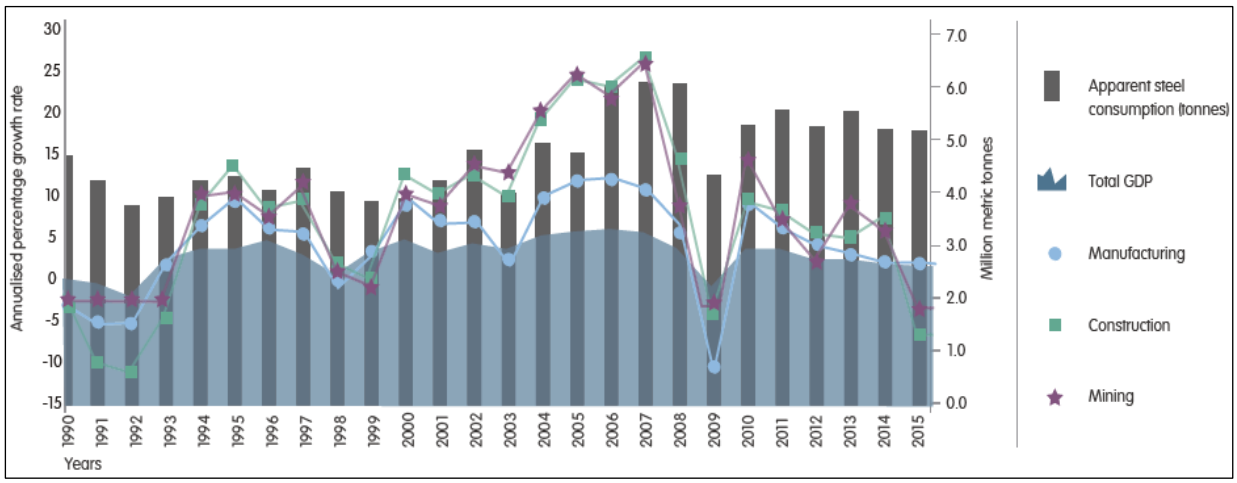
Figure 13 illustrates various types of manufacturing end users within the domestic market. Construction and the automotive sectors are the largest consumers of steel and steel related products in South Africa, followed by mining, machinery and equipment, and the packaging sectors. However, based on Figure 13, it can be observed that "manufacturers and end users of low steel intensity products consume approximately 85 percent of South African steel" (Kumba Iron Ore, 2011b, p. 3).



(Source Kumba, 2011)

Figure 13: South African steel consumption by sector

Low steel intensity sectors produce end products with less than 5 percent of steel content, whereas high steel intensity sectors (e.g. packaging and machinery and equipment manufacturers) steel's share of the final product value is relatively high (greater than 50 percent) (Kumba Iron Ore, 2011b). Figure 14 indicates apparent steel consumption for the following sectors; *mining*, *manufacturing* and *construction*, and compares the overall steel consumption of these three key sectors against the GDP growth rates (annualised percentage growth rate).



(Source ArcelorMittal, 2016)

Figure 14: Apparent steel consumption relative to annualised GDP growth rates

Construction, mining and manufacturing, constitute 80 percent of the total domestic steel demand (ArcelorMittalSA, 2016). The apparent steel consumption for these sectors tends to correlate with economic growth rates, which supports the notion presented in Section 1.2 that our economy's steel consumption can be used as one of the barometers to indicate economic growth.

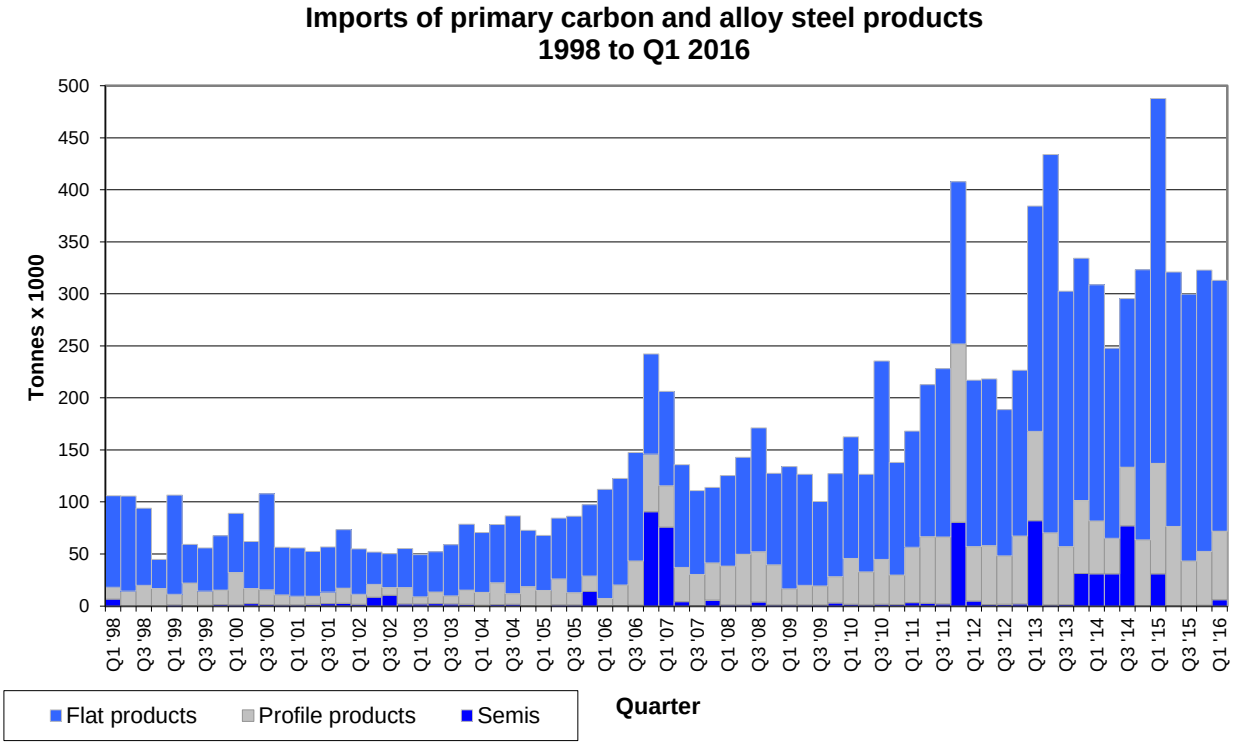
In comparison to historical steel consumption, South Africa currently consumes far less steel compared to the 1980s. The highest consumption of finished steel products was recorded towards the end of the 1980s where apparent steel consumption averaged around 125 kilograms of finished steel per capita, with data indicating that the highest historical level was reached in 1989 of 134.7 kilograms per capita (IISI, 1996), in contrast to recent data which show a decline in per capita consumption of 95.1 kilograms per capita for 2014, down 10.7 percent from 2013 (WorldSteel, 2016).

The competitiveness of our steel industry in export markets is threatened by other international steel producing countries. South African mill producers and manufacturers remain competitive within the *regional overland market,* as a result of logistical advantages due to locational proximity to this market (Kumba Iron Ore, 2011b). However, at *seaborne export market*, South Africa has a locational disadvantage as it "does not have the scale and cost advantage to compete on a sustainable basis" (Kumba Iron Ore, 2011b, p. 15) against other global steel producing countries.

2.3.5 *Growth in steel imports to the South African market*

Bilateral trade between South Africa and China has grown rapidly over the years since China joined the World Trade Organisation (WTO) in 2001 (Edwards & Jenkins, 2015). By 2009, China had become South Africa's largest trading partner after exceeding both Germany and the United States (Crul, 2013). Although the trade relations have been applauded for increased foreign direct investment (FDI) into the South African economy, concerns have been raised about the trade imbalance, where raw materials are exported without any value-adding and imported back, largely from China, as manufactured goods.

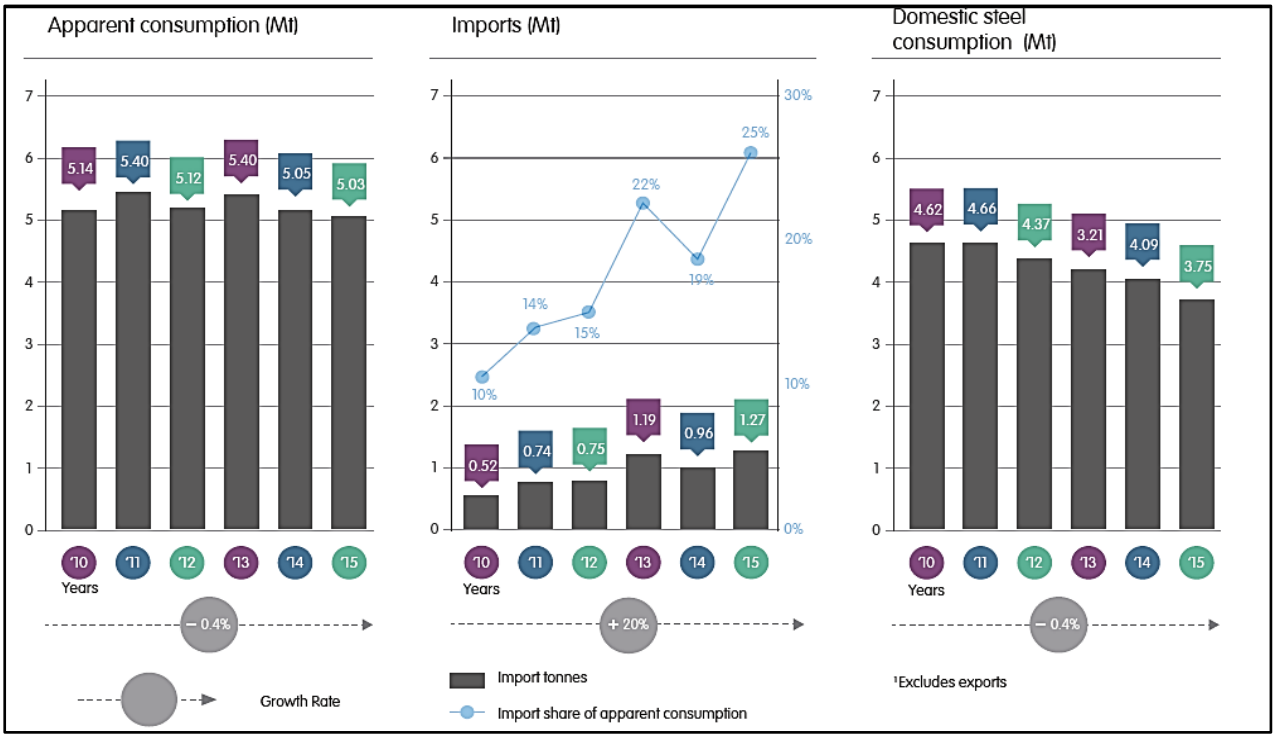
The rate of importation within the steel industry has raised concerns over the past years and its rapid rate of increase has reached levels where the future of the industry is now in jeopardy. Figure 15 illustrates the increasing influx of imports to the South African market.



(Source SAISI, 2016)

Figure 15: Imports of primary carbon and alloy steel products

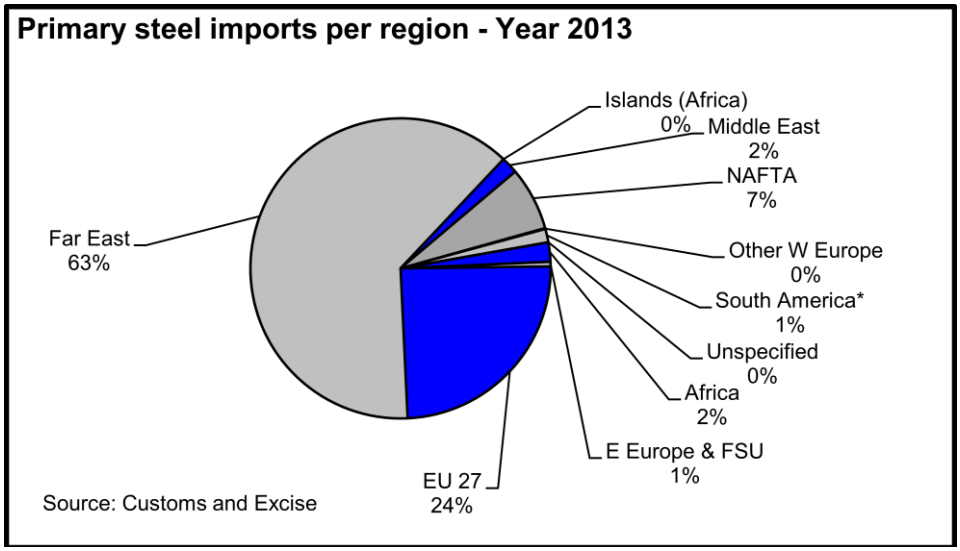
Imports averaged around 70,000 tonnes per quarter over the period 1998 to 2005, with average annual imports hardly exceeding 300,000 tonnes over the period. From 2005 onwards, the growth in imports accelerated, with total imports per quarter exceeding 100,000 tonne levels and per annum levels beginning to bridge the 500,000 tonnes levels. By the end of 2011, imports had reached the 1 million tonnes mark which at the time was equivalent to about 20 percent of domestic consumption. The increasing growth in steel imports is further illustrated in Figure 16 which shows an average annual growth rate of 20 percent per annum as observed over the past 5 years which, by 2016, constituted 25 percent of domestic steel consumption (ArcelorMittalSA, 2016).

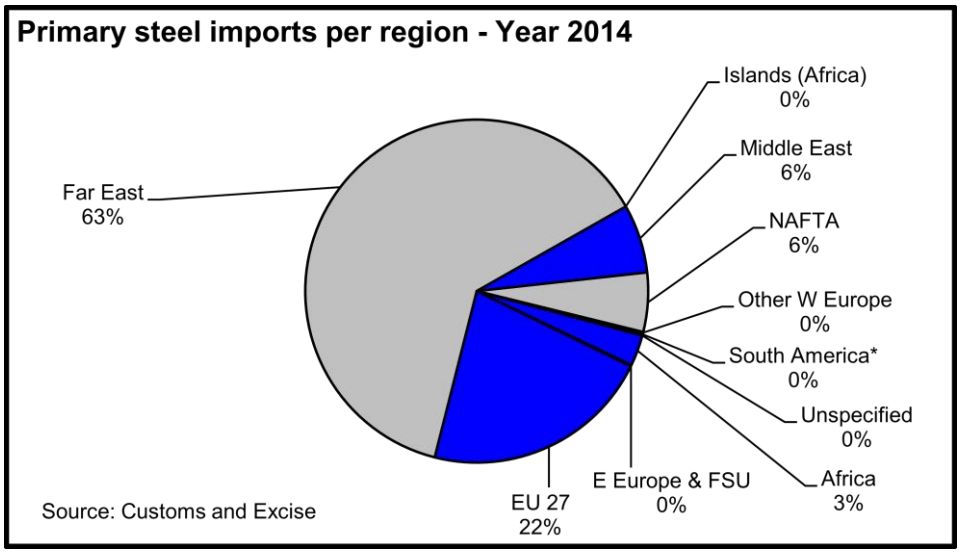


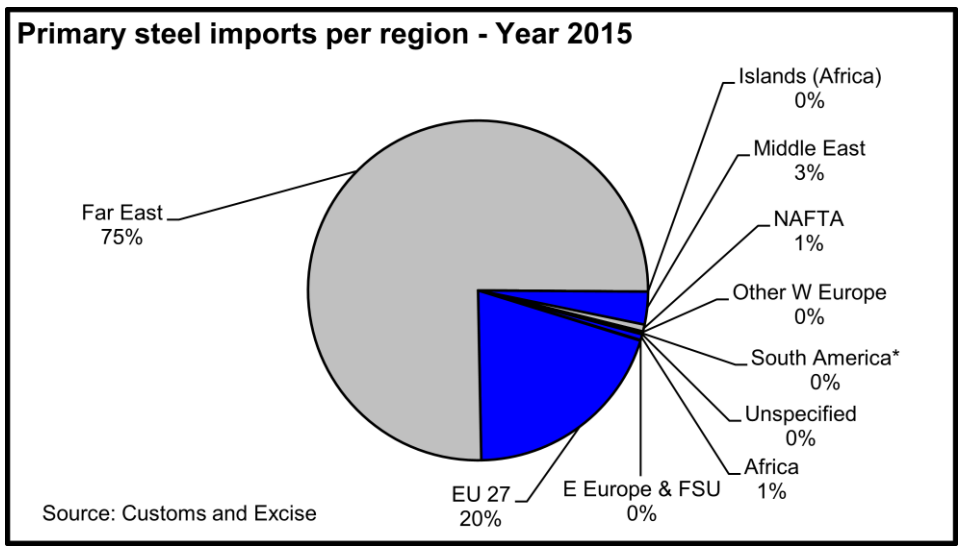
(Source ArcelorMittal, 2016)

Figure 16: Trends within the domestic steel market over the past five year

In addition to the increase in import penetration, Figure 16 also illustrates a decrease in apparent steel consumption of 0.4 percent year-on-year over the last five years, coupled with an average decrease of 4 percent per annum in domestic steel consumption over the same period (ArcelorMittalSA, 2016). Figure 17 looks deeper into the imports with regards to the country (or region) of origin. It can be noted from the data that, between 2013 and 2014, nearly two-thirds of the imported steel was from Far East Asia, with China leading as the major producer and exporter within the region. Between 2014 and 2015, the share of China as a major importer grew by nearly 20 percent to 75 percent of all imported steel.







(SAISI, 2016b)

Figure 17: Primary steel imports per region 2013 to 2015

Figure 17 also indicates that whilst the share of imports from other regions continues to decline year on year, China's import penetration continues to grow significantly and was expected to reach a record high by the end of the 4th quarter of 2016. Table 2 illustrates that China's increasing presence within the steel industry in South Africa can be traced back over a period of two decades. China's share of total SA's imports of structural steel products grew from 1.4 percent in 1995 to 13.4 percent in 2010; and its share of other fabricated metal products grew from 4.3 percent to 32.2 percent over the same period. By the end of 2010, China cemented its dominance as a leading exporter of basic iron and steel and other fabricated metal products to the South African market.

Table 2: Share of China's imports and ranking as exporter to South Africa, 1995 to 2010

		Country ranking as a source of imports by sector				Share of Chinese imports in total SA imports (%)			
Sic		1995	2000	2005	2010	1995	2000	2005	2010
351	Basic iron and steel	19	11	4	1	0.4	3.6	7.7	16.4
352	Non-ferrous metals	12	9	5	3	1.4	2.3	4.9	9.4
354	Structural steel products	21	13	8	3	0.4	1.5	4.5	13.4
355	Other fabricated metal products	6	4	1	1	4.3	9.9	22.4	32.2

(Adapted from Edwards & Jenkins, 2015)

2.3.6 *Increasing trade with China*

Edwards and Jenkins (2015, p. 447) discovered that the "falling shares of manufacturing in GDP and employment, which over the past decade have coincided with the rapid growth of imports from China". Over the period 2001 to 2011, South African imports from China grew by a factor of thirteen from $1.1 billion to $14.2 billion, whilst South Africa's exports to China grew from $0.5 billion to $12.4 billion, over the same period (Edwards & Jenkins, 2015). More concerning is not just the rapid growth in the volume of imports, but rather the composition of the bilateral trade flows (Edwards & Jenkins, 2015); as South Africa largely exports raw materials in exchange for imports of finished or processed goods. This is illustrated in Table 3.

Table 3: South Africa's trade with China by product type

	Exports (%)		Imports (%)	
	2000	2010	2000	2010
Primary	11	15	4	3
Manufacturing	89	85	96	97
Manufacturing by WTO classification				
Capital goods	11	2	25	42
Consumer goods	2	1	55	43
Intermediate goods	45	19	20	15
Raw materials	41	78	0	0

(Source Edwards & Jenkins, 2015)

In 2011, South Africa officially joined the group comprising of Brazil, Russian, India and China, but its inclusion was met with uncertainty and criticism as the South African economy (in terms of GDP) was much less than that of the other four countries (Gauteng Provincial Treasury, 2013). The inclusion of South Africa into the 'BRICS' group was largely criticised. Two years after the inclusion within the BRICS group, bilateral trade with China increased to R270 billion, a 32 percent increase as compared to 2012 figure of R205 billion (BusinessDay, 2014). These figures continued to further prompt questions about the unsustainable structure of trade as 90 percent of South Africa's top 10 exports to China were raw materials and whilst 100 percent of the top 10 imports from China were manufactured products (BusinessDay, 2014).

In December 2015, South Africa signed agreements worth R94 billion with China during the Forum on China-Africa Cooperation (FOCAC) summit (IOL, 2015). This agreement will extend the current bilateral trade agreements between the two nations, giving China a continued access to raw materials which are much needed to support its growth plans. The bilateral trade relations are more in favour of China, making South Africa more vulnerable to economic downturns within the Chinese economy. The slowdown in the Chinese economy poses a major threat to the prospect of growth in South Africa due to the potential decrease in demand for raw materials from China (Crul, 2013), which have over the years been the driving force behind China's trade with South Africa.

2.3.7 *Domestic pricing for steel*

Domestic pricing of steel products remains, by far, one of the most contentious issues in the steel industry in South Africa. Prior to March 2006, ArcelorMittal used to charge its flat steel products based on import parity pricing (IPP) across the domestic market, notwithstanding the fact that the steel was produced locally. A complaint of “excessive pricing” was lodged with the Competition Commission in 2002 by Harmony Gold Mining Company and DRD Gold Limited ("Harmony/DRD vs Mittal," 2009). According to duPlessis and Blignaut (2009, p. 14) an import parity price “is set equal to the world price converted into rand, plus any transport costs, insurance fees, taxes and tariffs and other costs the customer would bear if importing”.

Section 1 (vii) of the Competition Act defines “excessive pricing” as “a price for a good or service which bears no reasonable relation to the economic value of that good or service; and is higher than the economic value of that good or service” (Competition Act 89, 1998). The Act does not go further to describe how ‘economic value’ should be interpreted or worked out; Roberts (2008) suggests that ‘economic value’ should be left to the interpretation of the competition commission. However, he posits that “the most obvious determination of excessive pricing and economic value is the charging of (non-discriminatory) monopoly prices with a loss of consumer surplus and a deadweight loss” (Roberts, 2008, p. 2). Roberts (2008, p. 2) further describes this to result in “an efficiency loss to the economy and harm to consumers”. This has a detrimental effect in that it increases the input costs to downstream manufacturing end users, resulting in a decline in competitiveness and eventually reduces the country’s comparative advantage.

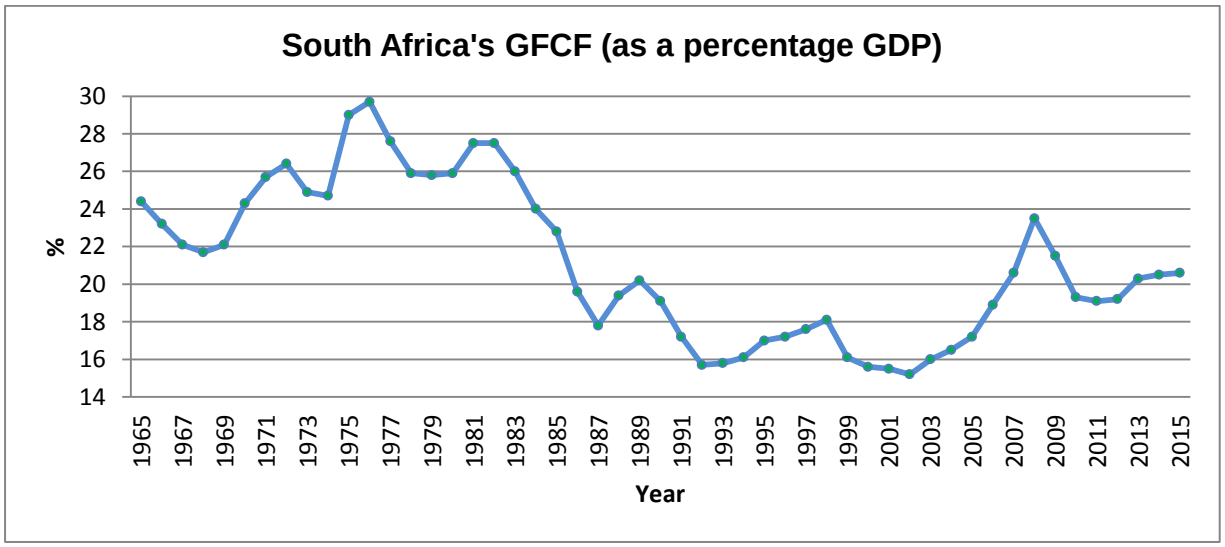
The Competition Tribunal found that ArcelorMittal (at the time Mittal SA) was guilty of excessive pricing; a judgment which saw Mittal SA becoming the first South African firm to be charged under this regulation (Garzarelli & Lloyd, 2014). In a settlement agreement reached with the Competition Commission, ArcelorMittal agreed to pay an administrative penalty of R1.5 billion in five annual payments of no less than R300 million; with an additional commitment of R4.6 billion towards capital expenditure over five years from 2017 (Department of Trade and Industry, 2016a). The company also further agreed to limit its EBIT margin to 10 percent for flat steel products produced and sold to the domestic market, with a provision to increase to a maximum of 15 percent based on

fluctuating market conditions as set out in the agreement (Department of Trade and Industry, 2016a).

2.3.8 *Infrastructure investment in South Africa*

South Africa's gross fixed capital formation (GFCF) peaked to its highest level of nearly 30 percent of GDP in 1976. This was as a result of rapidly increasing government spending on economic infrastructure and fixed capital stocks. The 1976 peak was thereafter followed by a nearly three decade long declining trend in public infrastructure investment, from the period 1976 to 2002, as illustrated in Figure 18. This lengthy period of decline and stagnation raised concerns from the private sector regarding the unreliability of existing infrastructure and increasing costs associated with infrastructure services (Perkins, Fedderke, & Luiz, 2005).

Perkins et al. (2005, p. 224) state that "while some degree of fluctuation in the level of infrastructure investment may be harmless or even appropriate, a long-term decline in infrastructure investment in relation to GDP, would probably be undesirable". Infrastructure investment remains paramount to the development and industrialisation of an economy, as it creates economies of scale and reduces the marginal cost of production by the private sector (McKibbin & Henckel, 2010).



(Source The World Bank, 2016)

Figure 18: South Africa's GFCF as a percentage of GDP

The decline in apparent steel consumption per capita can be correlated to the declining GFCF as a percentage of GDP, as illustrated in Figure 19.

The period 1989 to 2002 witnessed a decline in GFCF from 20.2 to 15.2 percent of GDP and over the same period, there was a corresponding decrease of 32 percent, from 137 kg to 93.2 kg, of apparent steel consumption per capita. During the rapid infrastructure development phase of between 2003 to 2008 as funds were channelled towards the construction of the Gautrain project and the 2010 FIFA World Cup Stadia, the GFCF as a percentage of GDP increased from 16 percent to 23.5 percent, and consequently over the same period apparent steel consumption per capita increased from 77 kg to 121.7 kg of finished steel (equating to a 58 percentage increase). Post the 2010 FIFA Wold Cup, the GFCF stagnated at around 19 percent of GDP whilst apparent steel consumption per capita stagnated at around 100 kg of finished steel per capita, over a three year period.

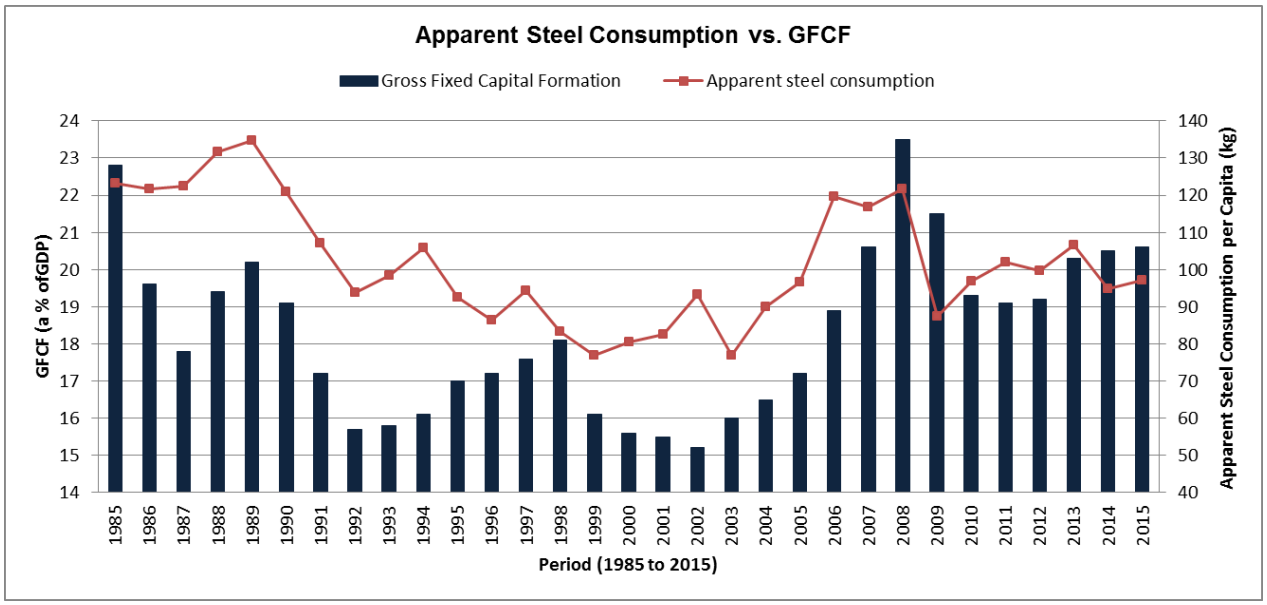
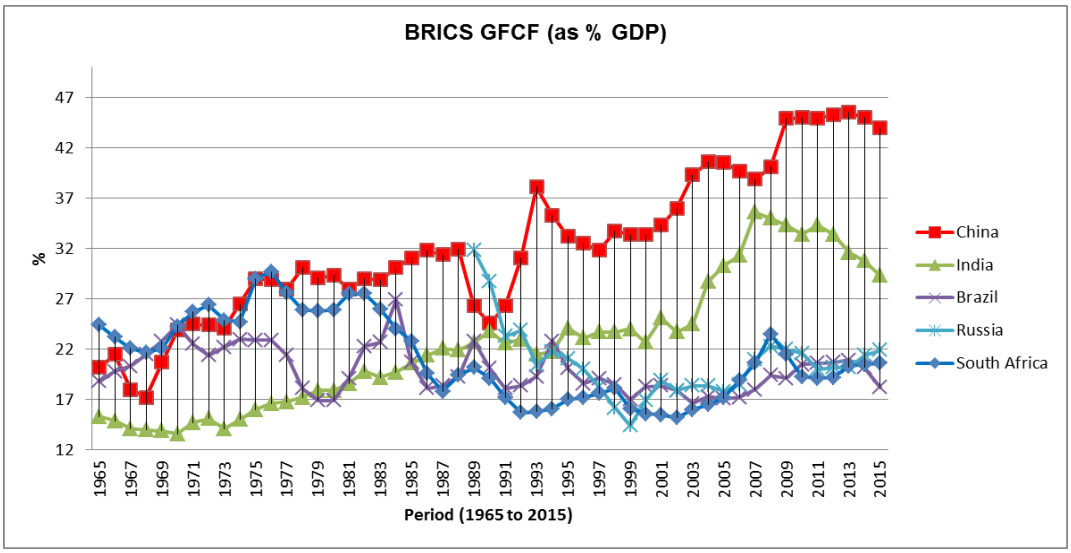


Figure 19: Steel consumption per capita vs. GFCF as a percentage of GDP

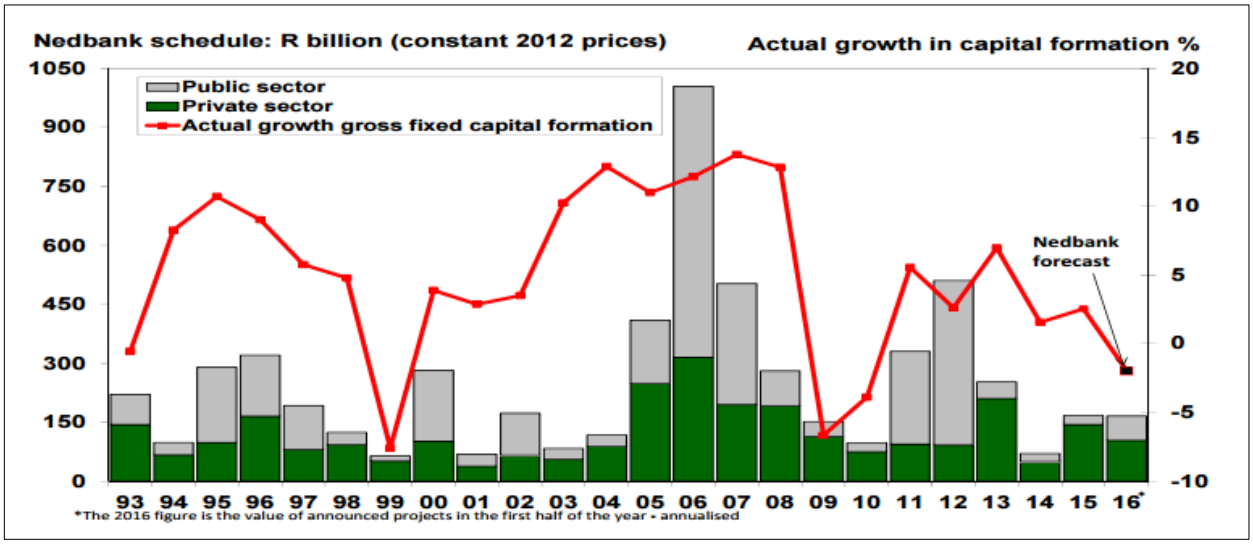
Figure 20 compares South Africa's GFCF as a percentage of GDP to other BRICS countries. South Africa trails behind China and India in terms of economic infrastructure and fixed capital investment, however its GFCF as a percentage of GDP is comparable to that of Brazil and Russia, but remains below the world average of 25 percent.



(Source The World Bank, 2016)

Figure 20: Comparing GFCF as a percentage of GDP across BRICS countries

Investment in infrastructure projects by the *private sector* has also declined over recent years, driven largely by declining business and consumer confidence levels. Nedbank (2016a, p. iii) attributes the decline to "softer global growth, lower commodity prices, subdued local demand, the noisy political environment and persistent threat of possible sovereign-risk rating downgrades by key rating agencies". The number of projects announced by the private sector declined from 58 in 2015 to 38 by end of June 2016 (on an annualised basis) and at 48 percent of the total number of projects, this is the lowest level ever recorded by Nedbank's Capital Expenditure Project Listing schedule (Nedbank, 2016a).



(Source Nedbank, 2016)

Figure 21: Capital expenditure project listing

The value of private sector projects amounted to R103.7 billion in 2016 on an annualised basis, equating to 63 percent of the total value of all projects. Figure 21 illustrates the decline in public sector projects from pre-2013 levels and the corresponding decline in capital formation (Nedbank, 2016a). The capital expenditure project listing also reveals that the private sector has largely carried the burden of infrastructure investment over the past four years in terms of the number of capital expenditure projects and the value of investments. The private sector maintained its large share of fixed capital investment, despite overall declining business confidence. The South African Chamber of Commerce and Industry (SACCI) business confidence index (BCI) figure decline from 92.9 in August 2016 to 90.3, its lowest level since July 1985 (Nedbank, 2016b).

2.4 Policy driven interventions towards addressing challenges within the steel industry in South Africa

2.4.1 *Trade protectionism measures*

The imposition of trade protectionist measures against imports, particularly originating from China, is a very contentious issue, given the political and bi-lateral trade agreements between China and South Africa.

Crul (2013) suggests that South Africa's integration into BRICS is a measure that moves towards more open trade and may eventually lead to free trade, which ideally should be more desirable for all members. Crul (2013) further describes free trade as a more generally favoured economic system above tariffs and trade barriers because it, in the long run, eventually leads to a more efficient allocation of global resources; however he does allude to the unfortunate reality that South Africa is not ready for free trade with China as the two countries have disproportionate levels of development. The balance of trade will unfortunately always be in the favour of the Chinese and their dominance will mean that they can source raw materials at cheap prices and resupply these back to the South African economy as manufactured goods - the steel industry being a good case study that particularly reaffirms this notion.

- **Application of tariffs on imported steel**

Prior to 2015, South Africa remained, for many years, as one of only a few countries in the world with primary steel producing capabilities that did not have any form of governmental or institutional policy framework that protected the sector against unfair global competition. Fine (1997, p. 30) posits that "prior to 1992, there was anti-dumping legislation in place, but it had never been used since other protectionist measures rendered it unnecessary". During the period, the policy implemented by government was geared toward Import Substitution Industrialisation (ISI) as an industrial policy, however, the dawn of democracy led to the evaporation of the ISI policies as government's trade liberalisation policies were relaxed in support of a more export-led economic policy (Adewale, 2012). The period thereafter, was followed by a period of significant reductions in tariffs and the number of tariffs lines (Hviding, 2005).

However, in response to the growing influx of cheap imports and claims of dumping taking place in the South African market by Chinese mill producers, in August 2015, the International Trade Administration Commission of South Africa (ITAC) imposed a 10 percent tariff on imported steel following an application by AMSA, the National Union of Metalworkers of South Africa (NUMSA) and the South African Iron and Steel Institute (SAISI) (Wilkinson, 2016). Further calls were made for additional commitment from government, including anti-dumping regulations, a ban on the export of scrap metals and a commitment that state-owned entities (SOE) (i.e. Eskom, Transnet, PRASA, etc.) would procure only local produced steel (Wilkinson, 2016).

Although the move was welcomed by mostly upstream industries (i.e. primary and secondary producers), the downstream industries (i.e. manufacturing end users) did not respond favourably to the intervention. Wilkinson (2016), in his interview with Kyle Mason (Credit Analyst at International Trade Credit insurer – Coface), notes that the views expressed were that the tariff imposed would only benefits the producer segment of the steel value chain, whilst the downstream manufacturing end users will have to pay more for the increased price of steel, adding to an already uncompetitive pricing structure. Lindsey, Griswold, and Lukas (2016) support this view, suggesting that steel protectionism has the disadvantage of imposing a heavy cost on the segment of the value chain that consumes steel as a major input in their production.

In contrast to the above view, Stillman (2011) suggests that because steel accounts for such a small share of the costs for downstream manufacturers (as illustrated in Figure 13), a reduction in the price of steel would not translate to a significant increase in output. This notion is based on the fact that the elasticity of demand of steel is about -0.2 to -0.3 as suggested by Stillman (2011) and that a reduction in price of about 10 percent will only increase downstream manufacturing use of steel by as little as 2 to 3 percent.

- **Application of designation for locally produced steel**

The South African government implemented the National Development Plan (NDP) as a policy to address future national economic and socio-development strategies (Zarenda, 2013). The composition and the formulation of the NDP was largely informed by the antecedents policies, the Industrial Policy Action Plan (IPAP) and the New Growth Path (NGP), which came into effect in 2007 and 2010, respectively (Zarenda, 2013).

One of the significant features of the IPAP is the Preferential Procurement Policy Framework Act (PPPFA) regulation which addresses local content within the public procurement framework, amongst other objectives. The longstanding criticism of the PPPFA was its exclusion of several primary steel products from the list of designated products within the public sector procurement scope.

In response to the increasing influx of steel imports, the subsequent recent decline in the steel industry in South Africa and lobbying efforts by both producer mills and industry associations; the National Treasury announced the designation of steel products and components for construction in terms of Regulation 9 (2) of the Preferential Procurement Regulation, 2011 effective from the 1st of February 2017 (National Treasury, 2017). Table 4 indicates the list of designated steel products and minimum threshold for procurement under the PPPFA.

Table 4: Minimum local content for primary and value-added steel products

Minimum Local Content for primary steel products	
Steel Construction Materials	**Local Content Threshold**
Plates (>4.5mm thick and supplied in flat pieces)	100%
Sheets (<4.5mm thick and supplied in coils)	100%
Galvanised and Colour Coated Coils	100%
Wire Rod and Drawn Wire	100%
Sections (Channels, Angles, I-Beams and H-Beams)	100%
Reinforcing Bars	100%
Minimum Local Content for steel value-added products	
Steel Construction Materials	**Local Content Threshold**
Fabricated Structural Steel (latticed steelwork, plate girders, trusses, scaffolding, etc.)	100%
Joining/Connecting components (Gussets, cleats, stiffeners, splices, brackets, etc.)	100%
Frames (Doors & Windows)	100%
Fasteners (Bolts, nuts, rivets and nails)	100%
Wire Products (all fencing products, all barbed wire and mesh fencing, etc.)	100%
Ducting and Structural Pipework (non-conveyance tubing fabricated from steel sheeting and plates)	100%
Gutters, downpipes and launders (fabricated from sheeting associated with roof drainage systems)	100%

(Source National Treasury, 2017)

As with the case of import tariffs, the designation of steel for construction under the Preferential Procurement Regulation may be construed as addressing the concerns of

upstream industries only with little assessment of its impact across downstream manufacturing end users. *Security of supply* remains a concern as the primary production of long steel products (i.e. sections, channels, etc.) as per Table 4 were produced locally by EvrazHighveld Steel which, at the time the regulation came into effect, was in a business rescue process and not producing and supplying any products to the market.

- **Rebate offerings to the steel industry**

To address the challenges faced by downstream industries, another policy driven intervention implemented by the Department of Trade and Industry (DTI) was a number of rebate offerings, aimed at improving competitiveness of manufacturing end users to promote the local manufacturing of steel products destined for export markets. Under the latest rebate offering structure ITAC made provision to offers the following rebates:

"(1) Rebate item 470.03 provides for a *full waiver of customs* duty on imported goods for use in the manufacture of goods exclusively for export; and

(2) Rebate item 521.00 provides a *full refund of custom duty* on imported goods used in the manufacture of goods exclusively for export " (Department of Trade and Industry, 2016b)

2.4.2 *Outlook of South Africa's economy*

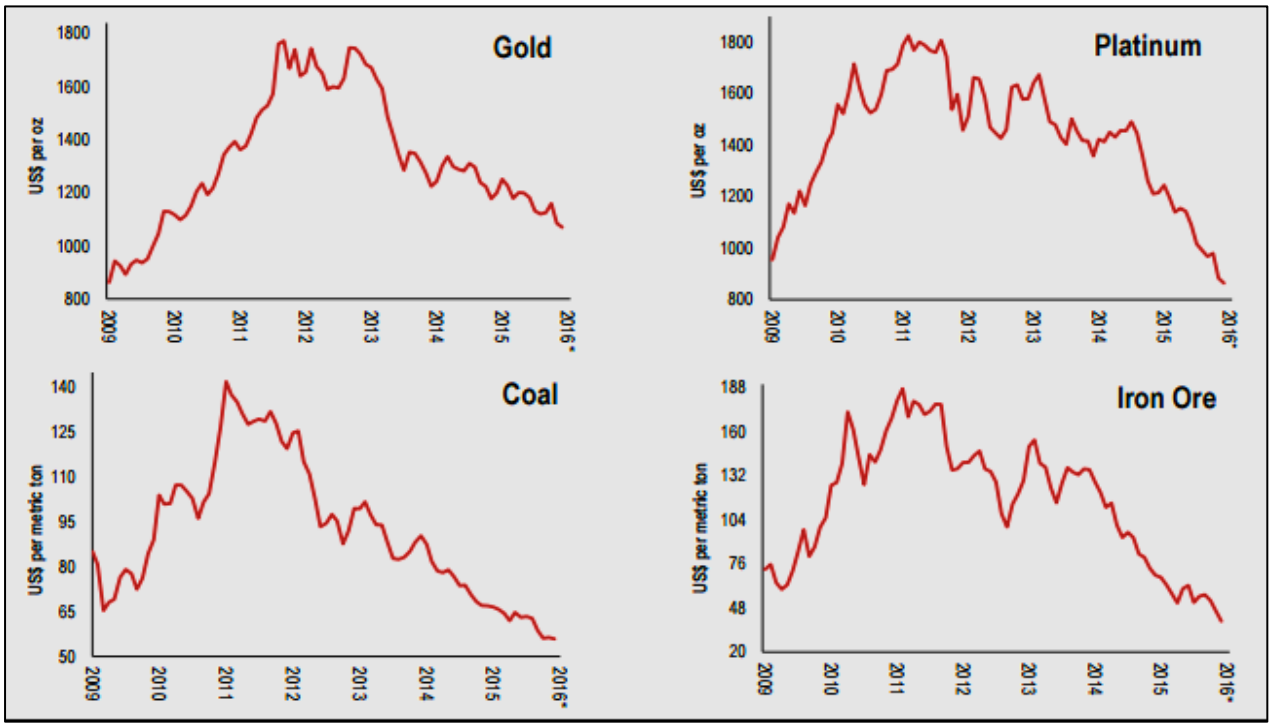
The intention of this section is not to give a comprehensive overview of South Africa's economic outlook, but rather a transitory overview of those economic factors and tenacious structural challenges that have a direct impact on the steel industry in South Africa.

- **Subdued Economic Growth**

National Treasury (2016) projected a GDP growth rate of 0.9 percent in 2016 with a gradual improvement to 1.7 percent in 2017 and 2.4 percent in 2018. These growth rates are far below the projected growth rate of 6 percent as envisaged by the NDP (National Planning Commission, 2011). Another alarming concern is that the projected growth rate of 0.9 percent in 2016 falls below the rate of population increase, indicating a decline in

per capita income (National Treasury, 2016). This is undesirable as it would indicate that "the average South African is getting poorer" (National Treasury, 2016, p. 3), which may result in a decrease in consumer spending – one of the drivers of economic growth. National Treasury (2016, p. 3) attributes the gloomy outlook to "low commodity prices, heightened financial market volatility, and diminished consumer and business confidence". Diminishing consumer and business confidence are largely attributed to the sentiment or uncertainty surrounding the current state of the economy. Carroll, Fuhrer, and Wilcox (1994) posit that there is positive correlation between sentiment and growth in spending, suggesting that the consumers will reduce their household spending when the prospects for economic growth seem gloomy.

South Africa's trade relations with international trading partners are largely dominated by commodity-based products. This compromises South Africa's growth prospects as "commodity prices have declined significantly since 2012" (National Treasury, 2016, p. 18). Figure 22 illustrates this decline based on the South Africa's major export commodities.



(Source NationalTreasury, 2016)

Figure 22: Prices of major commodity exports 2009 to 2016

This is exacerbated by a weaker commodity demand from China (South Africa's major trading partner), given their recent deceleration in economic growth rates.

- **Structural Challenges**

The steelmaking process is a highly energy intensive process, and the steel industry in South Africa has been significantly impacted by the *electricity* crises that occurred over the past few years. In addition to the sharp increases in electricity costs, "South Africa's electricity supply constraint has worsened, largely owing to inadequate maintenance, leading to unplanned outages" (National Treasury, 2016, p. 22). This remains a concern to steel producers as this leads to unplanned shutdowns which eventually lead to an increase in input production costs, exacerbating South Africa's lack of competitiveness against much cheaper imported steels. National Treasury (2016) projects that frequent unplanned outages will continue to persist over the next several years.

Department of Trade and Industry (2016a) reports that since 2007, energy costs related to electricity and gas prices have increased by more than 300 percent and 160 percent, respectively; with transport prices (rail tariffs) increasing by more than 100 percent over the same period. The increased logistical costs have created uncompetitive port charges and inefficiencies in domestic and export routes; coupled with the aging of producer mill plants due to excessive underinvestment and maintenance (Department of Trade and Industry, 2016a).

Augmenting to the above structural challenges is the austere skills scarcity within the South African economy. The crises of skills shortages is more notable within the manufacturing and engineering sectors of the economy due to the shortage of technical skilled workers, such as artisans and engineers (Pauw, Oosthuizen, & Westhuizen, 2006).

These structural challenges have resulted in a direct negative impact to the overall steel industry in South Africa, leading to lack of competitiveness across both upstream and downstream industries.

2.5 Conclusion of Literature Review

2.5.1 *Proposition 1*

Based on the literature review, it can be concluded that there are a multitude of factors that are attributable to the recent decline in the steel industry in South Africa. Some of the major factors are delineated in Table 5. It is worth noting that only key references are outlined, rather than an exhaustive list of references ascribed to each specific factor.

Table 5: List of factors identified from literature

List of factors identified from literature - Proposition 1		
Domestic / Local Factors	**Key references**	**Report Section**
Electricity supply constraints	Nedbank, 2016	*Section 2.4.2*
	Davies, 2015	*Section 1.2*
Increasing transport/logistical costs	TheDTI, 2016	*Section 2.4.2*
Declining GFCF (lack of government spending on infrastructure)	Perkins, Fedderke, & Luiz, 2005	*Section 2.3.8*
	Nedbank, 2016	*Section 2.3.8*
Influx of cheap steel imports from Far East Asia (in particular China)	ArcelorMittalSA, 2016	*Section 2.3.5*
	ITAC, 2016	*Section 2.3.3*
Lack of government support for value added, downstream manufacturing users	Lindsey, Griswold, & Lukas, 2016	*Section 2.4.1*
	Wilkinson, 2016	*Section 2.4.1*
Rising electricity costs	TheDTI, 2016	*Section 2.4.2*
Sluggish global economic growth	Caputo, Robinson & Wang, 2013	*Section 2.3.3*
Lack of government policy in terms of trade protectionism of the steel industry		*Section 2.4.2*
Increasing labour costs	TheDTI, 2016	*Section 2.4.2*
Lack of modernisation of local producer mills	TheDTI, 2016	*Section 2.4.2*
SA locational disadvantage: Un-competitiveness in seaborne export markets	Kumba, 2011	*Section 2.3.4*

Unfair pricing practices within the local steel industry	Garzarelli & Lloyd, 2014	*Section 2.3.7*
	Roberts, 2008	*Section 2.3.7*
	Harmony/DRD vs. Mittal, 2009	*Section 2.3.7*
South Africa's lack of structural competitive advantage	Kumba, 2011	*Section 2.3.4*
	TheDTI, 2016	*Section 2.4.2*
Lack of designation of locally produced steel		*Section 2.4.1*
Increasing input costs of production	TheDTI, 2016	*Section 2.4.2*
Declining business and consumer confidence	Nedbank, 2016a	*Section 2.3.8*
	NationalTreasury, 2016	*Section 2.4.2*
Declining domestic demand for steel & steel related products	WorldSteel, 2016	*Section 2.3.4*
Inefficiency of our local producer mills	TheDTI, 2016	*Section 2.4.2*
Lack of access to high grade coking coal	Coetze & Gebhard, 1972;	*Section 2.3.4*
Lack of competitiveness of our manufacturing sector	Lindsey, Griswold, & Lukas, 2016	*Section 2.4.1*
Increasing trade with China	Edwards & Jenkins, 2015	*Section 2.3.5, 2.3.6*
	Crul, 2013	*Section 2.3.5, 2.3.6, 2.4.1*
	Treasury, 2013	*Section 2.3.6*
Skills shortages within engineering and manufacturing sectors	Pauw, Oosthuizen & van der Westhuizen, 2006	*Section 2.4.1*
Declining consumer spending	NationalTreasury, 2016	*Section 2.4.2*
	Carroll, Fuhrer & Wilcox, 1994	*Section 2.4.2*
Global Factors	**Key references**	**Report Section**
Chinese steel production overcapacity	Holloway, Roberts, & Rush, 2010	*Section 2.3.2*
	USW, 2016	*Section 2.3.2*
	Brun, 2016	*Section 2.3.2*

Slowing Chinese economic growth	WSJ, 2016	*Section 2.3.2*
	ResearchChannel, 2016	*Section 2.3.2*
Chinese government export subsidies	Defever & Riano 2012	*Section 2.3.2*
Market liberalisation within the Chinese steel industry	Holloway, Roberts, & Rush, 2010	*Section 2.3.2*
Declining commodity prices	NationalTreasury,2016	*Section 2.4.2*
Global steel oversupply	USW, 2016	*Section 2.3.2*
	Brun, 2016	*Section 2.3.2*
Declining global steel prices for steel	ITAC, 2016	*Section 2.3.3*
	Richardson, 1998	*Section 2.3.3*
	Steel Benchmarker, 2017	*Section 2.3.3*
Declining demand for steel and steel related products	WorldSteel, 2016,	*Section 2.3.1*
	ResearchChannel, 2016	*Section 2.3.1*

Proposition 1

Amongst the multitude of factors attributable to the recent decline in the steel industry in South Africa, the following factors are influential drivers:

- *Increasing Steel Imports*
- *Chinese Steel Overcapacity*
- *Increasing Input Costs*
- *Subdued Economic Growth*
- *Inadequate Infrastructure Investment*
- *Lack of Government/Institutional Policy*

2.5.2 *Proposition 2*

The growth and sustainability of the steel industry in South Africa is dependent not only on policy interventions, but also on measures that would stimulate the demand for steel.

Under this proposition a number of scenario simulations ("what-if" analyses) were tested, to determine a range of plausible outcomes from which conditions required to ensure a viable and sustainable steel industry in South Africa will be determined.

Table 6 lists the scenarios to be tested. The scenario development and criteria for scenario selection is discussed in comprehensive detail in Section 5.4.1 of this report.

Table 6: Scenarios to be tested under Proposition 2 using the amplified FCM

Scenarios to be tested under Proposition 2	
Scenario	**Condition**
Scenario 1	To evaluate the influence of increasing steel imports, increasing Chinese overcapacity and increasing input costs, in a stagnant economy with decreasing infrastructure investment
Scenario 2	To evaluate the influence of increasing steel imports, increasing Chinese overcapacity and increasing input costs, under conditions of economic growth and increasing infrastructure investment
Scenario 3	To evaluate the influence of increasing input costs but under conditions of governmental/institutional policy intervention aimed at trade protectionism through the means of *only* tariffs, anti-dumping duties, countervailing measures and safeguards (P1 only)
Scenario 4	To evaluate the influence of increasing input costs but under conditions of governmental/institutional policy intervention aimed at trade remedial action through the means of rebates & designation and downstream beneficiations & localisation (P2 and P3)
Scenario 5	To evaluate the influence of governmental/institutional policy intervention aimed at trade protectionism and trade remedial action through a combination of *tariffs, anti-dumping duties, countervailing measures and safeguards* and *rebates & designation* and *downstream beneficiations & localisation* (P1, P2 and P3) but under conditions of receding economic growth and declining infrastructure investment.
Scenario 6	To evaluate the influence of governmental/institutional policy intervention aimed at trade protectionism and trade remedial action through a combination of *tariffs, anti-dumping duties, countervailing measures and safeguards* and *rebates & designation* and *downstream beneficiations & localisation* (P1, P2 and P3) but under conditions of economic growth and increasing infrastructure investment.
***Where*:**	
P1: Policy addressing "*Tariffs, anti-dumping duties, countervailing measures & safeguards*"	
P2: Policy addressing "*Rebates & designations*"	
P3: Policy addressing "*Downstream beneficiation & localisation*"	

CHAPTER 3. RESEARCH METHODOLOGY

The theoretical background relating to the chosen methodology is discussed in relation to its relevance and appropriateness to this research. The research design and research instruments give an overview of the methodological approach and its suitability for this study, highlighting advantages and disadvantages of the approaches. The research instrument is included in the Appendix section of the report. In addition, limitations and potentially weaknesses are also discussed and the section concludes with validity and reliability criteria, in order to ensure that there is quality in the research procedure.

3.1 Research methodology / paradigm

Fuzzy Cognitive Mapping (FCM) methodology was used for this research to model the steel industry in South Africa taking into consideration a number of factors and drivers influencing the industry. A mixed method approach was adopted, which used elements of both qualitative and quantitative methods used in conjunction. Brannen (2005, p. 175) suggests that “in the current trend towards evidence-based practice and the systematic review of social science research, research that combines qualitative and quantitative methods needs particular attention”. Johnson and Onwuegbuzie (2004, p. 15) support the views expressed by Brannen (2005), and posit that “today’s research world is becoming increasingly interdisciplinary, complex, and dynamic; therefore, many researchers need to complement one method with another”.

Kosko (1986, p. 65) defines FCMs as simply “fuzzy-graph structures for representing causal reasoning”. FCMs are constructed by a group of experts, with an abstract and adequate knowledge of a particular system or operation; they map out various entries or concepts that are necessary to model or simulate the system, then define causal relationships between various entries, taking into account the relative causal strengths between the various entries (Papageorgiou & Stylios, 2008).

FCMs consist of nodes which represent variable concepts, connected by links signed by either a “**+** or **–** to represent a positive or negative relationship”, respectively, between the nodes (Papageorgiou & Stylios, 2008, p. 757). A positive relationship represents a

"causal increase" and a negative relationship indicates a "causal decrease" (Kosko, 1986). This is further explained in Figure 23. C_1 causally increases C_3, hence increasing C_1 will cause C_3 to increase. C_2 causally decreases C_3, and hence increasing C_2 will decrease C_3.

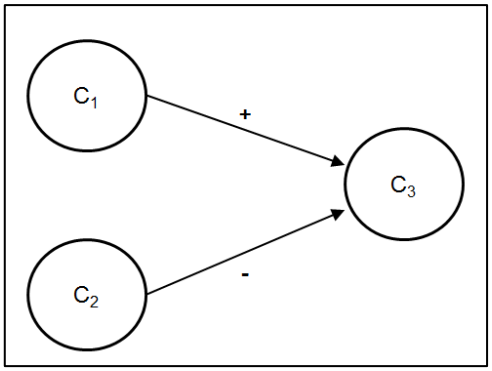
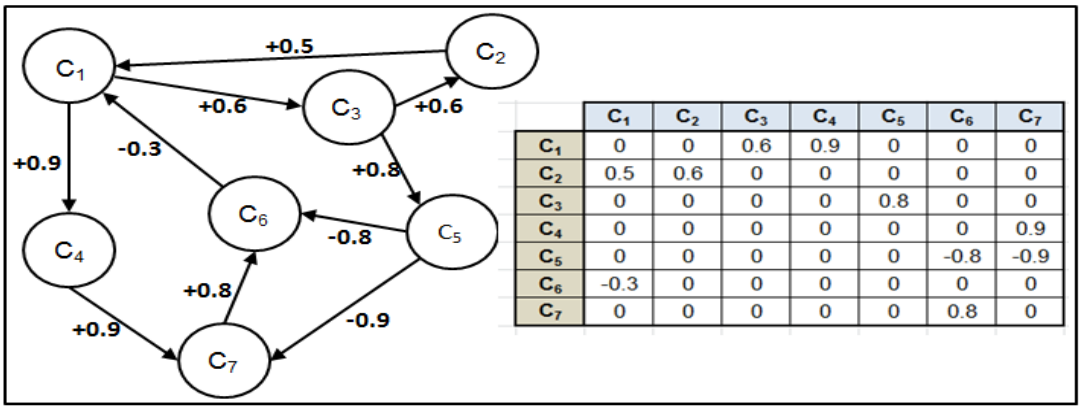


Figure 23: Degree of causality between nodes

A FCM consisting of *n* concepts can be represented by using an "*n* x *n* matrix where the causality between concepts" or nodes "is described by non-linear function $e(C_i)$ which describes the degree to which C_i influences C_j" (Papageorgiou & Stylios, 2008, p. 757). The causal influence function considers values within the interval [-1, 1] (Papageorgiou & Stylios, 2008). +1 indicates the strongest positive influence and -1 indicates the strongest negative influence and values in-between express different fuzzy levels of influence (Stach, Kurgan, & Pedrycz, 2005), as illustrated in Figure 24 below.



	C1	C2	C3	C4	C5	C6	C7
C1	0	0	0.6	0.9	0	0	0
C2	0.5	0.6	0	0	0	0	0
C3	0	0	0	0	0.8	0	0
C4	0	0	0	0	0	0	0.9
C5	0	0	0	0	0	-0.8	-0.9
C6	-0.3	0	0	0	0	0	0
C7	0	0	0	0	0	0.8	0

(Adapted from Stach, Kurgan, & Pedrycz, 2005)

Figure 24: Sample FCM graph and its connection matrix

The “causal relationship between two concepts” represents “the cause-and-effect relationship that exists between the two concepts” (Papageorgiou & Stylios, 2008, p. 759) and can be represented as follows: $e_{i,j} = \begin{Bmatrix} \delta_{i,j} = 1 \\ \delta_{i,j} = -1 \\ \delta_{i,j} = 0 \end{Bmatrix}$

C_i causally increases C_j if $e_{i,j} = 1$; C_i causally decreases C_j if $e_{i,j} = -1$ and C_i imparts no causality on C_j if $e_{i,j} = 0$ (Kosko, 1986).

3.2 Research Design

The methodological approach adopted in this research was based on a mixed method approach that combined both qualitative and quantitative elements. A number of endogenous and exogenous factors affecting the steel industry in South Africa were identified from literature and based on these factors (or concepts) a “**preliminary FCM”** was produced to create a simulation to represent the dynamics of the steel industry in South Africa. Previous research by Pillay (2008) and Gxavu (2011) used FCM to simulate the “impact of China’s future demand for raw materials” for different commodities. A similar methodological approach was adopted, and applied to the steel industry to identify and assess the causality and degree of causal influence between various factors identified from literature and to determine the impact of influential drivers (or key factors) on the sustainability of the industry.

A preliminary FCM was submitted to a selected panel of experts, referred to in this research as Subject Matter Experts (SMEs). The preliminary FCM is described in Section 3.3 of this report and was used to “describe the causality amongst concepts and the influence of one concept to another, using linguistic notions” (Papageorgiou & Stylios, 2008, p. 759) in the form of a causal map. The SMEs were interviewed in order to validate the preliminary FCM through a process of; first, describing the causality between concepts, adding additional concepts which they perceived to be imperative to have been excluded; and lastly, indicating the degree of influence between various concepts. As described by Papageorgiou and Stylios (2008), the role of the experts is described using the following steps:

- "Describe the direction of causality between two concepts" (i.e. C_i influences C_j or C_j influences C_i or simply, there is no connection between the two concepts)
- "Determine the type of relationship between the concepts" (i.e. does C_i causally increase C_j or C_i causally decrease C_j or simply, C_i imparts no causality on C_j)
- "Describe the degree of the causal relationship between the two concepts" using a linguistic variable *Influence* (i.e. 'strong', 'weak', etc.) (p. 759).

Papageorgiou and Stylios (2008, p. 759) further describe the *influence* between two concepts on one another as a grade or degree of influence, which is described linguistically as either; "negatively very strong", "negatively strong", "negatively medium", "negatively weak", "zero", "positively weak", "positively medium", "positively strong" or "positively very strong". These describe a set of nine levels of influence or degree of causal relationship which are illustrated in Table 7.

Table 7: Degree of causal relationship between concepts

Influence of one concept on another								
-1.0	**-0.75**	**-0.5**	**-0.25**	**0**	**+0.25**	**+0.5**	**+0.75**	**+1.0**
Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

Based on the results received from SMEs, an "**amplified FCM**" was created and used to represent a simulated model of the steel industry in South Africa and to determine the degree of influence between various causal factors. The amplified FCM is the expert validated version of the preliminary FCM which was created solely using literature.

This mixed method approach is superior as it combines both elements of qualitative and quantitative approaches to address the research problem. However, cognisance was taken that as much as there are numerous advantages to simulating or modelling complex and dynamic systems using FCM methodology, there are disadvantages as well, although the disadvantages are transcended upon by the advantages.

Table 8 lists a few key advantages and disadvantages pertaining to simulation methods based on Fuzzy Cognitive Mapping.

Table 8: Advantages and disadvantages of simulation using FCM

Advantages and disadvantages of a simulation method using Fuzzy Cognitive Mapping	
Advantages	**Disadvantages**
• FCM models are created using industry experts with in-depth and abstract knowledge of the industry • The simulated model allows for a number of scenarios to be tested in order to create a plausible set of outcomes (or projected future outcomes) • FCM is not a fixed model – can be refined to accommodate the dynamic nature of various systems or industries being modelled	• The model is based on a human views or perception to come up with a "fuzzy causal relation" between concepts, which may not always be accurate (Papageorgiou & Stylios, 2008, p. 771) • The higher the dynamic nature of a system modelled the more complex it is to simulate, as a large number of varying factors may lead to instability of the model and may increase simulation errors

3.3 Preliminary FCM

A preliminary FCM was produced, based on literature, to create a simulation of the dynamics of the steel industry in South Africa. To eliminate researcher bias, the preliminary FCM remained "preliminary" until it had been validated by industry experts. The preliminary FCM is illustrated in Figure 24 and was created based on factors identified from the literature review with the influential drivers as transmitter nodes. This preliminary FCM formed the basis of the research instrument. SMEs were interviewed and based on the results obtained; the preliminary FCM was validated after a number of expert knowledge amendments and modifications to form an "amplified FCM". Table 9 presents the nodes and links used to model the preliminary FCM and the type of causal relationship between causal nodes based solely on the literature review.

Table 9: Preliminary nodes and links and their causal relationship

Direction of causality between two factors/concepts		*Type of causal relationship*	
From - C_i	**To - C_j**	**Negative relationship**	**Positive relationship**
Increasing steel imports	Energy supply constraints	☑	☐
Increasing steel imports	Increasing trade with China	☐	☑
Energy supply constraints	Increasing energy costs	☐	☑
Energy supply constraints	Foreign Direct Investment (FDI)	☑	☐
Increasing energy costs	Increasing Production Costs	☐	☑
Modernisation of South African producer mills	Increasing Production Costs	☑	☐
Modernisation of South African producer mills	Capability to produce wide range of products at scale	☐	☑
Modernisation of South African producer mills	Efficiency of steel mills	☐	☑
Increasing energy costs	Downstream beneficiation & localisation	☑	☐
Declining global steel prices	Downstream beneficiation & localisation	☑	☐
Increasing trade with China	Downstream beneficiation & localisation	☑	☐
Increasing Selling Price of Steel	Downstream beneficiation & localisation	☑	☐
Downstream beneficiation & localisation	Modernisation of South African producer mills	☑	☐
Downstream beneficiation & localisation	Skills improvement	☐	☑
Downstream beneficiation & localisation	Security of supply	☐	☑
Downstream beneficiation & localisation	Competitive manufacturing end users	☐	☑
Downstream beneficiation & localisation	Employment creation	☐	☑

Chinese steel overcapacity	Global oversupply of steel	☑	☐
Sluggish global economic growth	Global oversupply of steel	☐	☐
Chinese economic growth	Global oversupply of steel	☑	☐
Global oversupply of steel	Declining global steel prices	☐	☑
Sluggish global economic growth	Foreign Direct Investment (FDI)	☑	☐
Chinese government export subsidies	Increasing trade with China	☐	☑
Chinese government export subsidies	Chinese economic growth	☐	☑
Chinese government export subsidies	Closure of South African steel mills	☐	☑
Closure of South African steel mills	Skills improvement	☑	☐
Closure of South African steel mills	Employment creation	☑	☐
Closure of South African steel mills	Access to regional overland market growth opportunities	☑	☐
Closure of South African steel mills	Security of supply	☑	☐
Skills improvement	Employment creation	☐	☑
Skills improvement	Growth of the steel industry	☐	☑
Skills improvement	Competitive manufacturing end users	☐	☑
Skills improvement	Structural Competitive advantages	☐	☑
Capability to produce wide range of products at scale	Security of supply	☐	☑
Security of supply	Seaborne Export Market growth	☐	☑
Unfair pricing practices in the local steel industry	Growth of the steel industry	☑	☐
Unfair pricing practices in the local steel industry	Competitive manufacturing end users	☑	☐

Unfair pricing practices in the local steel industry	Capability to produce wide range of products at scale	☑	☐
Increasing Input Costs	Increasing Production Costs	☐	☑
Increasing Production Costs	Increasing Selling Price of Steel	☐	☑
Increasing Production Costs	Efficiency of steel mills	☑	☐
Increasing Selling Price of Steel	Demand for steel and steel consuming products	☑	☐
Increasing Selling Price of Steel	Competitive manufacturing end users	☑	☐
Demand for steel and steel consuming products	Foreign Direct Investment (FDI)	☐	☑
Demand for steel and steel consuming products	Closure of South African steel mills	☑	☐
Government/institutional policy	Trade protectionism	☐	☑
Government/institutional policy	Unfair pricing practices in the local steel industry	☑	☐
Government/institutional policy	Downstream beneficiation & localisation	☐	☑
Trade protectionism	Increasing trade with China	☑	☐
Trade protectionism	Chinese government export subsidies	☑	☐
Economic Activity/Growth	South African consumer spending	☐	☑
Economic Activity/Growth	Demand for steel and steel consuming products	☐	☑
South African consumer spending	Demand for steel and steel consuming products	☐	☑
Infrastructure Investment	Increasing Cost of Capital	☑	☐
Infrastructure Investment	Demand for steel and steel consuming products	☐	☑
Infrastructure Investment	Reduced logistical costs	☐	☑
Infrastructure Investment	Energy supply constraints	☑	☐

Increasing Cost of Capital	Foreign Direct Investment (FDI)	☑	☐
Increasing Labour Costs	Foreign Direct Investment (FDI)	☐	☑
Increasing Labour Costs	Increasing Production Costs	☐	☑
Foreign Direct Investment (FDI)	Access to high grade coking coal	☐	☑
Foreign Direct Investment (FDI)	Growth of the domestic steel industry	☐	☑
Foreign Direct Investment (FDI)	Skills improvement	☐	☑
Access to high grade coking coal	Structural Competitive advantages	☐	☑
Access to high grade coking coal	Increasing Production Costs	☑	☐
Structural Competitive advantages	Growth of the domestic steel industry	☐	☑
Structural Competitive advantages	Seaborne Export Market growth	☐	☑
Reduced logistical costs	Structural Competitive advantages	☐	☑
Reduced logistical costs	Access to regional overland market growth opportunities	☐	☑
Reduced logistical costs	Seaborne Export Market growth	☐	☑
Access to regional overland market growth opportunities	Growth of the domestic steel industry	☐	☑

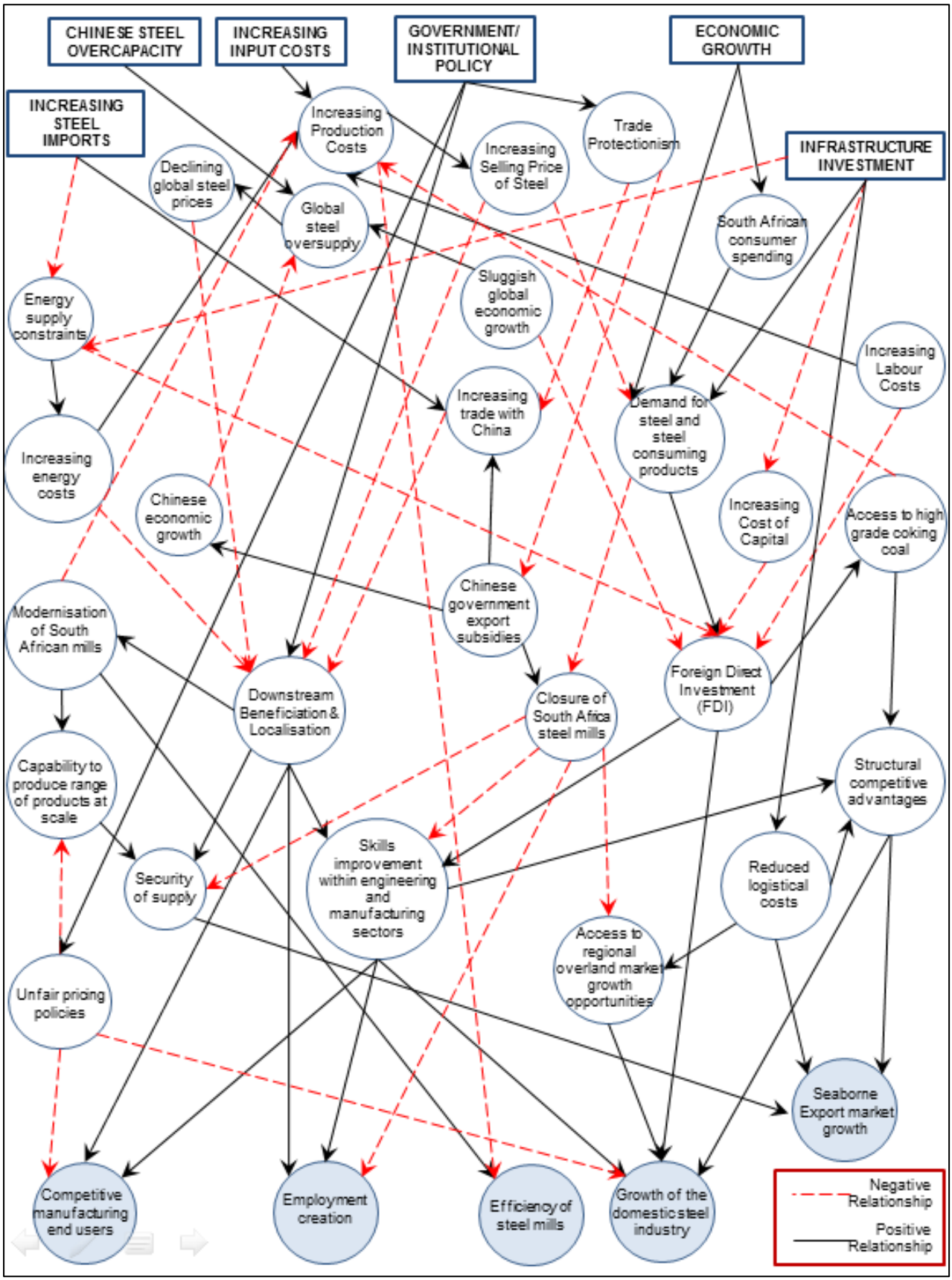


Figure 25: Preliminary FCM based on literature review

3.4 Population and sample

3.4.1 *Population*

The population for this research is composed of a selected number of Subject Matter Experts (SMEs) within the South African steel industry value chain, including its related industry institutes and government/institutional departments.

3.4.2 *Sample and sampling method*

The SMEs were selected based on their experience and extensive knowledge of the dynamics of the local and global steel industries. SMEs are described as organisational leaders and/or policy advisors, "often originating or participating in advisory boards or other high profile organizations, so they generally have a special in-depth knowledge" (Larmore, 2011, p. 5). Table 10 indicates the profile of selected SME respondents for this research.

Table 10: Profile of respondents – Subject Matter Experts

Description of respondent type, e.g. Manager, Union representative, student	Number sampled
Chief Executive Officers (CEO)	4
Economists	1
General Managers	3
Divisional Executives	2
Total Number of respondents	10

The respondents are from the following sectors within the steel industry value chain:

Table 11: Respondents' sectors within the steel industry

Respondents' sectors within the steel industry	
Steel Industry Associations	Steelwork Fabricators
Primary Steel Producers	Institutional/Government Department
Steel Merchants	

3.5 The research instrument

In order to create an amplified FCM, questionnaires were sent out and the researcher communicated directly with SMEs during a number of interspersed interview sessions, in order to gather expert opinion regarding causal relationships amongst factors or concepts and their perceived level of influence of one factor over another. The questionnaires discussed are included in **Appendix B** and **C**. In addition to this, the SMEs had an opportunity to add any other factors and causal links which they considered imperative and required in order to have a relatively accurate representative model of the steel industry in South Africa. A **Delphi Method** was used as a technique to gather data from SMEs. Dalkey and Helmer (1963) describe the objective of the Delphi method as a process of obtaining the most reliable consensus from a group of experts, using a series of intensive questionnaires interspersed with controlled opinion feedback.

3.6 Procedure for data collection

The procedure for data collection was structured using three rounds of interviews. Hsu and Sandford (2007) point out that various authors agree that three iterations are usually sufficient to collect the necessary information and to get consensus during a Delphi process. The details of the three rounds of data collection are described in Table 12:

Table 12: Application of the Delphi technique in data collection

Application of the Delphi Technique (Data collection procedure)	
Round of Interview	**Type of information collected**
Round 1 (Refer to **Appendix B** for the research instrument)	An introductory email was first sent to introduce the researcher and to request approval for a face-to-face interview. The FCM methodology was introduced and explained; followed by a discussion around the preliminary FCM and how it was constructed. The 1st round interviews were unstructured, allowing for the experts to give their in-depth knowledge about the history and dynamics of the steel industry. In their assessment of the preliminary FCM, the experts were asked if there were any factors

	or concepts that were not included in the preliminary model. In addition to that, they were asked to indicate if there were any causal relationships which were not defined by any causal links within the preliminary FCM model.
Round 2 (Refer to **Appendix C** for the research instrument)	All additional concepts which were included by SMEs during the 1st round interviews were amalgamated and presented to all SMEs in a questionnaire format for the second iteration of interviews. SME were requested to indicate the type of relationship between the two concepts, i.e. describing the causality between the two concepts (by indicating either **+** or **–** to represent a positive or negative relationship) (Papageorgiou & Stylios, 2008). The last requirement was for the SMEs to describe the degree (or influence) of the causal relationship (either as "negatively very strong", "negatively strong", "negatively medium", "negatively weak", "zero", "positively weak", "positively medium", "positively strong" or "positively very strong").
Round 3	All outcomes from various SMEs were combined to ensure that there was consensus among respondents. The results were concluded by combining all results and discussing them with all SMEs in order to get their final opinion and acceptability. This 3rd iteration was conducted through telephonic conversations with all participating SMEs. Once finalised, this formed a validated and amplified FCM, replacing the preliminary FCM previously created from literature.

3.7 Data analysis and interpretation

Once the data collection was concluded, an amplified FCM was created based on the views and responses from the subject matter experts. The amplified FCM then replaced the preliminary FCM and formed the final/validated model that represents the dynamics

steel industry in South Africa. The amplified FCM was tested using a fuzzy cognitive mapping model which uses an FCM matrix and various scenarios were tested against literature and their impact was used to simulate the prospective future of the steel industry in South Africa.

3.8 Limitation of the study

The technique for data collection and gathering was based on a Delphi method. This method requires at least three iterations or rounds of interviews to be conducted. This created a limitation with regards to access to industry experts and scheduling constraints. Hsu and Sandford (2007) describe the Delphi study as a time-consuming process, where respondents need to be allocated large amounts of time to complete the questionnaires. Another limitation was the restriction in terms of the number of causal nodes to include for modelling. To minimise the complexity of the analysis, only concepts and causal relationships of significant influence were considered.

3.9 Validity and reliability

The validity of the research is “the degree to which the study accurately answers the question it was intended to answer” as defined by Gravetter and Farzano (2012, p. 167) and reliability is “the stability or consistency of the measurement” (Gravetter & Farzano, 2012, p. 115). Gravetter and Farzano (2012, p. 118) state that “reliability is a prerequisite for validity; that is; a measurement procedure cannot be valid unless it is reliable”. This section addresses the quality of the research process and the accuracy of the data, including the overall consistency pertaining to what was measured.

3.9.1 *External validity*

External validity refers to the extent to which we can generalise the results of a research study to settings other than those used in the study (Gravetter & Farzano, 2012). Gravetter and Farzano (2012) describe the threat to external validity as any characteristic that does not enable the results of the study to be generalised beyond the research study. This research used a preselected group of experts who are considered

subject matter experts within the steel industry and as such, their views were regarded as expert insight and in-depth knowledge, but are not necessarily intended to represent a generalised view. However, the research methodology can be generalised to model any industry or sector other than the steel industry.

3.9.2 *Internal validity*

A research study is considered to have internal validity "if it produces a single, unambiguous explanation for the relationship between two variables" (Gravetter & Farzano, 2012, p. 170). The development of the preliminary FCM was followed by preliminary testing of the model to ensure node consistency with literature. The preliminary FCM model (Figure 25) was considered internally valid provided that preliminary simulations between variables or causal relationships produced results or predicted outcomes consistent to literature.

3.9.3 *Reliability*

"The reliability of a measurement is the stability or consistency of the measurement" (Gravetter & Farzano, 2012, p. 115). A measurement procedure is considered to be reliable if it produces an identical, or near identical, result when it is tested repeatedly to measure the same variable under the same conditions (Gravetter & Farzano, 2012). For scenarios analysis using the amplified FCM model, this research considered the alternative formulation as proposed by Stacey (2016) to check for system stability and convergence in order to test for internal validity. In contrast to conventional methods of FCM analysis which assume system stability, "the alternative formulation does not assume system stability", but rather "facilitates diagnosis of system stability" (Stacey, 2016, p. 283). System stability is checked using the convergence charts. "In order for the system to be stable…the values of the response nodes must converge to a steady state" (Stacey, 2016, p. 278). **Appendix E** summarises the outputs for the system stability and convergence checks carried out on the amplified FCM model.

CHAPTER 4. PRESENTATION OF RESULTS

4.1 Introduction

This section presents the results obtained from the interviews conducted. The methodology for data gathering was based on three rounds of interviews as described in Section 3.6. A Delphi Method was used as a technique for gathering data from the industry experts. Dalkey and Helmer (1963) describe the objective of the Delphi method as a process of obtaining the most reliable consensus from a group of experts, using a series of intensive questionnaires interspersed with controlled opinion feedback. This approach was vital from the aspect of eliminating researcher bias and validation of the preliminary FCM.

The conclusion of the interviews resulted, ultimately, in the development of the amplified FCM model as represented in Section 4.4. The amplified FCM represents a model of the steel industry in South Africa, from which a range of scenarios and plausible future outcomes were tested.

4.2 Results pertaining to Proposition 1

4.2.1 *Round 1 Interviews*

The objective of the 1st round of interviews was to introduce the principles behind fuzzy cognitive mapping to the industry experts, to critique the preliminary FCM and to include any additional concepts or factors which they deemed to be critical to be omitted. The interviews were conducted using face-to-face interviews in an unstructured discussion format. This allowed the expert an opportunity to draw on a number of industry related factors, their institutional memory and expert opinion on a number of wide industry factors.

To a large extent, the SMEs agreed to the model and various factors identified and no major flaws were identified; however, a number of key drivers which were not included in the preliminary FCM were highlighted. These are highlighted in Table 13:

Table 13: 1st Round Interviews – Preliminary FCM model validation based questionnaires

1st Round Interviews – Preliminary FCM Model based questionnaires	
Model Validation based question	**Additional Factors/Concepts Included**
In your assessment of the preliminary FCM, would you say there are any factors or causal relationships that were not included in the model?	• Exchange Rates (i) • Political instability (ii) • Business confidence (iii) • Trade Protectionism & Remedies (iv)
Are there any causal relationships or causal links which the preliminary FCM did not define?	• Reduced logistical costs – *to* – Increasing production costs (iv)

(i) **Exchange Rates**

The concept of exchange rates was highlighted during the interviews, and the SMEs agreed that its inclusion is vital given its influence on the cost structure and production costs, as commodities and the global price of steel are US-dollar denominated. Coking coal, which forms one of the key raw material inputs in the production of steel, is imported by South African producer mills and accounts for up to 27 percent of the production costs (Kumba Iron Ore, 2011b). The influence of our exchange rate against the US dollar has a major impact of the costs associated with the domestic production of steel.

The exchange rate factor also has an influential impact on export market growth opportunities. As the rand depreciates against the US dollar and other major global currencies, this gives our producer mills and downstream manufacturing end users a competitive advantage over global competitors.

(ii) **Political instability**

The second concept that was highlighted during the interview was political instability. Alesina and Tabellini (1989) posit that political or governmental instability has the impact of increasing policy uncertainty which in turn, reduces private investment (as cited in Brunetti, 1997). The impact of this is reducing business confidence and deteriorating levels of inbound foreign direct investment. This is notable in the South African context where over a period of time, political instability and lack of policy certainty has led to the decline in private sector investment in new projects and a decline in our South Africa's global attractiveness to foreign direct investment opportunities.

(iii) **Business confidence**

Business confidence facilitates higher levels of investment within the private sector in the form of capital expenditure. Nedbank (2016b) indicates that the private sector accounts for more than 60 percent of fixed investments in South Africa. Also linked to business confidence is the ability to attract inbound Foreign Direct Investments (FDI) and the much needed capital flows into the country. This is a vital concept that was indicated during the Round 1 interviews, as it plays a crucial role in increasing levels of infrastructure spend from the private sector, which in turn, stimulates demand for steel and steel consuming products.

(iv) **Trade protectionism and trade remedies**

Although the preliminary FCM included "Trade Protectionism" as a broad term to cover all measures instituted by the government to protect the steel industry against unfair foreign-based competition, the experts noted that these measures have different objectives and hence cannot be broadly classified within a single concept. They argued that a distinction needs to be made between the supply side and demand side measures. The "trade protectionism and remedies" concept is split into the following:

- Tariffs, anti-dumping duties, countervailing measures and safeguards (*major impact - upstream*); and
- Rebates and designation (*major impact – downstream*)

The experts indicated that the "rebate offering" and "designation of locally produced steel" should be included, and isolated from the broad term as it represents a

government policy measure aimed at enhancing the demand side to support the both the upstream and downstream industries.

(iv) **A causal Link from "Reduced logistical costs"- to -"Increasing Production Costs**"

During the interviews, the experts highlighted the impact of logistical costs on the cost structure of steel firms. From an upstream side, the cost of transportation can be as much as 15 percent of the overall production costs. The proportion is much higher on the downstream side as finished goods are much more expensive to transport, as opposed to the raw iron ore or coking coal on the upstream steelmaking side. A causal link was then introduced between the nodes "logistical costs" and "production costs".

Based on the above additional concepts, the following is a summary of all nodes and concepts within the amplified FCM.

Table 14: Summary of all nodes for the amplified FCM

Summary of nodes representing variable concepts			
1	Increasing steel imports	21	Chinese government export subsidies
2	Chinese overcapacity	22	Chinese economic growth
3	Increasing input costs	23	Energy supply constraints
4	Government/Institutional Policy	24	Modernisation of mills
5	Economic growth	25	Capability to produce wide range of steel products
6	Infrastructure Investment	26	Security of supply
7	Declining global steel prices	27	Downstream beneficiation & localisation
8	Increasing production costs	28	Skills improvement
9	Increasing selling price	29	Employment creation
10	Global oversupply of steel	30	Access to high grade coking coal
11	Sluggish global economic growth	31	Closure of mills
12	Tariffs, anti-dumping duties & safeguards	32	Foreign Direct Investment (FDI)
13	Rebates & designations	33	Structural competitive advantages
14	Consumer spending	34	Logistical costs
15	Business confidence	35	Unfair pricing practices
16	Political Instability	36	Access to regional overland growth opportunities
17	Demand for steel & steel consuming products	37	Competitive manufacturing end users
18	Exchange rates (depreciating currency)	38	Efficiency of mills
19	Increasing cost of capital	39	Growth of the domestic & regional steel industry
20	Trade with China	40	Seaborne export market growth

The preliminary FCM, previously created based on literature, as depicted in Figure 25, consisted of 38 nodes or concepts; with a total of 71 causal links or causal relationships amongst the concepts. The amplified FCM removes two concepts from the preliminary FCM and adds an additional four nodes, resulting in a total of 40 nodes with a total of 84 connections (causal relationships).

4.2.2 *Round 2 Interviews*

The 2nd round of interviews were a follow-up to the 1st round, however this iteration consisted of a number of questions which required expert opinion feedback from the industry experts. The objective of the 2nd round of interviews (structured through a questionnaire format) was to describe the causality between concepts and to indicate their perceived level or degree of influence one concept has on another. These questionnaires were structured on 40 concepts (as per Table 14) with a total of 84 causal relationships or causal links.

The results obtained were analysed to indicate the following:

- *Percentage of expert respondents in agreement with the suggested causal relationship or causal link*;
- *The type of causal relations and level (or degree) of influence selected by each expert respondent*, and
- *Ultimate degree of influence based on the majority consensus*

Some level of discrepancy was anticipated with regards to type of causal relationship (i.e. “causal increase” or “causal decrease”) and the degree of influence one concept has over the other, between expert respondents. However, this was expected due to varying opinions depending on the sector or industry to which the expert belongs, within the South African steel industry value chain. Bearing this in mind, however, a majority consensus was expected over a number of views and as such, prodigious disparities between the responses were not expected.

Given the small number of experts who were selected to participate in this research, to achieve consensus, a two-thirds majority in responses was selected as the determining basis. As the SMEs selected are industry experts, with above average knowledge about

the steel industry; Ramney, Weller, and Batchelder (1986, p. 325) suggest that "the higher the average competence of the sample the smaller the sample needed". Guest, Bunce, and Johnson (2006) suggest that six to 12 interviews are sufficient to ensure useful data interpretation, provided the target audience is a homogenous audience (e.g. experts within a similar industry) and the research is of a narrow scope.

As only 10 SMEs were part of the study, the causal relationship and the degree of influence between concepts were selected on the basis that six or more experts agree to a specific similar response. The 3rd round of interviews addressed causal relationships where experts responded with large disparities in their responses. These are discussed in Section 4.4.1. The complete results of the 2nd round interview questionnaires are tabulated in **Appendix D** – Table D1, Table D2 and Table D3.

Table D1 – Number of Experts confirming the causal link between concepts

All respondents confirmed the existence of causal links in 72 connections out of 84, leaving only 12 of the connections not getting 100 percent causal link confirmation. 90 percent of respondents confirmed the existence of causal links in nine out of the remaining 12. Only two links received the lowest confirmation of 70 percent, that is, Link 3 and Link 46.

Link 3: "*Increasing production costs*" to "*Efficiency of steel mills*"

Three out of 10 respondents felt that the link between the two concepts does not exist; however, the other seven respondents agreed that South African producer mills' inability to control production costs has a causal influence to the mills ultimately being inefficient as compared to other foreign-based producer mills.

Link 46: "*Tariffs, anti-dumping duties & safeguards*" to "*Chinese government export subsidies*"

Three out of 10 respondents felt that the link between the two concepts is negligible and hence can be ignored, however, seven out of the 10 respondents felt that the trade protectionist barriers of imposing tariffs, anti-dumping duties and safeguards has the effect of counteracting against the export subsidies from South Africa's major exporter of steel and major trading partner, China.

Table D2 – Level (or degree) of influence one concept has on another

The expert respondents had, to a very large extent, similar views on the causal relationships between the concepts, although with varying degrees of influence on certain connections; with the exception of Link 6 and Link 14.

Link 6: "*Chinese economic growth*" to "*Global oversupply*"

Half of the respondents felt that there was a positive causal relationship between "Chinese economic growth" and "Global oversupply" whereas the other half of the respondents felt that the causal relationship was negative. The respondents with the positive causal relationship selection felt that the link was "positively strong" to "positively very strong" however the other half felt that the relationship was "negatively medium" to "negatively strong".

Link 14: "*Modernisation of South African producer mills*" to "*Increasing production costs*"

The effects of short-run versus long-run economic benefit of modernising a steel mill created disparities in responses. Out of the experts that responded, one felt that there was no confirmed causal relationship between the two concepts, three out of the responding nine felt that there was a positive causal relationship, whilst the remaining six felt that there was a negative causal relationship.

Table D3 – Degree of influence on causal links based on majority consensus

Seventy-two causal links had a clear majority of 60 percent and more, however, 12 causal links did not meet the majority consensus rule. These were links 6, 14, 18, 28, 30, 46, 48, 59, 64, 66, 69 and 77 as highlighted in Table D3 (**Appendix D**).

These were discussed with the experts and were addressed during the 3rd round interviews, as discussed in further detail in Section 4.2.3

4.2.3 *Round 3 Interviews*

In the 3rd round interviews, the results were concluded by combining all results and discussing them with all SMEs, to get their final opinions and acceptability of the

validated and amplified FCM model. The casual links not receiving majority of 60 percent or more, were discussed with the experts, however all justified their decisions with regards to their causal influence perceptions between concepts. Given the disparity with regards to 12 links where there was no 60 percent plus majority, a decision was made that the degree of influence would be based on the causal degree with the highest score. These are outlined in Table 15.

Table 15: Connections/Links without majority and selected influence factor

Link No	-1	-0.75	-0.5	-0.25	0	0.25	0.5	0.75	1.00	Maximum	2/3 Majority	Selected Degree
6	0.0%	20.0%	30.0%	0.0%	0.0%	0.0%	0.0%	30.0%	20.0%	30.0%	No	**0.75**
14	0.0%	44.4%	22.2%	0.0%	0.0%	11.1%	22.2%	0.0%	0.0%	44.4%	No	**-0.75**
18	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%	50.0%	37.5%	50.0%	No	**0.75**
28	0.0%	50.0%	30.0%	0.0%	0.0%	10.0%	10.0%	0.0%	0.0%	50.0%	No	**-0.75**
30	0.0%	11.1%	55.6%	11.1%	0.0%	0.0%	11.1%	11.1%	0.0%	55.6%	No	**-0.50**
46	14.3%	14.3%	14.3%	57.1%	0.0%	0.0%	0.0%	0.0%	0.0%	57.1%	No	**-0.25**
48	0.0%	0.0%	10.0%	0.0%	0.0%	30.0%	40.0%	10.0%	10.0%	40.0%	No	**0.50**
59	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	50.0%	20.0%	10.0%	50.0%	No	**0.50**
64	0.0%	0.0%	0.0%	0.0%	0.0%	40.0%	40.0%	10.0%	10.0%	40.0%	No	**0.25**
66	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	40.0%	10.0%	50.0%	No	**0.50**
69	0.0%	10.0%	40.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	No	**-0.25**
77	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	50.0%	No	**0.75**

4.2.4 *Amplified FCM*

On conclusion of the three rounds of interviews and by amalgamating all the results obtained, a validated fuzzy cognitive map was finalised.

Figure 26 concluded the FCM validation by amalgamating and mapping out the final results graphically, to form an amplified FCM. This amplified FCM represent a final, expert validated FCM.

The amplified FCM was used in Chapter 5 to test a number of plausible scenarios to determine conditions required to ensure a viable and sustainable steel industry in South Africa.

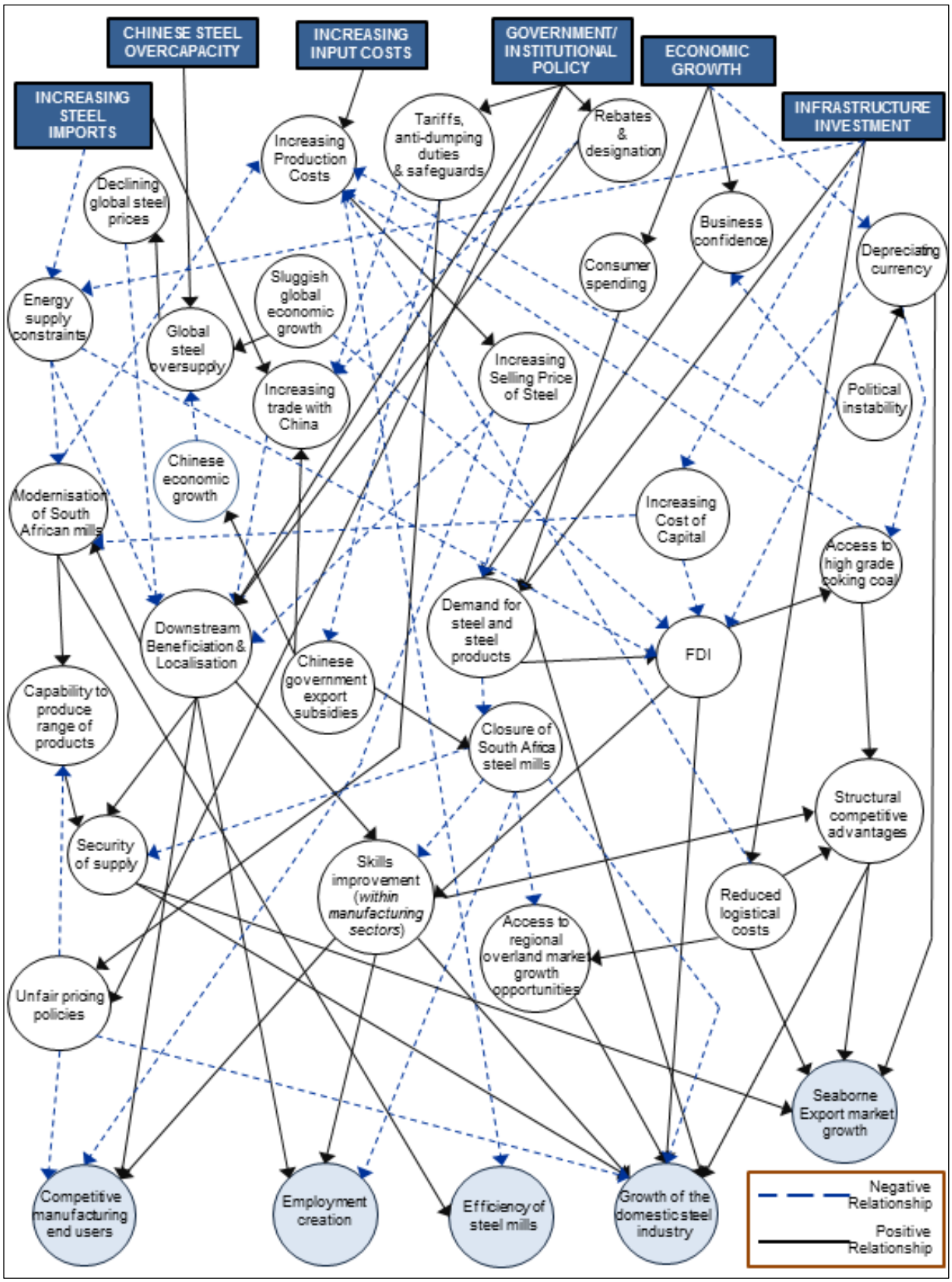


Figure 26: Amplified FCM

4.3 Results pertaining to Proposition 2

Various exogenous and endogenous factors that impact the steel industry in South Africa are represented by the amplified FCM as illustrated in Figure 26. This formed the validated model from which the influence of various drivers can be modelled holistically within the framework of the simulation model, as represented by the amplified FCM.

Proposition 2 proposes that:

The growth and sustainability of the steel industry in South Africa is dependent not only on policy interventions, but also on measures that would stimulate the demand for steel.

Under this proposition a number of scenario simulations ("what-if" analyses) were tested, to determine a range of plausible outcomes from which conditions required to ensure a viable and sustainable steel industry in South Africa would be determined.

4.4 Summary of results

Based on literature, a preliminary FCM consisting of 38 nodes and 71 causal relationships was modified through an expert validated process to create, ultimately, an amplified FCM with 40 nodes and 84 connections (causal links). The preliminary FCM did not encompass any differential weightings or varying degrees of causal relationships, because at the preliminary stage (i.e. literature based modelling); the emphasis was more on whether a causal relationship existed or not and what type of causal relationship influenced any two concepts, if any.

The results indicated that all respondents confirmed the existence of causal links in 72 connections out of a total of 84, leaving only 12 of the connections not getting 100 percent causal link confirmation. Only two links received the lowest confirmation of 70 percent.

The results indicated "strong" to "very strong" causal influences from mostly the key factors (or influential drivers) which are transmitter nodes within the model and "weak" to "medium" causal influences generally amongst the receiver nodes.

CHAPTER 5. DISCUSSION OF THE RESULTS

5.1 Introduction

This chapter discusses the results obtained through a process of various model simulations and scenario analyses. In this chapter, the amplified fuzzy cognitive map (FCM) as developed in Chapter 4 was used to address proposition 1, by evaluating the impact of the influential drivers on the steel industry in South Africa and addressed proposition 2, by testing a number of scenario simulations ("what-if" analyses) to represent a range of plausible future outcomes. From the amplified FCM model, validated through a number of expert interviews, certain transmitter nodes (including normal and receiver nodes) were activated and deactivated to evaluate the model responses, from which conditions required to warrant a viable and sustainable steel industry in South Africa were determined.

5.2 Demographic profile of respondents

The respondents in this research were a group of experts within various sectors of the South African steel value chain. These experts were selected on the basis of their in-depth knowledge of the steel industry, their number of years within the industry and their level of involvement within steel committee structures, industry associations and leadership positions within their organisations.

The respondents are from the following sectors within the steel value chain:

- *Steel Industry Associations*
- *Primary Steel Producers*
- *Steel Merchants and Stockists*
- *Manufacturing and Fabrication*
- *Institutional and government departments*

5.3 Discussion pertaining to Proposition 1

This section discusses the results with reference to Proposition 1, as stated below:

Proposition 1: Amongst the multitude of factors attributable to the recent decline in the steel industry in South Africa, the following are influential drivers: *Increasing Steel Imports*, *Chinese Steel Overcapacity*, *Increasing Input Costs*, *Subdued Economic Growth*, *Inadequate Infrastructure Investment* and *Lack of Governmental/Instructional Policy*.

This proposition relates to the current state of the steel industry in South Africa, with reference to influential drivers that have and are currently impacting the industry, leading to the industry's recent decline and subsequent uncertainties about its viability and future sustainability. In order to understand the impact of each influential driver on the industry, each factor was considered on an isolated basis and modelled using the amplified FCM to determine its impact on the overall industry. This was done by *activating* a specific influential driver, whilst others were *deactivated*, and then determining its cause and effect across the entire system. To *deactivate* an influential driver a factor zero "0" was used; to *activate an increase* in an influential driver, the factor "+1" was used; and to *activate a decrease* in an influential driver a factor "-1" was used as input functions in the model.

5.3.1 *Increasing Steel Imports*

Under this condition, the transmitter node representing the "Increasing Steel Imports" influential driver was activated, whilst all other influential drivers were deactivated within the amplified FCM model.

Steel imports to the South African market reached 1 million tonnes by the end of 2011, constituting about 20 percent of domestic consumption (ArcelorMittalSA, 2016). This was a rapid increase in the growth of imports which were merely at 100,000 tonnes per annum by the year 2005. The origins of the imports were predominantly from Far East Asia in which China accounts for more than 90 percent of the market share.

This condition modelled the impact of increasing steel imports *only* from foreign based producer mills and what consequential impact this has (or has had) on the entire industry.

Table 16: Impact of Increasing Steel Imports

5.3.1 - Impact of Increasing Steel Imports				
Cause		**Effect**		
Influential Driver:	**Activated**	**Output:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports	**1**	Competitive manufacturing end users	-0.08	
Chinese Steel Overcapacity	0	Employment creation	-0.25	
Increasing Input Costs	0	Efficiency of producer mills		0.02
Government/Institutional Policy	0	Growth of the domestic steel industry		0.22
Economic Growth	0	Seaborne export market growth	-0.07	
Infrastructure Investment	0			

As the influence of increasing steel imports was activated, the model responded by indicating a decline in employment as the major negative effect. Due to the labour intensity of the steel sector, an increase in steel imports has a negative impact on jobs within the sector. A study by the SAISC found that for every 1000 tons of steel imported, approximately 100 jobs are negatively impacted (deBeer, 2013). Statistics South Africa reports that the number of jobs within the metals industry declined from 284,000 in 2005 to 250,000 by the end of 2014 (StatsSA, 2014). The model predicted a decline in competitiveness of manufacturing end user and also a negative impact on seaborne export market growth opportunities. The decline in competitiveness of manufacturing end users can be attributed to the increased landed costs of steel products sourced from international mills which incur insurance and freight costs, which in turn, impacts on the prospects for seaborne export opportunities. The model, however, predicted a positive impacts or causal increases in both efficiency of producer mills and growth of the domestic steel industry, which can be attributed to the decline in electrical energy constraints. The steel making process is a highly energy intensive process. At primary level, energy intensity for the production of steel ranges from 0.7 to 1.0 GJ/ton for the OBF process and 3.9 to 5.0 GJ/ton of steel for the OHF process; and at the secondary level of steel production where the EAF process is predominately used, the energy intensity required to produce a tonne of steel ranges 4.0 to 6.5 GJ/ton (Price et al., 2002). Ingesi-Lotz and Blignaut (2011) in their sectoral decomposition analysis, showed

that the ‘iron and steel’ sector was the second largest consumer of electricity in South Africa, after the ‘non-ferrous metals’ sector. Steel imports inherently decrease demand for domestic production and thus reduce electricity consumption at producers mills (both at primary and secondary levels), thereby reducing the energy costs which in turn, allows for more efficient domestic production.

5.3.2 *Chinese Steel Overcapacity*

Under this condition, the transmitter node representing the “Chinese Steel Overcapacity” influential driver was activated, whilst all other influential drivers were deactivated within the amplified FCM model.

This condition modelled the impact of the increasing Chinese overcapacity *only* on the steel industry in South Africa and what consequential impact this has (or has had) on the entire industry.

Table 17: Impact of Increasing Chinese Steel Overcapacity

5.3.2 - Impact of Increasing Chinese Steel Overcapacity				
Cause		**Effect**		
Influential Driver:	**Activated**	**Output:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports	0	Competitive manufacturing end users	-0.33	
Chinese Steel Overcapacity	**1**	Employment creation	-0.45	
Increasing Input Costs	0	Efficiency of producer mills	-0.22	
Government/Institutional Policy	0	Growth of the domestic steel industry	-0.41	
Economic Growth	0	Seaborne export market growth	-0.34	
Infrastructure Investment	0			

As the influence of increasing overcapacity in China was activated, the model responded to indicate a negative overall response for the steel industry in South Africa. The weighting factors, however, indicate weak to slightly moderate direct impacts to the domestic industry. The increasing overcapacity directly increases the global oversupply, which not only negatively impacts the pricing for steel, but also South Africa’s prospects of promoting downstream beneficiation and localisation. This is as a direct consequence of the increased availability and oversupply of steel in the global market, rendering the domestic production and procurement of steel locally, unfeasible.

5.3.3 *Increasing Input Costs*

Under this condition, the transmitter node representing the “Increasing Input Costs” influential driver was activated, whilst all other influential drivers were deactivated within the amplified FCM model.

Department of Trade and Industry (2016a) reports that electricity and gas prices have risen more than 300 percent and 160 percent, respectively, since 2007; with transport costs (i.e. rail tariffs) increasing more than 100 percent over the same period. Hence, the condition of *increasing inputs costs* models the impact of rapidly increasing input costs in the steelmaking process within a South Africa context and assesses what consequential impact this has (or has had) on the entire industry.

Table 18: Impact of Increasing Input Costs

5.3.3 - Impact of Increasing Input Costs				
Cause		**Effect**		
Influential Driver:	**Activated**	**Output:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports	0	Competitive manufacturing end users	-0.77	
Chinese Steel Overcapacity	0	Employment creation	-0.59	
Increasing Input Costs	**1**	Efficiency of producer mills	-0.71	
Government/Institutional Policy	0	Growth of the domestic steel industry	-0.86	
Economic Growth	0	Seaborne export market growth	-0.43	
Infrastructure Investment	0			

In contrast to increasing steel imports and steel overcapacities within the Chinese market, the impact of increasing input costs in the production of steel domestically have far reaching negative impacts on the steel industry in South Africa. As the influence of increasing input costs was activated, the model responded to indicate a decline in production efficiencies, a decline in the competitiveness of manufacturing end users and the decline in growth of the domestic industry, as the major negative effects. Based on the model response under this condition, the impact of increasing input costs over the past few years can certainly be observed as a major attributing factor to the recent decline in the steel industry in South Africa.

5.3.4 *Lack of Government/Institutional Policy*

Under this condition, the transmitter node representing the "Lack of government/institutional Policy" influential driver was activated, whilst all other influential drivers were deactivated within the amplified FCM model.

Prior to August 2015, the steel industry in South Africa did not have any trade protectionism in the form of import duties, tariffs or safeguards, making South Africa one of only a few countries in the world with primary steel making capability without any form of protection from unfair foreign based competition. In addition to that, the steel industry did not have any local content designation policies in place for locally produced steel, meaning that large scale projects, such as power stations (Kusile and Medupi Power Stations), were not bound to use locally produced steel, and as such, a large majority of the steelwork was imported from international mills during the construction of the of the power stations.

Hence, under this condition, the impact of lack of government and institutional policy framework was modelled and the consequential impact this has (or has had) on the steel industry was evaluated.

Table 19: Impact of No Governmental or Institutional Policy

5.3.4 - Impact of No Government or Institutional Policy				
Cause		**Effect**		
Influential Driver:	**Activated**	**Output:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports	0	Competitive manufacturing end users	-2.35	
Chinese Steel Overcapacity	0	Employment creation	-3.69	
Increasing Input Costs	0	Efficiency of producer mills	-1.70	
Government/Institutional Policy	**-1**	Growth of the domestic steel industry	-3.58	
Economic Growth	0	Seaborne export market growth	-2.79	
Infrastructure Investment	0			

As the influence of lack of government or institutional policy was activated, the model predicted an overall negative response for the steel industry in South Africa. The negative impact was most notable by assessing the weighting factors for employment creation and growth of the steel industry, which were at -3.69 and -3.58, respectively. The model predicted the impact of lack of government or institutional policy framework,

aimed at preserving and promoting the domestic steel industry, to have a substantial negative impact on jobs and employability within the sector.

5.3.5 *Subdued Economic Growth*

Under this condition, the transmitter node representing the "Subdued Economic Growth" influential driver was activated, whilst all other influential drivers were deactivated within the amplified FCM model.

South Africa's "economy is forecast to have grown by a mere 0.4 percent in 2016, down from the 1.3 percent recorded in 2015 and 1.4 percent in 2014" (SEIFSA, 2017). The Reserve Bank forecasts a GDP growth of 1.2 percent for 2017, whilst the World Bank and the rating agency Moody's is forecasting 1.1 percent (Nedbank, 2016b). The economic growth rate remains at levels far below the target as set out in the NDP. SEIFSA (2017) attributes the recent subdued economic prospects to inherent economic challenges and a volatile political landscape, amongst others factors; and Nedbank (2016b) suggests that the economic growth trajectory will be dependent on emerging political developments within the country.

This condition modelled the impact of subdued or stagnant economic growth within South Africa's economy and what consequential impact this has (or has had) on the steel industry.

Table 20: Impact of Subdued or Stagnant Economic Growth

5.3.5 - Impact of Subdued/Stagnant Economic Growth				
Cause		**Effect**		
Influential Driver:	**Activated**	**Output:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports	0	Competitive manufacturing end users	-1.19	
Chinese Steel Overcapacity	0	Employment creation	-2.10	
Increasing Input Costs	0	Efficiency of producer mills	-0.31	
Government/Institutional Policy	0	Growth of the domestic steel industry	-5.35	
Economic Growth	**-1**	Seaborne export market growth	-1.31	
Infrastructure Investment	0			

As the influence of subdued or stagnant economic growth was activated, the model predicted an overall negative response for the steel industry in South Africa, with a

substantial negative impact to the growth prospects of the industry. The impact of subdued economic growth was notable when examining its impact on business confidence, consumer spending, FDI and their consequential decline in demand for steel and steel related products, such as cars and white goods. The lack of demand for steel and steel products reduces steel consumption and in turn, affects to a large extent, the growth of the domestic steel industry and its ability to retain jobs within the sector. As anticipated, the model predicted the least impact to be on efficiency of steel producer mills as their production efficiencies are not affected to a large extent be economic growth.

5.3.6 *Inadequate Infrastructure Investment*

Under this condition, the transmitter node representing the "Inadequate Infrastructure Investment" influential driver was activated, whilst all other influential drivers were deactivated within the amplified FCM model.

South Africa's growth in fixed investment, measured by GFCF, fell by 4.6 percent in the second quarter of 2016 from a drop of 10 percent in the first quarter (Nedbank, 2016b). A long term assessment of GFCF indicates a more prolonged decline in fixed investments which was observed to have had a direct negative causal impact on steel consumption (Figure 18).

This condition modelled the impact of declining levels of infrastructure investment and what consequential impact this has (or has had) on the steel industry.

Table 21: Impact of Declining or Inadequate Infrastructure Investment

5.3.6 - Impact of Declining Infrastructure Investment				
Cause		**Effect**		
Influential Driver:	**Activated**	**Output:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports	0	Competitive manufacturing end users	-2.21	
Chinese Steel Overcapacity	0	Employment creation	-2.94	
Increasing Input Costs	0	Efficiency of producer mills	-1.43	
Government/Institutional Policy	0	Growth of the domestic steel industry	-7.00	
Economic Growth	0	Seaborne export market growth	-2.95	
Infrastructure Investment	**-1**			

As the influence of declining and/or inadequate infrastructure investment was activated, the model predicted an overall negative response for the steel industry in South Africa, with an anticipated substantial negative impact on the growth prospects of the steel industry. With construction alone accounting for nearly 40 percent of steel consumption (Figure 13), a decline in infrastructure investment has a considerable negative impact on the steel industry. The model predicted a corresponding decline in employment creation, competitiveness of manufacturing end users and a decline in seaborne export market growth. A decline in infrastructure investment, especially by the general government and public corporations increases the cost of doing business through major factors such as increased transportation costs, increased electricity costs, etc. leading to a decline in overall competitiveness. The model therefore simulated the decline by predicting an increase in the following receiver nodes; logistical costs, energy supply constraints and an overall decline in the node representing structural competitive advantage(s).

5.4 Discussion pertaining to Proposition 2

This section discusses the results with reference to Proposition 2, as stated below:

Proposition 2: The growth and sustainability of the steel industry in South Africa is dependent not only on policy interventions but also on measures that would stimulate the demand for steel.

Under this proposition, a number of scenario simulations ("what-if" analyses) were tested, to determine a range of plausible outcomes from which measures, interventions or a combination of measures and interventions required to ensure a viable and sustainable steel industry in South Africa would be determined.

5.4.1 *Scenario development*

Amongst a multitude of different versions to the definition of scenarios, perhaps more relevant for this study is the definition by Kahn and Wiener (1967), who define scenarios as "hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision points" (as cited by Kosow & Gabner, 2008, p. 11). The definition captures the methodological approach as used in this study, and the end

part of the definition addresses the objective of the study as the objective is to create a model of the industry through testing a range of scenarios and use that as a basis (or guideline) from which decisions can be taken about the future sustainability of the industry.

With regard to the question of the appropriate number of scenarios to be modelled; Amer, Diam, and Jetter (2013) suggest that there is no precise response, as the number depends on how best the dynamics of a particular situation can be captured. From their study, through an assessment of various authors and previous researches, a typical range of between three to six scenarios are shown to be sufficient (Amer et al., 2013). Wilson (1998) proposes that a minimum number of scenarios must be developed that best captures "the areas of uncertainty" and that the selection criteria must be based on a mixture of both intuition and rationality. Wilson (1998) further proposes the consideration of the following five components, as criteria for scenario development:

> "*(1) Plausibility. The selected scenarios must be plausible; that is, they must fall within the limits of what might conceivably happen;*
>
> *(2) Differentiation. They should be structurally different. In other words, they should not be so close to one another that they become simply variations of a base case;*
>
> *(3) Consistency. They must be internally consistent. The combination of logics in a scenario must not have any built-in inconsistency that would undermine the credibility of the scenario;*
>
> *(4) Decision-making Utility. Each scenario, and all the scenarios as a set, should contribute specific insights into the future that will bear on the decision focus you have selected;*
>
> *(5) Challenge. The scenarios should challenge the organization's conventional wisdom about the future"* (p. 91)

Based on the consideration of the above selection criteria as proposed by Wilson (1998); for this research, a total number of six scenarios were developed and modelled using the amplified FCM. Table 22 details the scenarios selected; where, as in Section 5.3 the influential driver factor of "0" indicates a *deactivated* influential driver, "+1"indicates an

activation of an influential driver i*ncrease* and “-1” activates a *decrease* in the influential driver.

Table 22: Scenario formulation

Scenario Formulation								
Scenarios	Increasing Steel Imports	Chinese Steel Overcapacity	Increasing Input Costs	Government/Institutional Policy			Economic Growth	Infrastructure Investment
				P1	P2	P3		
Scenario 1	**1**	**1**	**1**	0	0	0	0	**-1**
Scenario 2	**1**	**1**	**1**	0	0	0	**1**	**1**
Scenario 3	0	0	**1**	**1**	0	0	0	0
Scenario 4	0	0	**1**	0	**1**	**1**	0	0
Scenario 5	0	0	0	**1**	**1**	**1**	**-1**	**-1**
Scenario 6	0	0	0	**1**	**1**	**1**	**1**	**1**
***Where*:**								
P1: Policy addressing "*Tariffs, anti-dumping duties, countervailing measures & safeguards*"								
P2: Policy addressing "*Rebates & designation*s"								
P3: Policy addressing "*Downstream beneficiation & localisation*"								

Scenario 1: To evaluate the influence of increasing steel imports, increasing Chinese overcapacity and increasing input costs, in a stagnant economy with decreasing infrastructure investment

Scenario 2: To evaluate the influence of increasing steel imports, increasing Chinese overcapacity and increasing input costs, under conditions of economic growth and increasing infrastructure investment

Scenario 3: To evaluate the influence of increasing input costs but under conditions of governmental/institutional policy intervention aimed at trade protectionism through the means of *only* tariffs, anti-dumping duties, countervailing measures and safeguards (P1 only)

Scenario 4: To evaluate the influence of increasing input costs but under conditions of governmental/institutional policy intervention aimed at trade remedial action through the means of rebates & designation and downstream beneficiations & localisation (P2 and P3)

Scenario 5: To evaluate the influence of governmental/institutional policy intervention aimed at trade protectionism and trade remedial action through a combination of *tariffs, anti-dumping duties, countervailing measures and safeguards* and *rebates & designation* and *downstream beneficiations & localisation* (P1, P2 and P3) but under conditions of receding economic growth and declining infrastructure investment.

Scenario 6: To evaluate the influence of governmental/institutional policy intervention aimed at trade protectionism and trade remedial action through a combination of *tariffs, anti-dumping duties, countervailing measures and safeguards* and *rebates & designation* and *downstream beneficiations & localisation* (P1, P2 and P3) but under conditions of economic growth and increasing infrastructure investment.

An intuitive and rational approach was followed during the formulation of the above scenarios. These were guided by recent developments within the steel industry in South Africa and a number of possible interventions proposed, which are aimed at addressing the challenges within the industry. All scenarios were checked to assess whether they conform to the selection criteria as proposed by Wilson (1998), as detailed in Table 23.

Table 23: Assessment on scenario selection criteria

	Assessment on scenario selection criteria				
	Plausibility	Differentiation	Consistency	Utility	Challenge
Scenario 1	✓✓✓	✓✓	✓✓✓	✓✓	✓
Scenario 2	✓✓✓	✓✓	✓✓✓	✓✓	✓
Scenario 3	✓✓✓	✓✓	✓✓✓	✓✓	✓
Scenario 4	✓✓✓	✓✓	✓✓✓	✓✓	✓
Scenario 5	✓✓✓	✓✓	✓✓✓	✓✓	✓
Scenario 6	✓✓✓	✓✓	✓✓✓	✓✓	✓

5.4.2 *Scenario 1*

This scenario considered the influence of increasing steel imports and increasing Chinese overcapacity as global factors and increasing input costs within the domestic market, given conditions of a stagnant economy with decreasing infrastructure investment. This scenario is plausible as it may be elicited by political instability, reduction in inbound FDI or continuing deterioration in business confidence.

Table 24: Scenario 1

Increasing steel imports, Increasing Chinese overcapacity and Increasing input costs, in a stagnant economy where with decreasing infrastructure investment					
Cause			**Effect**		
Influential Driver:		**Activated**	**Major Receiver Nodes:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports		**1**	Increasing Production Costs		2.46
Chinese Steel Overcapacity		**1**	Downstream beneficiation & localisation	-1.58	
Increasing Input Costs		**1**	Skills Improvement	-3.33	
Government/Institutional Policy	P1	0	**Output:**	**Negative Impact**	**Positive Impact**
	P2	0	Competitive manufacturing end users	-3.38	
	P3	0	Employment creation	-4.25	
Economic Growth		0	Efficiency of producer mills	-2.34	
Infrastructure Investment		**-1**	Growth of the domestic steel industry	-8.05	
			Seaborne export market growth	-3.79	

Under this scenario, the steel industry would find itself in a state of rapid decline, characterised by a decrease in employment (retrenchments, downsizing, forced retirement, etc.), un-competitiveness of downstream manufacturing end users, inefficiency of upstream producer mills and an inability to compete at seaborne export markets. Production costs would increase, exacerbating inefficiencies and un-competitiveness and skills improvement would be jeopardised, affecting the employability within the sector.

5.4.3 *Scenario 2*

The second scenario considered the influence of increasing steel imports, increasing Chinese overcapacity and increasing input costs, but under conditions of economic growth and increasing infrastructure investment. Under this scenario, no governmental or institutional policy is implemented, and hence the steel industry is not protected against the influx of imports.

Table 25: Scenario 2

Increasing steel imports, Increasing Chinese overcapacity and increasing input costs, under conditions of economic growth and increasing infrastructure investments					
Cause			**Effect**		
Influential Driver:		**Activated**	**Major Receiver Nodes:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports		**1**	Demand for steel & steel products		2.39
Chinese Steel Overcapacity		**1**	Foreign Direct Investment (FDI)		3.10
Increasing Input Costs		**1**	Skills Improvement		4.07
Government/Institutional Policy	P1	0	**Output:**	**Negative Impact**	**Positive Impact**
	P2	0	Competitive manufacturing end users		2.23
	P3	0	Employment creation		3.76
Economic Growth		**1**	Efficiency of producer mills		0.83
Infrastructure Investment		**1**	Growth of the domestic steel industry		11.3
			Seaborne export market growth		3.42

Under this scenario, the model predicted growth within the steel industry stimulated by the overarching influence of economic growth, which increases the demand for steel and steel consuming products such as built infrastructure and white goods. The model predicted growth in FDI, creating a stimulus for employment creation and skills improvement. Increasing input costs, however, were observed to have a negative impact on production, creating reduced efficiency within primary and secondary producer mills. The model predicted that although the sector would not be benefiting from any governmental or institutional policy support, economic growth and increasing infrastructure would induce demand, significantly stimulating growth within the domestic steel industry. This scenario indicates that impact of increasing imports, increasing Chinese overcapacity and increasing input costs, can all be mitigated under conditions of economic growth and rapid infrastructure investment, even if government or institutional policy interventions are not instituted.

5.4.4 *Scenario 3*

The third scenario excluded the influence of globally induced factors, i.e. increasing steel imports and global steel overcapacity, and considered only the influence of increasing input costs. This condition was considered in parallel to the condition of governmental/institutional policy intervention aimed at trade protectionism as a barrier against imported steel. The trade protectionist measure considered under this scenario was “tariffs, anti-dumping duties, countervailing measures and safeguards” (i.e. P1 only).

Table 26: Scenario 3

Increasing input costs, under conditions of governmental/institutional policy intervention aimed at trade protectionism through means of *only* "tariffs, anti-dumping duties, countervailing measures and safeguards"					
Cause			**Effect**		
Influential Driver:		**Activated**	**Major Receiver Nodes:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports		0	Increasing Production Costs		1.00
Chinese Steel Overcapacity		0	Increasing Trade with China	-0.63	
Increasing Input Costs		**1**	Unfair pricing policies		0.50
Government/Institutional Policy	**P1**	**1**	**Output:**	**Negative Impact**	**Positive Impact**
	P2	0	Competitive manufacturing end users	-0.99	
	P3	0	Employment creation		0.40
Economic Growth		0	Efficiency of producer mills	-0.32	
Infrastructure Investment		0	Growth of the domestic steel industry	-0.13	
			Seaborne export market growth		0.21

Under this scenario, the model predicted that the growth of the industry would not be induced solely by means of *trade protectionist measures such as tariffs, anti-dumping duties, countervailing measures* or *safeguards*. The model predicts that the imposition of such measures may, in actual fact, induce unfair pricing practices by upstream domestic producers and imposed directly on downstream manufacturing end users, leading to their un-competitiveness. The model predicts a marginal positive effect on employment creation or job preservation, however, this would most likely be beneficial to upstream jobs and the effects may not filter downstream to manufacturing end users, which are predominately the most labour intensive industries of the steel value chain.

5.4.5 *Scenario 4*

The fourth scenario excluded the influence of global induced factors, i.e. increasing steel imports and global steel overcapacity, and considered only the influence of increasing input costs, but under conditions of governmental/institutional policy intervention aimed at trade remedial action through the measures of “rebates & local content designations” and “downstream beneficiations & localisation” (i.e. only P2 and P3).

Table 27: Scenario 4

Increasing input costs, under conditions of governmental/institutional policy interventions aimed at trade remedial action through means of *only* "rebates & designations" and "downstream beneficiation & localisation"					
Cause			**Effect**		
Influential Driver:		**Activated**	**Major Receiver Nodes:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports		0	Downstream beneficiation & localisation		2.07
Chinese Steel Overcapacity		0	Skills improvements		1.51
Increasing Input Costs		**1**	Security of supply		2.12
Government/Institutional Policy	P1	0	**Output:**	**Negative Impact**	**Positive Impact**
	P2	**1**	Competitive manufacturing end users		1.70
	P3	**1**	Employment creation		2.80
Economic Growth		0	Efficiency of producer mills		0.92
Infrastructure Investment		0	Growth of the domestic steel industry		2.27
			Seaborne export market growth		2.15

Under this scenario, the model predicted a positive impact on the steel industry in South Africa stimulated by policy intervention aimed at downstream beneficiation, local content procurement and rebate policies aimed at improving competitiveness for downstream manufacturing end users. Owing to downstream beneficiation policies and local content production, the model predicted a positive impact on security of supply, meaning improved availability of steel and steel products locally (including fabricated or manufactured steel products) which would subsequently improve seaborne export opportunities for excess steel produced and not consumed domestically. Employment creation would be improved under this scenario; however there would be a marginal improvement in the efficiency of producer mills owing to the conditions of increasing input costs which would, as a consequence, would increase production costs, unless production efficiency measures are implemented by primary and secondary producers.

5.4.6 *Scenario 5*

The fifth scenario excluded the influence of global induced factors, i.e. increasing steel imports and global steel overcapacity, and within the domestic market excluded the influence of increasing input costs. Under this scenario, the influence of governmental/institutional policy intervention aimed at trade protectionism and trade remedial action through a combination of *tariffs, anti-dumping duties, countervailing measures and safeguards* and *rebates & designation* and *downstream beneficiations & localisation* (P1, P2 and P3) was considered; however, under conditions of receding economic growth and declining levels of infrastructure investment.

Table 28: Scenario 5

Governmental/institutional policy interventions aimed at trade protectionism and trade remedial action through a combination of "tariffs, anti-dumping duties, countervailing measures and safeguards" and "rebates & designations" and "downstream beneficiation & localisation", but under conditions of receding economic growth and declining infrastructure investment					
Cause			**Effect**		
Influential Driver:		**Activated**	**Major Receiver Nodes:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports		0	Foreign Direct Investment (FDI)	-2.73	
Chinese Steel Overcapacity		0	Demand for steel and steel products	-2.40	
Increasing Input Costs		0	Downstream beneficiation & localisation		2.09
Government/Institutional Policy	**P1**	**1**	**Output:**	**Negative Impact**	**Positive Impact**
	P2	**1**	Competitive manufacturing end users	-1.66	
	P3	**1**	Employment creation	-0.66	
Economic Growth		**-1**	Efficiency of producer mills		0.27
Infrastructure Investment		**-1**	Growth of the domestic steel industry	-8.50	
			Seaborne export market growth	-1.04	

The steel industry would be impacted negatively under this scenario. Without the stimuli of demand; i.e. economic growth and infrastructure investment, the influence of government or institutional policy intervention would have a futile impact on the growth of the steel industry. The model predicts a decline in employment creation, competitiveness of manufacturing end users and a decline in seaborne export market growth. Other nodes with major negative impacts include; a decrease in inbound-FDI and a decrease in demand for steel and steel consuming products.

5.4.7 *Scenario 6*

The sixth scenario excluded the influence of global induced factors, i.e. increasing steel imports and global steel overcapacity, and within the domestic market excluded the influence of increasing input costs. Under this scenario, the influence of governmental/institutional policy intervention aimed at trade protectionism and trade remedial action through a combination of *tariffs, anti-dumping duties, countervailing measures and safeguards* and *rebates & designation* and *downstream beneficiations & localisation* (P1, P2 and P3) was considered; however, under conditions of economic growth and increasing infrastructure investment by both the private and the public sector (including public corporations).

Table 29: Scenario 6

Governmental/institutional policy interventions aimed at trade protectionism and trade remedial action through a combination of "tariffs, anti-dumping duties, countervailing measures and safeguards", "rebates & designations" and "downstream beneficiation & localisation", but under conditions of economic growth and increasing infrastructure investment					
Cause			**Effect**		
Influential Driver:		**Activated**	**Major Receiver Nodes:**	**Negative Impact**	**Positive Impact**
Increasing Steel Imports		0	Foreign Direct Investment (FDI)		2.94
Chinese Steel Overcapacity		0	Downstream beneficiation & localisation		3.73
Increasing Input Costs		0	Skills improvement		7.14
Government/Institutional Policy	**P1**	**1**	**Output:**	**Negative Impact**	**Positive Impact**
	P2	**1**	Competitive manufacturing end users		5.64
	P3	**1**	Employment creation		9.43
Economic Growth		**1**	Efficiency of producer mills		3.75
Infrastructure Investment		**1**	Growth of the domestic steel industry		16.2
			Seaborne export market growth		7.48

Under this scenario, the amplified FCM model predicted a considerable improvement to the overall growth of the domestic steel industry, including seaborne export market growth. Economic growth and infrastructure investment would stimulate the demand for steel, steel consuming and steel manufactured products which would, as a consequence, induce growth within the sector. The model accordingly predicts growth in inbound-FDI which would subsequently accelerate growth within the sector and stimulate employment creation. The model predicts that the supplementary introduction of government/institutional policy, given conditions of economic growth and increasing infrastructure, would induce outcomes leading to the overall growth of the steel industry.

5.5 Conclusion

This section summarises the discussion of results in Chapter 5 and concluding remarks are made with regards to the propositions.

5.5.1 *Conclusion with regards to Proposition 1*

The results obtained from the survey and presented in Chapter 4 indicated strong causal influences between influential drivers; and by considering the influence of influential drivers on an isolated basis, modelled using the amplified FCM, the consequential negative impact of each influential driver on the overall industry was predicted by the model. The model-simulated overall negative impacts can be correlated to a large extent to the recent decline to the steel industry in South Africa. Table 30 summarises the discussion results with regards to proposition 1, indicating the significant overall negative impact the influential drivers have (or have had) on the steel industry in South Africa.

Table 30: Summary of discussion results – Proposition 1

Summary of discussion results - Proposition 1										
Influential Drivers	**Output Measures**									
	Competitive manufacturing end users		*Employment creation*		*Efficiency of producer mills*		*Growth of the domestic steel industry*		*Seaborne export market growth*	
Increasing Steel Imports	-0.08	Negative	-0.25	Negative	0.02	Positive	0.22	Positive	-0.07	Negative
Increasing Chinese Steel Overcapacity	-0.33	Negative	-0.45	Negative	-0.22	Negative	-0.41	Negative	-0.34	Negative
Increasing Input Costs	-0.77	Negative	-0.59	Negative	-0.71	Negative	-0.86	Negative	-0.43	Negative
Lack of Government/Institutional Policy	-2.35	Extremely Negative	-3.69	Extremely Negative	-1.70	Extremely Negative	-3.58	Extremely Negative	-2.79	Extremely Negative
Subdued/Stagnant Economic Growth	-1.19	Extremely Negative	-2.10	Extremely Negative	-0.31	Negative	-5.35	Extremely Negative	-1.31	Extremely Negative
Declining Infrastructure Investment	-2.21	Extremely Negative	-2.94	Extremely Negative	-1.43	Extremely Negative	-7.00	Extremely Negative	-2.95	Extremely Negative

To reaffirm proposition 1, amongst a number of factors of varying influence and impact, based on the results discussion, the factors of *increasing steel imports*, *Chinese steel overcapacity*, *increasing input costs*, *subdued economic growth*, *inadequate infrastructure investment* and *lack of government/institutional policy* were observed as influential drivers within the steel industry in South Africa.

5.5.2 *Conclusion with regards to Proposition 2*

By creating "what-if" simulation, a number of scenarios were tested using the amplified FCM. A total of six scenarios were considered, based on a brief scenario development guided by criteria as proposed by Wilson (1998). The discussion results are best summarised by grouping them into three main outcomes; "*current-trend outcomes*", "*worst-outcomes*" and "*best-outcomes*" scenarios are tabulated below (Table 31).

Table 31: Summary of discussion results – Proposition 2

Summary of discussion results - Proposition 2										
Scenarios	**Output Measures**									
	Competitive manufacturing end users		*Employment creation*		*Efficiency of producer mills*		*Growth of the domestic steel industry*		*Seaborne export market growth*	
Current-trend outcomes Scenarios										
Scenario 1	***Increasing steel imports, Increasing Chinese overcapacity and Increasing input costs, in a stagnant economy where with decreasing infrastructure investment***									
	-3.38	Extremely Negative	-4.25	Extremely Negative	-2.34	Extremely Negative	-8.05	Extremely Negative	-3.79	Extremely Negative
Worst-outcomes Scenarios										
Scenario 3	***Increasing input costs, under conditions of governmental/institutional policy intervention aimed at trade protectionism through means of only "tariffs, anti-dumping duties, countervailing measures and safeguards"***									
	-0.99	Negative	0.4	Positive	-0.32	Negative	-0.13	Negative	0.21	Positive
Scenario 5	***Governmental/institutional policy interventions aimed at trade protectionism and trade remedial action through a combination of "tariffs, anti-dumping duties, countervailing measures and safeguards" and "rebates & designations" and "downstream beneficiation & localisation", but under conditions of receding economic growth and declining infrastructure investment***									
	-1.66	Extremely Negative	-0.66	Negative	0.27	Positive	-8.5	Extremely Negative	-1.04	Extremely Negative
Best-outcomes Scenarios										
Scenario 2	***Increasing steel imports, Increasing Chinese overcapacity and increasing input costs, under conditions of economic growth and increasing infrastructure investments***									
	2.23	Extremely Positive	3.76	Extremely Positive	0.83	Positive	11.3	Extremely Positive	3.42	Extremely Positive
Scenario 4	***Increasing input costs, under conditions of governmental/institutional policy interventions aimed at trade remedial action through means of only "rebates & designations" and "downstream beneficiation & localisation"***									
	1.7	Extremely Positive	2.8	Extremely Positive	0.92	Positive	2.27	Extremely Positive	2.15	Extremely Positive
Scenario 6	***Governmental/institutional policy interventions aimed at trade protectionism and trade remedial action through a combination of "tariffs, anti-dumping duties, countervailing measures and safeguards", "rebates & designations" and "downstream beneficiation & localisation", but under conditions of economic growth and increasing infrastructure investment***									
	5.64	Extremely Positive	9.43	Extremely Positive	3.75	Extremely Positive	16.2	Extremely Positive	7.48	Extremely Positive

The scenario analysis led to outcomes that can be best grouped under three outcomes:

The **current-trend outcome** scenario correlates to a large extent to conditions under which the steel industry in South Africa currently finds itself. Under this scenario, the industry is negatively impacted by subdued or stagnant economic growth with a decline

or reduction in infrastructure investment (especially within the public sector). The impact of increasing imports, increasing overcapacity in the global steel market and increasing input costs were shown to be significantly impacting the viability and sustainability of the industry. The conditions within the industry were also exacerbated by the fact that no governmental or institutional policy interventions were instituted to protect the industry against the emerging impacts of unfair foreign based competition.

The **worst-outcomes** scenarios depicts plausible scenarios under which government or institutional policy interventions are implemented, but under conditions where either the economy is stagnant or receding; and investment in infrastructure is either not improving or in decline. Under these scenarios, i.e. Scenario 3 and 5, the results indicated that without the stimuli of demand; i.e. economic growth and infrastructure investment, the influence of government or institutional policy interventions would have a futile impact on the prosperity of the industry, irrespective of the type or combination of policy interventions instituted.

The **best-outcomes** scenarios depict plausible scenarios under which there is economic growth and increasing infrastructure investments. Scenario 2 indicated that the impact of influential drivers related to increasing imports, overcapacity and increasing input costs, can all be mitigated against given conditions of economic growth and rapid infrastructure investment, even if government or institutional policy interventions are not instituted. Under prevailing conditions of economic growth and increasing infrastructure investment, the supplementary implementation of government and/or institutional policy interventions are predicted to induce outcomes leading to an overall growth and sustainability within the steel industry, as best modelled under Scenario 6.

Based on the above, to reaffirm proposition 2, it can be stated that the growth and sustainability of the steel industry in South Africa is dependent, not only on policy interventions aimed at controlling the influx of imports or promoting downstream beneficiation and localisation policies, but also more prominently, on measures that would stimulate or induce demand for steel and steel consuming products.

CHAPTER 6. CONCLUSION & RECOMMENDATIONS

6.1 Introduction

This chapter concludes the research by summarising the findings and specific conclusions to the research findings. The conclusions are then followed by a set of recommendations to key stakeholders within the steel industry value chain based on the main findings of this research and on what interventions, measures and ideal set of outcomes that would best position the steel industry in South Africa on a path of growth and sustainability. And lastly, the chapter is concluded by making suggestions for further research.

6.2 Conclusion of the study

The recent developments with the steel industry in South Africa led to the industry's decline in recent years, raising serious concerns and uncertainties about this key industry's viability, casting doubts about its future prosperity and sustainability; as policy makers, businesses and industry leaders grappled to identify and address a range of factors impacting the industry.

Using Fuzzy Cognitive Mapping (FCM) methodology, this research developed an empirical model that represents the steel industry in South Africa taking into account a range of factors that influence and impact on the dynamics of the industry. A two-phased approach was followed in the development of the model, which commenced with the creation of a preliminary model and in the last phase, refined and validated the model to create an amplified FCM model. In the initial phase, literature formed the basis to the modelling of the preliminary FCM, based on gathered data about the steel industry in South Africa, taking into account micro- and macro-economic factors that influence and impact the industry. Literature identified a multitude of factors that are interconnected and can be mapped out, graphically; based on their causal relationships to simulate the influence they have on one another. This literature driven process led to the development of a preliminary FCM model and as part of the model validation process, this preliminary FCM model was subjected to expert review. Subject Matter Experts

(SMEs) were consulted/interviewed using a Delphi Method structured over three rounds of interviews to gather expert opinion and consensus on a wide range of factors required to create a final and validated model. At the end of this process, the preliminary FCM model was refined and slightly remodelled to create a validated model, referred to in this research as the amplified FCM model. This amplified FCM represented a model of the steel industry in South Africa from which a range of scenarios could be tested.

The first sub-problem to this research was to identify key factors (or influential drivers) that are attributable to the recent decline in the steel industry in South Africa and the second sub-problem was to determine which measures or interventions (or which combination of measures or interventions) would be required to address the influential drivers in order to ensure the growth and sustainability of the steel industry. Two propositions were made, one for each sub-problem, and based on empirical results obtained from a number of simulations and scenario analyses; the following were the findings to this research:

To reaffirm proposition 1, the study concluded that amongst a number of factors of varying influence and impact; based on the results obtained, the factors of *increasing steel imports*, *Chinese steel overcapacity*, *increasing input costs*, *subdued economic growth*, *inadequate infrastructure investment* and *lack of government/institutional policy* were observed to be the most influential drivers within the steel industry in South Africa. Modelled on an isolated basis, these factors were observed to have strong causal influences to the recent decline in the steel industry in South Africa.

The impact of the influential drivers were evaluated empirically using a number of scenarios simulations (“what-if” analyses) to test a range of plausible outcomes from which conditions required to ensure a viable and sustainable steel industry in South Africa could be determined. A total of six scenarios were modelled and based on the empirical results, three groups of scenario outcomes were observed; i.e. *current trend outcomes*, *worst-case outcomes* and *best-case outcomes*. Through an analysis of the scenarios representative of the best-case outcomes, proposition 2 was confirmed and measures, interventions and conditions required to ensure the sustainability of the steel industry were identified.

To reaffirm proposition 2, it can be stated that the growth and sustainability of the steel industry in South Africa is dependent not only on policy interventions aimed at controlling the influx of imports or promoting downstream beneficiation and localisation policies, but also more prominently on measures that would stimulate or induce demand for steel and steel consuming products.

6.3 Recommendations

Based on the above findings and conclusions from the research, the following recommendations are made, which are intended not to be proposals to solutions to the current steel crises, but rather to provide guidance when policies are debated, and which measures and interventions to prioritise when decisions are taken.

These recommendations are made to the following key stakeholders within the steel industry value chain; *policy makers* (government and institutional departments), *steel industry associations* and primary and secondary producers. **Appendix F** illustrates a detailed list of these key stakeholders, and others, within the steel value chain.

- **Policy makers (government and institutional departments)**

As the main priority for governmental or institutional departments would be to protect jobs and to provide the legislative and policy framework to ensure that industries are protected and remain as a going concern, the decision to institute trade protectionism and trade remedial policies such as anti-dumping duties, countervailing measures or safeguards; may be considered to be a more trivial solution. This tends to be a rather “quick solution” given the pressure from industry and corporates, with threats of retrenchments and downsizing. Although, the principles behind these measures are in many cases justified, their implementation without any urgent measures aimed at stimulating domestic demand, may have futile consequences. The research provided evidence that the implementation of such policy interventions under conditions of subdued or stagnant economic growth, with declining levels of infrastructure investments may lead to unintended consequences, as the industry may still continue to decline, putting many jobs at risk.

The steel industry value chain spans multiple sectors (as illustrated in Figure 3 of this report) with each sector represented by its own association; hence these recommendations are for the various industry associations:

- **Industry associations**

As the steel industry value chain spans multiple sectors; the complexity of engagement between various sectors, businesses and associations may lead to disparities in views and delays in reaching consensus or lobbying for action from government institutions. The need to communicate in “one voice” is vitally important. Fuzzy Cognitive Mapping used as a methodology for this research provides such a technique that allows for the steel industry to be considered on a holistic basis, rather than in a silo approach which may inherently consists of biased views on a number of factors. As identified during the interview process, the views from upstream industries tend to be fundamentally different to those within downstream industries. Scenario 3 best represented this. Upstream industries (primary and secondary producers) advocate extensively for protectionist measures such as tariffs, anti-dumping duties and safeguards against imported primary steels, as this is vitally important for their sales and profitability. However, the views from downstream industries are different, as these measures somewhat have negative effects, as they tend to induce unfair pricing structures on their businesses, leading ultimately to their uncompetitiveness. The role of collective dialogue is hence vital and the need to communicate as a collective unit is of extreme importance across industry associations.

- **Primary and Secondary Producers**

As much as the trade barriers are favourable to the upstream industries and in particular local operations; the simulations based on the scenarios intrinsically indicate very little influence in achieving efficiencies within operations. To curb the effects of increasing input costs, operations need to be upgraded and/or modernised in order to control more efficiently the costs of production. This would require a firm commitment to investment in operating activities and capital expenditure. The added cost of capital would increase production costs in the short-run; however, in the long run, the marginal costs of production would be significantly reduced. The added benefits to modernisation would

also ensure a reduction in carbon emissions, a reduction in the carbon footprint across plants and ultimately result in the reduction in the organisation's carbon tax liability.

Further applications have been made to ITAC to deliberate on the case of instituting additional safeguard duties against imported steel (Department of Trade and Industry, 2016a). These measures should only be instigated following exhaustive engagement with downstream industries, with regards to the potential impact these interventions would have on competitiveness and the profitability of downstream industries. During the expert interviews, the view expressed by some downstream manufacturing end users, especially the medium to large enterprises, were inclined towards adopting the concept of "best-cost country sourcing" (BCCS) as their procurement strategy. Baldassarre and Campo (2015) define BCCS as a global supply management approach that evaluates a range of factors associated with "best cost" and "best value" sourcing rather than just low-cost country sourcing. This is prompted by; the need to procure steel in countries where they have a comparative advantage over our local producers, the need to source the best quality products at the best cost, the need to avoid bearing the cost for the producer's inefficiencies and the need to ensure security of supply, given the closure of some of our local producer mills (in particular, Evraz Highveld Steel, that predominantly supplies long-products). Hence, the necessity to engage the downstream industries on a consultative basis is of paramount importance.

6.4 Suggestions for further research

During the research process a number of limitation areas were identified which are suggested in this section as possible areas for further research.

- **Scenario Development**

The limited availability of time and constraints related to scheduling appointments limited the ability to create an expert-driven scenario development process. A more intuitive and rational approach was adopted in formulating the scenarios, informed by literature and trends within the steel industry in South Africa based on lobbying efforts by industry associations and established steel committee structures. An ideal scenario development process would have been one that involves the engagement of subject matter experts

(SMEs) as well, ideally in a workshop-type environment. A further research is suggested wherein the scenario development process is also driven by an industry expert-led team.

- **Time-series analysis**

For this research, the scenarios are essentially a cross-sectional analysis of outcomes at a given point in time, based on prevailing conditions. The analyses, however, do not distinguish between short-run and long-run outcomes, but rather considers a specific point in time in future. As an example, the amplified FCM predicted an improvement in efficiency following the modernisation of steel mills. The expert respondents noted that the short-run impact of modernisation would be increased costs; however, the long-run impact would be a reduction in the marginal cost of production. This notion takes into account the effect of time and that some measures or interventions have short-term and long-term effects which may be fundamentally different from one another. A further study could be undertaken to evaluate the impact of various outcomes over certain periods of time in future (e.g. long-range forecasting) rather than at a specific point in future.

- **Restriction in terms of number of nodes (causal relationships)**

The preliminary FCM consisted of 38 nodes or concepts; with a total of 71 causal links or causal relationships amongst the concepts with the final, amplified FCM model consisting of a total of 40 nodes with 84 connections (causal relationships). This was a simplified analysis taking into account a limited number of concepts which were of vital importance. Other nodes/concepts or causal links could have been integrated and explored as well, to create a more exhaustive model. For this research, this was deemed unnecessary as it would have increased the complexity of the analysis and discouraged the expert interviewees; however opportunities for further research exist wherein the FCM model can be expanded to take into account a wide range of other factors.

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APPENDIX A – CONSISTENCY MATRIX

Research Title: The sustainability of the steel industry in South Africa						
Purpose of study: The purpose of this study is to identify factors that impact the steel industry in South Africa and to determine whether there are any key factors (or influential drivers) that have resulted in the recent decline in the industry. Moreover, this study aims to develop an empirical model that represents the industry, allowing for simulations and plausible future scenarios to be tested to identify measures, interventions and outcomes required to ensure the sustainability of the industry						
Main Problem	**Sub-problem**	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Type of data**	**Analysis**
To identify factors that have resulted in the recent decline in the steel industry in South Africa and to determine measures or interventions required to address these factors in order to ensure the growth and sustainability of the industry.	The first sub-problem is to identify key factors (influential drivers) that are attributable to the recent decline in the steel industry in South Africa	**The following are key references**: Edwards & Jenkins, 2015 ResearchChannel, 2016 Kumba, 2011 ArcelorMittal, 2016 SAISI, 2016 Davies, 2015 NationalTreasury, 2016 Comprehensive List of reference included in **Table 5**	Amongst the multitude of factors attributable to the recent decline in the steel industry in South Africa, the following factors are influential drivers; *Increasing Steel Imports*, *Chinese Steel Overcapacity*, *Increasing Input Costs*, *Subdued Economic Growth*, *Inadequate Infrastructure Investment* and *Lack of Government/Institutional Policy*	Data gathered from literature review and validated with data received from actual interviews with Subject Matter Experts	Combination of nominal and ordinal data	Simulations using Fuzzy Cognitive Mapping (FCM)
	The second sub-problem is to determine which measures or interventions would be required to address the influential drivers in order to ensure the growth and sustainability of the steel industry	**The following are key references:** ResearchChannel, 2016 Holloway, Roberts & Rush, 2010 SAISI, 2016 USW, 2016 Brun, 2016 TheDTI, 2016	The growth and sustainability of the steel industry in South Africa is dependent not only on policy interventions but also on measures that would stimulate demand for steel.	Data gathered from literature review and validated with data received from actual interviews with Subject Matter Experts	Combination of nominal and ordinal data	Simulations and Scenario Forecasting using Fuzzy Cognitive Mapping (FCM)

APPENDIX B – RESEARCH INSTRUMENT (1ST ROUND INTERVIEWS)

RESEARCHER'S DETAILS	
Student Name	Tebogo Immaculate Raaleka
Student Number	0407248G
Institution	Wits Business School
Degree	Master of Business Administration (MBA)

Wits Business School
Sculpting global leaders

Good Day **type the name of the expert here**,

My name is Tebogo Immaculate Raaleka, a final year MBA student at the Wits Business School. I have selected you as one of the respondents for my research titled **"The sustainability of the steel industry in South Africa"**. The interview should not be more than **30mins** and all the information supplied will be treated as confidential.

Purpose of the study

The purpose of this study is to identify factors that impact the steel industry in South Africa and to determine whether there are any key factors (or influential drivers) that have resulted in the recent decline in the industry. Moreover, this study aims to develop an empirical model that simulates the industry, allowing for plausible future scenarios to be tested representing conditions required to ensure the sustainability of the industry.

Method for data gathering

The **1st round interviews** will be conducted using a face-to-face interview, in an unstructured discussion format. A **Delphi Method** will be used as a technique to gather data from SMEs. Dalkey and Helmer (1963) describes the objective of the Delphi method as a process of obtaining the most reliable consensus from a **group of experts**, using a series of intensive questionnaires interspersed with controlled **opinion feedback**. The objective of the 1st round interview is to introduce the research and to start the process of validating the **preliminary FCM** which was modelled by the researcher based on current literature on the steel industry in South Africa.

Attachments

The **Preliminary FCM** is attached – to be validated by the expert over a number of 3 rounds of interviews.

Research Questions

1. After your assessent of the preliminary FCM, would you say there are any factors or causal relationships that were not included in the preliminary FCM? If yes, please indicate the factors below:-

…… ……

…… ……

2. Are there any causal relationships or causal links which the preliminary FCM did not define?

…… ……

…… ……

>>>>>>>>>>>>>>>>>> END OF QUESTIONNAIRES <<<<<<<<<<<<<<<<<<

I would like to take this opportunity to thank you for your patience and insightful input into the dynamics of the steel industry in South Africa. Your input is highly valued.

Regards,

Tebogo Raaleka

Student Email: 0407248g@students.wits.ac.za

Contact Number: 078 708 1640

APPENDIX C – RESEARCH INSTRUMENT (2nd ROUND INTERVIEWS)

RESEARCHER'S DETAILS	
Student Name	Tebogo Immaculate Raaleka
Student Number	0407248G
Institution	Wits Business School
Degree	Master of Business Administration (MBA)

Hi **type the name of the expert here**,

Thank you for your time and valued input during the 1st round interview, for my research on the following topic: **"The sustainability of the steel industry in South Africa"**.

This 2nd round interview (questionnaire format) should not take more than **20mins** to complete. There are a total of 84 questions and you answer the questions by simply ticking / selecting the box (☐) to indicate the "*type of incluence on concept has on another",* and then highlighting your percieved "level of influence" (or "degree of influcnce") the concept has on another (from a scale ranging from -1.0 to +1.0, in intervals of 0.25) These steps are further explained below:

Research questionnaires

Step 1: Please respond to the question by selection either a "**negative relationship**" or "**positive relationship**" to each of the line items on the table on the next page. A **+** relationship indicates a "causal increase" and **–** reationship a "causal decrease"

Step 2: Between each concepts indicate the "degree of influence" (or "level of influence") one concept has on the other. Indicate by selecting between the intervals "negatively very strong" to "positively very strong"

Below is an illustrative example:

Question : What influence does "**studying very hard**" have on "**getting a good mark**"?

Concept C_i is "**studying very hard**"

Concept C_j is "**getting a good mark**"

Answer : Your answer would be: there's a **positive relationship** between studying hard and getting a good mark. And your influence would most likely be a **strong positive influence**

You would then **tick** to select your answer and **highlight the block** corresponding to your perceived "level of influence" as follows:

Direction of causality between two factors/concepts		*Type of causal relationship*		*Influence of one concept on another*								
From - C_i	**To - C_j**	**Negative relationship**	**Positive relationship**	**-1.0**	**-0.75**	**-0.5**	**-0.25**	**0**	**+0.25**	**+0.5**	**+0.75**	**+1.0**
Studying very hard	**Getting a good text mark**	☐	☑	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

There is a total of 84 questions as listed below:

	Direction of causality between two factors/concepts		*Type of causal relationship*		*Influence of one concept on another*								
Link No.	**From - C_i**	**To - C_j**	**Negative relationship**	**Positive relationship**	**-1.0**	**-0.75**	**-0.5**	**-0.25**	**0**	**+0.25**	**+0.5**	**+0.75**	**+1.0**
Answer questions from 1 to 80													
1	Increasing Input Costs	Increasing Production Costs	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
2	Increasing Production Costs	Increasing Selling Price of Steel	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
3	Increasing Production Costs	Efficiency of steel mills	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
4	Chinese steel overcapacity	Global oversupply of steel	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
5	Sluggish global economic growth	Global oversupply of steel	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
6	Chinese economic growth	Global oversupply of steel	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
7	Global oversupply of steel	Declining global steel prices	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
8	Increasing steel imports	Increasing trade with China	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
9	Increasing steel imports	Energy supply constraints	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
10	Energy supply constraints	Foreign Direct Investment (FDI)	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
11	Energy supply constraints	Downstream beneficiation & localisation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
12	Declining global steel prices	Downstream beneficiation & localisation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
13	Increasing Selling Price of Steel	Downstream beneficiation & localisation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
14	Modernisation of South African producer mills	Increasing Production Costs	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

15	Access to high grade coking coal	Increasing Production Costs	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
16	Depreciating local currency	Increasing Production Costs	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
17	Reduced logistical costs	Increasing Production Costs	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
18	Economic Activity/Growth	Consumer spending	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
19	Economic Activity/Growth	Business confidence	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
20	Political instability	Business confidence	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
21	Business confidence	Demand for steel and steel consuming products	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
22	Increasing Selling Price of Steel	Demand for steel and steel consuming products	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
23	Consumer spending	Demand for steel and steel consuming products	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
24	Infrastructure Investment	Demand for steel and steel consuming products	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
25	Infrastructure Investment	Increasing Cost of Capital	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
26	Infrastructure Investment	Reduced logistical costs	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
27	Infrastructure Investment	Energy supply constraints	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
28	Government/institutional policy	Tariffs, anti-dumping duties & safeguards	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

29	Government/institutional policy	Unfair pricing practices in the local steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
30	Government/institutional policy	Downstream beneficiation & localisation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
31	Government/institutional policy	Rebates & designation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
32	Tariffs, anti-dumping duties & safeguards	Increasing trade with China	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
33	Rebates & designation	Increasing trade with China	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
34	Rebates & designation	Downstream beneficiation & localisation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
35	Demand for steel and steel consuming products	Foreign Direct Investment (FDI)	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
36	Sluggish global economic growth	Foreign Direct Investment (FDI)	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
37	Increasing Cost of Capital	Foreign Direct Investment (FDI)	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
38	Political instability	Foreign Direct Investment (FDI)	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
39	Foreign Direct Investment (FDI)	Access to high grade coking coal	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
40	Foreign Direct Investment (FDI)	Growth of the domestic steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
41	Foreign Direct Investment (FDI)	Skills improvement	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
42	Demand for steel and steel consuming products	Closure of South African steel mills	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

43	Demand for steel and steel consuming products	Growth of the steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
44	Tariffs, anti-dumping duties & safeguards	Chinese government export subsidies	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
45	Chinese government export subsidies	Chinese economic growth	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
46	Chinese government export subsidies	Closure of South African steel mills	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
47	Chinese government export subsidies	Increasing trade with China	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
48	Closure of South African steel mills	Skills improvement	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
49	Closure of South African steel mills	Employment creation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
50	Closure of South African steel mills	Access to regional overland market growth opportunities	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
51	Closure of South African steel mills	Security of supply	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
52	Increasing trade with China	Downstream beneficiation & localisation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
53	Increasing Cost of Capital	Modernisation of South African producer mills	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
54	Downstream beneficiation & localisation	Modernisation of South African producer mills	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
55	Downstream beneficiation & localisation	Skills improvement	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
56	Downstream beneficiation & localisation	Security of supply	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

57	Downstream beneficiation & localisation	Competitive manufacturing end users	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
58	Downstream beneficiation & localisation	Employment creation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
59	Modernisation of South African producer mills	Capability to produce wide range of products at scale	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
60	Modernisation of South African producer mills	Efficiency of steel mills	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
61	Skills improvement	Employment creation	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
62	Skills improvement	Growth of the steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
63	Skills improvement	Competitive manufacturing end users	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
64	Skills improvement	Structural Competitive advantages	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
65	Unfair pricing practices in the local steel industry	Growth of the steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
66	Unfair pricing practices in the local steel industry	Competitive manufacturing end users	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
67	Unfair pricing practices in the local steel industry	Capability to produce wide range of products at scale	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
68	Capability to produce wide range of products at scale	Security of supply	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
69	Security of supply	Seaborne Export Market growth	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
70	Security of supply	Growth of the steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

71	Reduced logistical costs	Structural Competitive advantages	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
72	Reduced logistical costs	Access to regional overland market growth opportunities	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
73	Reduced logistical costs	Seaborne Export Market growth	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
74	Structural Competitive advantages	Growth of the domestic steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
75	Structural Competitive advantages	Seaborne Export Market growth	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
76	Depreciating local currency	Seaborne Export Market growth	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
77	Depreciating local currency	Access to high grade coking coal	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
78	Access to high grade coking coal	Structural Competitive advantages	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
79	Access to regional overland market growth opportunities	Growth of the domestic steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
80	Increasing Selling Price of Steel	Competitive manufacturing end users	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
81	Closure of South African steel mills	Growth of the domestic steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
82	Tariffs, anti-dumping duties & safeguards	Competitive manufacturing end users	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
83	Closure of South African steel mills	Growth of the domestic steel industry	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong
84	Tariffs, anti-dumping duties & safeguards	Competitive manufacturing end users	☐	☐	Negatively very strong	Negatively strong	Negatively medium	Negatively weak	Zero	Positively weak	Positively medium	Positively strong	Positively very strong

APPENDIX D – RESULTS (2nd ROUND QUESTIONNAIRES)

Table D1

Number of experts confirming the causal link between concepts					
Link No	**From Node - C_i**	**To Node - Cj**	**# Expert respondents**	**# Experts in support of link**	**%**
1	Increasing Input Costs	Increasing Production Costs	10	10	100%
2	Increasing Production Costs	Increasing Selling Price of Steel	10	10	100%
3	Increasing Production Costs	Efficiency of steel mills	10	7	70%
4	Chinese steel overcapacity	Global oversupply of steel	10	10	100%
5	Sluggish global economic growth	Global oversupply of steel	10	10	100%
6	Chinese economic growth	Global oversupply of steel	10	10	100%
7	Global oversupply of steel	Declining global steel prices	10	9	90%
8	Increasing steel imports	Increasing trade with China	10	10	100%
9	Increasing steel imports	Energy supply constraints	10	10	100%
10	Energy supply constraints	Foreign Direct Investment (FDI)	10	10	100%
11	Energy supply constraints	Downstream beneficiation & localisation	10	10	100%
12	Declining global steel prices	Downstream beneficiation & localisation	10	10	100%
13	Increasing Selling Price of Steel	Downstream beneficiation & localisation	10	10	100%
14	Modernisation of South African producer mills	Increasing Production Costs	10	9	90%
15	Access to high grade coking coal	Increasing Production Costs	10	10	100%
16	Depreciating local currency	Increasing Production Costs	10	9	90%
17	Reduced logistical costs	Increasing Production Costs	10	9	90%
18	Economic Activity/Growth	Consumer spending	10	8	80%
19	Economic Activity/Growth	Business confidence	10	10	100%
20	Economic Activity/Growth	Depreciating local currency	10	10	100%
21	Political instability	Business confidence	10	10	100%
22	Business confidence	Demand for steel and steel consuming products	10	10	100%

23	Increasing Selling Price of Steel	Demand for steel and steel consuming products	10	10	100%
24	Consumer spending	Demand for steel and steel consuming products	10	10	100%
25	Infrastructure Investment	Demand for steel and steel consuming products	10	10	100%
26	Infrastructure Investment	Increasing Cost of Capital	10	10	100%
27	Infrastructure Investment	Reduced logistical costs	10	9	90%
28	Infrastructure Investment	Energy supply constraints	10	10	100%
29	Government/institutional policy	Tariffs, anti-dumping duties & safeguards	10	10	100%
30	Government/institutional policy	Unfair pricing practices in the local steel industry	10	9	90%
31	Government/institutional policy	Downstream beneficiation & localisation	10	9	90%
32	Government/institutional policy	Rebates & designation	10	10	100%
33	Tariffs, anti-dumping duties & safeguards	Increasing trade with China	10	10	100%
34	Rebates & designation	Increasing trade with China	10	10	100%
35	Rebates & designation	Downstream beneficiation & localisation	10	10	100%
36	Demand for steel and steel consuming products	Foreign Direct Investment (FDI)	10	10	100%
37	Sluggish global economic growth	Foreign Direct Investment (FDI)	10	10	100%
38	Increasing Cost of Capital	Foreign Direct Investment (FDI)	10	10	100%
39	Political instability	Foreign Direct Investment (FDI)	10	10	100%
40	Political instability	Depreciating local currency	10	10	100%
41	Foreign Direct Investment (FDI)	Access to high grade coking coal	10	10	100%
42	Foreign Direct Investment (FDI)	Growth of the domestic steel industry	10	10	100%
43	Foreign Direct Investment (FDI)	Skills improvement	10	10	100%
44	Demand for steel and steel consuming products	Closure of South African steel mills	10	10	100%
45	Demand for steel and steel consuming products	Growth of the steel industry	10	10	100%
46	Tariffs, anti-dumping duties & safeguards	Chinese government export subsidies	10	7	70%
47	Chinese government export subsidies	Chinese economic growth	10	10	100%
48	Chinese government export subsidies	Closure of South African steel mills	10	10	100%
49	Chinese government export subsidies	Increasing trade with China	10	10	100%
50	Closure of South African steel mills	Skills improvement	10	10	100%

51	Closure of South African steel mills	Employment creation	10	10	100%
52	Closure of South African steel mills	Access to regional overland market growth opportunities	10	10	100%
53	Closure of South African steel mills	Security of supply	10	10	100%
54	Increasing trade with China	Downstream beneficiation & localisation	10	10	100%
55	Increasing Cost of Capital	Modernisation of South African producer mills	10	10	100%
56	Downstream beneficiation & localisation	Modernisation of South African producer mills	10	9	90%
57	Downstream beneficiation & localisation	Skills improvement	10	10	100%
58	Downstream beneficiation & localisation	Security of supply	10	10	100%
59	Downstream beneficiation & localisation	Competitive manufacturing end users	10	10	100%
60	Downstream beneficiation & localisation	Employment creation	10	10	100%
61	Modernisation of South African producer mills	Capability to produce wide range of products at scale	10	10	100%
62	Modernisation of South African producer mills	Efficiency of steel mills	10	10	100%
63	Skills improvement	Employment creation	10	10	100%
64	Skills improvement	Growth of the steel industry	10	10	100%
65	Skills improvement	Competitive manufacturing end users	10	10	100%
66	Skills improvement	Structural Competitive advantages	10	10	100%
67	Unfair pricing practices in the local steel industry	Growth of the steel industry	10	9	90%
68	Unfair pricing practices in the local steel industry	Competitive manufacturing end users	10	10	100%
69	Unfair pricing practices in the local steel industry	Capability to produce wide range of products at scale	10	10	100%
70	Capability to produce wide range of products at scale	Security of supply	10	10	100%
71	Security of supply	Seaborne Export Market growth	10	10	100%
72	Security of supply	Growth of the steel industry	10	10	100%
73	Reduced logistical costs	Structural Competitive advantages	10	10	100%
74	Reduced logistical costs	Access to regional overland market growth opportunities	10	10	100%
75	Reduced logistical costs	Seaborne Export Market growth	10	10	100%
76	Structural Competitive advantages	Growth of the domestic steel industry	10	10	100%
77	Structural Competitive advantages	Seaborne Export Market growth	10	10	100%
78	Depreciating local currency	Seaborne Export Market growth	10	10	100%

79	Depreciating local currency	Access to high grade coking coal	10	10	100%
80	Access to high grade coking coal	Structural Competitive advantages	10	10	100%
81	Access to regional overland market growth opportunities	Growth of the domestic steel industry	10	10	100%
82	Increasing Selling Price of Steel	Competitive manufacturing end users	10	10	100%
83	Closure of South African steel mills	Growth of the domestic steel industry	10	10	100%
84	Tariffs, anti-dumping duties & safeguards	Competitive manufacturing end users	10	10	100%

Table D2

Level (or degree) of influence concept C_i has on concept C_j										
Link No	**# 1**	**# 2**	**# 3**	**# 4**	**# 5**	**# 6**	**# 7**	**# 8**	**# 9**	**# 10**
1	1.00	1.00	0.75	1.00	1.00	1.00	0.75	1.00	1.00	0.75
2	1.00	1.00	0.50	0.50	0.50	1.00	0.50	1.00	0.50	0.50
3	**X**	-0.75	-0.50	-0.25	**X**	-0.50	-0.50	-0.75	**X**	-0.50
4	0.75	1.00	0.75	1.00	1.00	0.75	0.75	0.75	1.00	0.75
5	0.75	0.75	0.50	0.75	0.75	0.75	1.00	0.75	1.00	0.75
6	1.00	0.75	0.75	-0.75	1.00	-0.50	0.75	-0.75	-0.50	-0.50
7	1.00	**X**	0.50	0.75	0.75	0.50	0.75	0.75	0.75	0.75
8	0.75	0.50	0.50	0.75	0.75	0.75	0.75	0.50	0.75	0.75
9	-0.50	-0.50	-0.50	-0.25	-0.25	-0.50	-0.75	-0.50	-0.50	-0.50
10	-1.00	-0.75	-0.50	-0.75	-1.00	-0.75	-0.75	-0.75	-0.75	-0.50
11	-1.00	-0.75	-0.50	-0.75	-0.50	-0.50	-0.75	-0.50	-0.50	-0.50
12	-1.00	-0.75	-0.50	-0.50	-0.50	-0.75	-0.50	-0.75	-0.50	-0.50
13	-0.75	-0.75	-0.50	-0.25	-0.50	-0.50	-0.50	-0.75	-0.50	-0.50
14	-0.75	0.50	0.25	-0.75	0.50	-0.50	-0.75	-0.75	**X**	-0.50
15	0.50	-0.50	-0.50	-0.75	-0.50	-0.50	-0.50	-0.25	-0.75	-0.50
16	**X**	0.75	0.50	0.50	0.75	0.50	0.50	0.75	0.50	0.50
17	**X**	-0.50	-0.75	-0.50	-0.50	-0.50	-0.75	-0.50	-0.50	-0.50
18	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.50	**X**	**X**
19	1.00	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	1.00
20	-0.25	-0.50	-0.25	-0.50	-0.25	-0.50	-0.25	-0.25	-0.25	-0.50
21	-1.00	-0.75	-0.50	-1.00	-1.00	-1.00	-0.50	-1.00	-1.00	-0.75
22	1.00	0.75	0.75	0.75	0.75	0.50	0.75	0.75	0.50	0.75
23	-1.00	-0.50	-0.25	-0.25	-0.25	-0.75	-0.50	-0.25	-0.25	-0.25
24	1.00	0.75	0.50	0.75	0.75	0.75	0.75	1.00	0.75	0.50
25	1.00	0.75	0.75	1.00	1.00	1.00	0.75	1.00	0.75	1.00
26	-0.50	-0.50	-0.50	-0.50	-0.25	-0.25	-0.50	-0.50	-0.75	-0.50
27	**X**	0.50	0.50	0.50	0.75	0.50	0.50	0.75	0.50	0.50
28	-0.75	-0.75	-0.50	-0.50	-0.75	0.25	0.50	-0.75	-0.75	-0.50

29	0.75	0.75	0.50	0.75	0.75	0.50	0.75	1.00	1.00	0.75
30	-0.75	**X**	-0.25	-0.50	-0.50	-0.50	0.75	0.50	-0.50	-0.50
31	**X**	1.00	0.75	1.00	1.00	1.00	0.75	1.00	1.00	0.50
32	1.00	0.75	0.75	1.00	1.00	0.75	1.00	0.75	0.75	0.75
33	-1.00	-0.50	-0.25	-0.75	-0.50	-0.75	-0.50	-0.50	-0.50	-0.50
34	-1.00	-0.50	-0.50	-0.75	-0.50	-0.50	-0.75	-0.50	-0.75	-0.50
35	0.75	0.75	0.75	0.75	0.25	0.75	0.75	0.50	0.75	0.25
36	0.75	1.00	0.75	0.75	0.75	0.75	0.75	1.00	0.75	1.00
37	-1.00	-0.75	-0.50	-0.50	-0.50	-0.25	-0.50	-0.75	-0.50	-0.50
38	-1.00	-0.50	-0.75	-0.75	-0.75	-0.75	-0.75	-0.50	-0.75	-0.50
39	-1.00	-0.75	-0.75	-1.00	-1.00	-1.00	-1.00	-1.00	-0.75	-0.75
40	0.50	0.25	0.50	0.25	0.25	0.50	0.25	0.50	0.25	0.25
41	1.00	-0.50	0.50	0.50	0.25	0.50	0.50	0.75	0.50	0.50
42	1.00	0.75	0.75	0.75	1.00	0.75	0.75	0.75	0.50	0.50
43	1.00	0.75	0.75	0.75	0.75	0.75	0.50	0.75	0.75	0.50
44	-1.00	-0.50	-0.75	-0.75	-0.75	-1.00	-1.00	-0.75	-0.75	-0.75
45	1.00	0.75	0.75	1.00	1.00	1.00	1.00	1.00	1.00	0.75
46	-1.00	-0.50	-0.75	-0.25	**X**	-0.25	-0.25	**X**	-0.25	**X**
47	1.00	0.50	0.50	-0.25	0.50	0.75	0.75	0.50	0.50	0.50
48	1.00	0.75	-0.50	0.25	0.25	0.50	0.50	0.50	0.50	0.25
49	1.00	0.75	0.50	0.50	0.50	0.75	0.50	0.50	1.00	0.50
50	-1.00	-1.00	-0.75	-1.00	-0.50	-1.00	-1.00	-1.00	0.75	-0.50
51	-1.00	-1.00	-0.75	-1.00	-1.00	-1.00	-0.75	-1.00	-0.50	-1.00
52	-1.00	-1.00	-0.75	-0.75	-0.75	-0.75	-0.75	-0.50	-0.75	-0.75
53	-1.00	-0.50	-0.50	-0.75	-0.50	-0.50	-0.50	-0.75	-0.75	-0.50
54	-1.00	-0.75	-0.75	-0.50	-1.00	-0.75	-1.00	-0.75	-0.75	-0.75
55	-0.75	-0.75	-0.50	-0.75	-0.50	-0.50	-0.75	-0.50	-0.50	-0.50
56	1.00	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.25	0.50
57	1.00	0.75	0.75	0.75	1.00	0.75	0.75	0.75	0.75	0.75
58	1.00	0.75	0.50	0.75	0.75	0.50	0.75	0.75	0.75	0.50
59	1.00	0.75	0.75	0.50	0.25	0.25	0.50	0.50	0.50	0.50
60	1.00	1.00	0.75	1.00	1.00	0.75	0.75	1.00	1.00	1.00
61	1.00	0.75	0.75	1.00	0.75	0.50	0.75	0.75	0.75	0.75
62	1.00	0.50	0.75	1.00	1.00	1.00	1.00	0.75	0.50	1.00
63	1.00	0.50	0.75	0.75	0.50	0.50	0.75	0.50	0.50	0.50
64	1.00	0.75	0.50	0.50	0.25	0.50	0.25	0.50	0.25	0.25
65	1.00	0.50	0.75	0.50	0.50	0.75	0.50	0.50	0.50	0.50
66	1.00	0.75	0.75	0.50	0.50	0.75	0.75	0.50	0.50	0.50
67	-1.00	**X**	-0.50	-0.50	-0.50	-0.50	-0.75	-0.50	-0.50	-0.25
68	-0.75	-0.50	-0.75	-0.50	-1.00	-0.75	-0.75	-0.75	-0.75	-0.50
69	-0.50	-0.50	-0.75	-0.25	-0.25	-0.25	-0.50	-0.25	-0.50	-0.25

70	1.00	0.50	0.50	0.75	0.75	0.75	0.75	0.50	0.75	0.75
71	0.75	0.75	0.50	0.75	0.75	0.75	1.00	1.00	0.75	0.75
72	0.75	0.75	0.75	0.50	0.50	0.75	0.75	0.50	0.75	0.50
73	0.75	0.50	0.75	0.75	0.75	1.00	0.50	0.50	0.75	0.75
74	0.75	0.75	0.75	0.75	0.50	0.75	0.75	0.75	1.00	0.75
75	0.75	0.50	0.50	0.50	0.75	0.50	0.50	0.50	0.50	0.25
76	0.75	0.50	0.75	0.75	0.75	0.50	0.50	0.50	0.50	0.50
77	0.75	0.75	0.50	0.50	0.50	0.75	0.50	0.75	0.50	0.75
78	0.75	0.50	0.25	0.75	0.50	0.50	0.75	0.50	0.50	0.50
79	-1.00	-0.50	-0.50	-0.75	-0.50	-0.75	-0.75	-0.50	-0.50	-0.50
80	0.75	0.75	0.50	0.50	0.25	0.25	0.50	0.50	0.50	0.50
81	1.00	0.75	0.50	0.75	0.75	0.50	0.75	0.50	0.75	0.75
82	-0.75	-0.75	-0.50	-0.75	-0.25	-0.75	-0.75	-0.50	-0.25	-0.75
83	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-0.75	-0.75	-0.75
84	-0.50	-0.75	-0.50	-0.50	-0.25	-0.50	-0.25	-0.50	-0.25	-0.50

Table D3

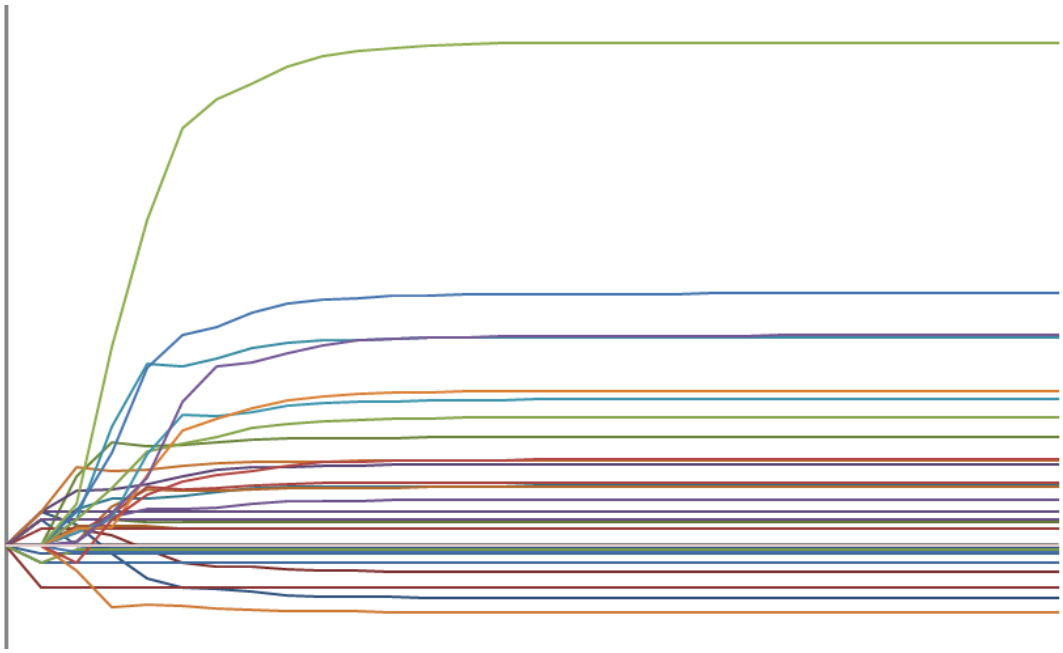
Level (or degree) of influence concept C_i has on concept C_j												
Link No	**-1**	**-0.75**	**-0.5**	**-0.25**	**0**	**0.25**	**0.5**	**0.75**	**1.00**	**Maximum**	**2/3 Majority**	**Degree**
1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	70.0%	70.0%	Yes	**1.00**
2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	0.0%	40.0%	60.0%	Yes	**0.50**
3	0.0%	28.6%	57.1%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	57.1%	No	**-0.50**
4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	40.0%	60.0%	Yes	**0.75**
5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	70.0%	20.0%	70.0%	Yes	**0.75**
6	0.0%	20.0%	30.0%	0.0%	0.0%	0.0%	0.0%	30.0%	20.0%	30.0%	No	
7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.2%	66.7%	11.1%	66.7%	Yes	**0.75**
8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	70.0%	0.0%	70.0%	Yes	**0.75**
9	0.0%	10.0%	70.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	Yes	**-0.50**
10	20.0%	60.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.75**
11	10.0%	30.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
12	10.0%	30.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
13	0.0%	30.0%	60.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
14	0.0%	44.4%	22.2%	0.0%	0.0%	11.1%	22.2%	0.0%	0.0%	44.4%	No	
15	0.0%	20.0%	60.0%	10.0%	0.0%	0.0%	10.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%	33.3%	0.0%	66.7%	Yes	**0.50**
17	0.0%	22.2%	77.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	77.8%	Yes	**-0.50**

18	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%	50.0%	37.5%	50.0%	No	
19	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	70.0%	70.0%	Yes	**1.00**
20	0.0%	0.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.25**
21	60.0%	20.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-1.00**
22	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	70.0%	10.0%	70.0%	Yes	**0.75**
23	10.0%	10.0%	20.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.25**
24	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	60.0%	20.0%	60.0%	Yes	**0.75**
25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	40.0%	60.0%	60.0%	Yes	**1.00**
26	0.0%	10.0%	70.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	Yes	**-0.50**
27	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	77.8%	22.2%	0.0%	77.8%	Yes	**0.50**
28	0.0%	50.0%	30.0%	0.0%	0.0%	10.0%	10.0%	0.0%	0.0%	50.0%	No	
29	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	60.0%	20.0%	60.0%	Yes	**0.75**
30	0.0%	11.1%	55.6%	11.1%	0.0%	0.0%	11.1%	11.1%	0.0%	55.6%	No	
31	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.1%	22.2%	66.7%	66.7%	Yes	**1.00**
32	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	40.0%	60.0%	Yes	**0.75**
33	10.0%	20.0%	60.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
34	10.0%	30.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
35	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	10.0%	70.0%	0.0%	70.0%	Yes	**0.75**
36	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	30.0%	70.0%	Yes	**0.75**
37	10.0%	20.0%	60.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
38	10.0%	60.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.75**
39	60.0%	40.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-1.00**
40	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	40.0%	0.0%	0.0%	60.0%	Yes	**0.25**
41	0.0%	0.0%	10.0%	0.0%	0.0%	10.0%	60.0%	10.0%	10.0%	60.0%	Yes	**0.50**
42	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	60.0%	20.0%	60.0%	Yes	**0.75**
43	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	70.0%	10.0%	70.0%	Yes	**0.75**
44	30.0%	60.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.75**
45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	70.0%	70.0%	Yes	**1.00**
46	14.3%	14.3%	14.3%	57.1%	0.0%	0.0%	0.0%	0.0%	0.0%	57.1%	No	
47	0.0%	0.0%	0.0%	10.0%	0.0%	0.0%	60.0%	20.0%	10.0%	60.0%	Yes	**0.50**
48	0.0%	0.0%	10.0%	0.0%	0.0%	30.0%	40.0%	10.0%	10.0%	40.0%	No	
49	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	20.0%	20.0%	60.0%	Yes	**0.50**
50	60.0%	10.0%	20.0%	0.0%	0.0%	0.0%	0.0%	10.0%	0.0%	60.0%	Yes	**-1.00**
51	70.0%	20.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	Yes	**-1.00**

52	20.0%	70.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	Yes	**-0.75**
53	10.0%	30.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
54	30.0%	60.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.75**
55	0.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
56	0.0%	0.0%	0.0%	0.0%	0.0%	11.1%	77.8%	0.0%	22.2%	77.8%	Yes	**0.50**
57	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	80.0%	20.0%	80.0%	Yes	**0.75**
58	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	60.0%	10.0%	60.0%	Yes	**0.75**
59	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	50.0%	20.0%	10.0%	50.0%	No	
60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	70.0%	70.0%	Yes	**1.00**
61	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	70.0%	20.0%	70.0%	Yes	**0.75**
62	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	20.0%	60.0%	60.0%	Yes	**1.00**
63	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	30.0%	10.0%	60.0%	Yes	**0.50**
64	0.0%	0.0%	0.0%	0.0%	0.0%	40.0%	40.0%	10.0%	10.0%	40.0%	No	
65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	20.0%	10.0%	70.0%	Yes	**0.50**
66	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	40.0%	10.0%	50.0%	No	
67	11.1%	11.1%	66.7%	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%	Yes	**-0.50**
68	10.0%	60.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.75**
69	0.0%	10.0%	40.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	No	
70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	60.0%	10.0%	60.0%	Yes	**0.75**
71	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	70.0%	20.0%	70.0%	Yes	**0.75**
72	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	40.0%	60.0%	0.0%	60.0%	Yes	**0.75**
73	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	60.0%	10.0%	60.0%	Yes	**0.75**
74	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	80.0%	10.0%	80.0%	Yes	**0.75**
75	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	70.0%	20.0%	0.0%	70.0%	Yes	**0.50**
76	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	40.0%	0.0%	60.0%	Yes	**0.50**
77	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	50.0%	No	
78	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	60.0%	30.0%	0.0%	60.0%	Yes	**0.50**
79	10.0%	30.0%	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**
80	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	60.0%	20.0%	0.0%	60.0%	Yes	**0.50**
81	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	60.0%	10.0%	60.0%	Yes	**0.75**
82	0.0%	60.0%	20.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.75**
83	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	Yes	**-1.00**
84	0.0%	10.0%	60.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.0%	Yes	**-0.50**

APPENDIX E – TEST FOR STABILITY AND CONVERGENCE FOR THE AMPLIFIED FCM MODEL

TEST FOR STABILITY AND CONVERGENCE OF AMPLIFIED FCM SIMULATION MODEL									
	Increasing Production Costs	Increasing Selling Price of steel	Global oversupply of steel	Sluggish global economic growth	Chinese economic growth	Declining global steel prices	Increasing trade with China	Energy supply constraints	Foreign Direct Investment
Steady State	-1.554	-0.777	0.680	0.000	-0.094	0.510	-0.094	-1.250	3.193
	Downstream beneficiation & localisation	Modernisation of SA mills	Access to high grade coking coal	Depreciating local currency	Reduced logistical costs	Consumer spending	Business confidence	Political instability	Demand for steel/steel products
Steady State	2.392	1.758	1.721	-0.250	0.500	0.750	1.000	0.000	2.507
	Increasing cost of capital	Tariffs, anti-dumping & safeguards	Unfair pricing practices	Rebates & designation	Skills improvement	Closure of SA mills	Chinese gov. export subsidies	Access to regional overland market opportunities	Security of supply
Steady State	-0.500	0.750	-0.125	0.750	6.162	-1.974	-0.188	1.855	3.793
			Capability to produce range of production	Structural competitive advantages	COMPETITIVE MANFACTURING END USERS	EMPLOYMENT CREATION	EFFECIENCY OF STEEL MILLS	GROWTH OF THE DOMESTIC STEEL INDUSTRIES	SEABORNE EXPORT MARKET GROWTH
Steady State			1.350	4.317	4.578	7.446	2.535	14.873	6.207



APPENDIX F – LIST OF KEY STAKEHOLDERS WITHIN THE SOUTH AFRICAN STEEL VALUE CHAIN

Key Stakeholders within the South African Steel Industry Value Chain	
Industry Associations	
Acronym	**Full Name**
SAISI	South African Iron and Steel Institute
SAISC	Southern African Institute of Steel Construction
SEIFSA	Steel and Engineering Industries Federation of South Africa
ISF	International Steel Fabricators
POLASA	Powerline Association of South Africa
SAMCRA	Southern African Metal Cladding and Roofing Association
STEASA	Steel Tube Export Association of South Africa
SASFA	Southern African Light Steel Frame Building Association
ASTPM	Association of Steel Tube and Pipe Manufacturers
NAACM	National Association of Automotive Components and Allied Manufacturers of South Africa
MRA	Metal Recyclers Association of South Africa
ECSA	Engineering Council of South Africa
Government and Institutional Bodies	
DTI	Department of Trade and Industry
ITAC	International Trade Administration Commission of South Africa
SACU	South African Customs Union
NEDLAC	National Economic Development and Labour Council
Trade Unions	
NUMSA	National Union of Metalworkers of South Africa
COSATU	Congress of South African Trade Union
NUM	National Union of Mineworkers
NEASA	National Employers' Association of South Africa
Steel Producer Mills of South Africa	
AMSA	ArcelorMittal South Africa
EVRAZ	Evraz Highveld Steel
SCAW	Scaw Metals
	Columbus Steel
	Cape Gate
Steel Merchants and Steel Traders & Stockists (*list of only major merchants*)	
Macsteel Services Centres South Africa	
Aveng Trident Steel	
BSI Steel	
Stewards & Lloyds	
Allied Steelrode	
NJR Steel	
****This is not an exhaustive list - only shows a few key stakeholders*	