Crossing the innovation chasm in the South African ferroalloy industry

FC Hannemann

orcid.org 0000-0003-4068-5836

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

Supervisor: Mr. JC Coetzee

Graduation: May 2020

Student number: 28297970

ABSTRACT

Exploratory research and an empirical study were conducted to define the perceived variables that affect the rate of technology adoption and increase the likelihood of successful innovation diffusion within the South African ferroalloy industry. This objective was framed within the context of crossing the innovation chasm into the mainstream market. The cardinal variables that have the greatest effect in persuading potential adopters to adopt a given technology early in the diffusion process were identified, thereby creating the conditions for the technology product to successfully cross the innovation chasm.

From the research, the factors “relative advantage,” “result demonstrability” and “ease of use” were found to be the most important and strategic characteristics that should be communicated to potential adopters with the aim of increasing the rate of innovation diffusion and technology adoption.

Three new adopter types emerged from the research pertaining to the degree of personal innovativeness of adopters. “Eager innovators” and “innovative leaders” were found to be the ideal market segment for a targeted marketing campaign, due to their inherent willingness to change and ability to influence adoption decisions within the industry.

Key terms: diffusion of innovations, perceived attributes of innovation, perceived characteristics of innovating, rate of adoption, chasm theory, personal innovativeness, adopter categories, metals, ferroalloys

ACKNOWLEDGEMENTS

The last several years have been very challenging for me for a variety of reasons, particularly punctuated with serious health challenges. I am eternally thankful for the opportunity to fight through the obstacles, keep going and ultimately complete my studies despite these difficulties. I am weary, but I have completed this part of the race at least.

I would like to thank the following people who played a key role during this period in my life, helped me with my studies and played a part in making this document a reality:

(i) My mother for teaching me never to give up despite what the world throws at you and for somehow scraping the money together to pay for my first degree;

(ii) Dr. Marc Meyer for his ongoing excellent chiropractic treatment which kept my body in check;

(iii) Dr. Crista Janse van Rensburg for her novel and open-minded approach towards treating my auto-immune conditions;

(iv) My employer for giving me the opportunity and means to study, and more specifically Mr. Thomas Kingsley for his ongoing support and maturity in striking an effective balance between my work commitments, studies and health;

(v) Prof. Lotriet who actively supported me to complete my studies, challenged me not to give up and encouraged me to avoid further postponement when I was at my lowest point; and

(vi) Mr. Johannes Coetzee, my study leader, for his ongoing feedback and support.

This work is dedicated to my children, Daniel, Mikayla and Evan: “Pappa is baie lief vir julle en ek is baie trots op julle.”

Finally, none of this would have been possible without my beautiful wife’s ongoing and unwavering support. Our marriage has truly been tested and refined, for better and for worse, for richer and for poorer, in sickness and in health. You are the love of my life and the most wonderful mother any man can hope to have for our children. Thank you. I love you.

“Where can I go from Your spirit? Or where can I flee from Your presence? If I ascend into heaven, You are there; If I make my bed in hell, behold, You are there. If I take the wings of the morning, And dwell in the uttermost parts of the sea, Even there Your hand shall lead me, And Your right hand shall hold me.”

Psalm 139:7-10

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND DEFINITIONS

CSR	Corporate Social Responsibility
CAGR	Compound Annual Growth Rate
EFA	Exploratory Factor Analysis
Eskom	South African public electricity utility
GDP	Gross Domestic Product
FAPA	Ferro Alloy Producers' Association
JSE	Johannesburg Stock Exchange
KIC	Key Industrial Consumer
MCSA	Minerals Council of South Africa (formerly the Chamber of Mines of South Africa)
NDP	National Development Plan
PCI	Perceived Characteristics of Innovating
PE Ratio	Price to Earnings Ratio
R&D	Research and Development
SSA	Sub-Saharan Africa
TAM	Technology Acceptance Model

CHAPTER 1

ORIENTATION AND PROBLEM STATEMENT

1.1 INTRODUCTION

"The rate of change is not going to slow down anytime soon. If anything, competition in most industries will probably speed up even more in the next few decades."
(Kotter, 1996).

The concept that all things are in flux, that change is truly the only constant, was first introduced by the Greek philosopher Heraclitus approximately 2 500 years ago. This premise still holds true in our modern inter-connected world, with the rate of change increasing as technology companies contend to innovate and adapt their offerings to cater to increasing customer demands. Modern producers strive not only to maximise profit, but also to create value for their shareholders and to ensure that their operations are sustainable in the long term. These forces culminate in the concept of corporate social responsibility (CSR) with forward-thinking producers striving to conduct operations with due consideration to all the pillars of the 4P business model, namely profit, planet, people and purpose, thereby redefining outdated measures of success. Therefore, aligning internal operations with these equivalent goals of achieving financial profit, complying with changing environmental legislation, integrating with local communities and conducting operations according to a mandated mission and vision are intended to guarantee wealth creation and sustainability (Enderle, 2009:284,292-293; Lane & Beier, 2015:1; Whitchurch, 2016:223–224).

For producers to achieve these lofty goals, innovation coupled with the willingness to change existing business systems, operating principles and processes are crucial for long-term sustainability and will facilitate a transition from the realms of mere profit acquisition or redistribution towards genuine wealth creation. Moreover, it is imperative for producers to implement innovative ideas and adopt new technologies and products to better navigate modern pressures and ultimately gain competitive advantage in the marketplace. Producers and individuals who are not willing to change, face being left behind in the wake of their competition (Johnson, 2015; Lane & Beier, 2015:1; Whyle, 2016).

Furthermore, innovation and the adoption of new technologies are key drivers for the advancement and improvement of society at large. Innovative approaches to problems and more effective use of finite resources promise ever-increasing gains in efficiency and productivity. As early humans transitioned away from the stone age, not due to a lack of stones, but in order to find better ways of doing things, so our modern world has recognised the need for innovation and its potential to unlock competitive advantage (Johnson, 2015).

Moreover, it is understood and accepted that change is non-linear, often unpredictable and accelerating at a rapid pace in today's business environment. Compounding this uncertainty, the notion of disruptive innovation has received much traction in literature as a driver of radical change in industrial and commercial settings alike. The end result is that the rate of change is now very rapid, with producers and industry as a whole being forced to embrace positive change or risk losing market share and being leap-frogged by their competitors (Goldsmith & Balash, 2014:33).

1.2 CONTEXT

In keeping with the theme of corporate social responsibility, the Minerals Council of South Africa (MCSA) has identified the strategic need to make mining and metals operations more sustainable in South Africa through promoting community development, an acceptance of ongoing operations and a drive towards innovation through increased research and development (R&D) funding. Therefore, stimulating innovation in the sector is a long-term strategic goal for the MCSA with the aim of unlocking the full potential of industry, thereby creating an environment that is conducive to direct foreign investment by "creating the mines of tomorrow." This initiative of next generation mining, which can only be unlocked through innovation, has been hailed as a solution to improve productivity and to reduce cost pressures on South African producers while also uplifting the local economy (Baxter, 2016:38; Jamasmie, 2013:2; Mineral council of South Africa, 2018a:7-9,77).

South Africa is blessed with an abundance of natural resources. With reference to various metal commodities, extraction is ongoing and currently economically feasible at large scale for, amongst others, aluminium, chrome, iron, gold, manganese, platinum, silver and vanadium. The South African metals sector is a world leader in terms of the volume of supply of these commodities to the international market, whether in the form of raw ore, refined alloy products or as a base metal product (Mineral council of South Africa, 2018a; PWC, 2017:7-13).

This study focuses on technology adoption in the ferroalloy sector of the South African mining and metals industry. More specifically, the focus is on production units associated with the final alloy product, which include all pyrometallurgical processes, product handling and recovery units at the back end of the overall product value chain. Therefore, the rate of technology adoption will be considered at plants that typically include any combination of pelletising, sintering, smelting and metal recovery units, with these units typically co-located within the same site to simplify logistics. These operational units are more complex and more challenging to operate from a process control perspective and are also more highly instrumented than the upstream mining, extraction and beneficiation processes. Therefore, continuous improvement and ongoing technology adoption are key success factors at these sites and should be of particular interest. This collective focus area will henceforth be referred to as the ferroalloy industry.

1.3 CAUSAL FACTORS

A large body of literature exists around innovation in general and more specifically the diffusion of innovation and adoption of new technologies. Furthermore, much literature is available around the general state of innovation, including critiques on the perceived slow rate of adoption of new technology within the mining and metals sector (Bass, 1969; Christensen, 2016; Moore, 2014; Rogers, 2003).

However, the literature lacks research around the factors that influence the rate of adoption of new technology within the South African ferroalloy sector. The causal factors that form the basis for this study are as follows:

(i) The MCSA has identified the need to create a successful mining and metals sector by implementing 'next generation mining' through innovation (Baxter, 2016:38);

(ii) There is growing and increased awareness in the broader metals community around the imperative to innovate within the industry (Leach, 2014);

(iii) Limited research has been conducted on the actual drivers of technology adoption within the South African ferroalloy sector (Monitor Deloitte, 2016:12); and

(iv) Limited research has been conducted to define typical technology adopter profiles within the South African ferroalloy sector.

The combination of these factors provides a compelling justification for further study on innovation diffusion within the South African ferroalloy sector, specifically given that producers face being left behind in the wake of increasing international competition without deliberate strategic changes.

1.4 IMPORTANCE OF THIS STUDY

The study of factors that influence the rate of technology adoption within the South African ferroalloy sector is primarily necessary due to limited literature on the subject within the geography and market. Secondly, this study focuses on subject matter that is fundamentally significant for South Africa as a whole, given the importance of the economic, social and environmental imperatives around the topic of innovation. Therefore, the study sets out to add to the literature regarding the diffusion of innovations in support of the imperatives described below.

As an example of the impact that the mining and metals industry can have, the upturn in the commodity price cycle from 2001 to 2011 led to a commodity price boom in Australia, which allowed the country to increase its living standards by 10% due to the associated rise in national income. Similarly, the economies of Indonesia and many other Asia-Pacific economies also benefited from this boom in prices. Therefore, maintaining a healthy metals industry provides real and tangible benefits to communities and countries (Koukoulas, 2015).

1.4.1 Social and environmental imperatives

The mining and metals industry is inherently dangerous and associated with extreme hazards, with workers often exposed to serious risks during their routine working day that can directly affect their welfare. Producers have a social responsibility to reduce the number of injuries and fatalities in the workplace by reducing the exposure of workers. However, despite their best efforts to mitigate these risks with existing tools and processes, the required mitigating technology is often not available or has not been successfully commercialised. Moreover, following the logic of the hierarchy of hazard controls, the most effective means of control is eliminating the hazard by removing the worker from harm's way, which can only be achieved through automation or the complete elimination of the activity. Furthermore, producers have a responsibility towards local communities and a regulatory directive to measure the impact of their operations on the environment and enforce effective controls in mitigation. Both these objectives require the adoption of new technology and innovative thinking (PWC, 2017:49).

South African women are underrepresented in the engineering and technical disciplines and often face obstacles when pursuing a career in mining and metals. Producers are starting to accept more women into the workforce, partly due to community pressures and partly since they have come to realise that there are long-term benefits associated with having a more integrated workforce. Through various conducive policies, the number of female mineworkers is gradually increasing with women beginning to play an ever-increasingly important role in the industry. However, women lack the pure physical strength and stamina that men have, therefore a need exists to automate heavy manual work and to better leverage the fine motor skills, dexterity and problem-solving ability of women in the workplace. Consequently, the introduction of new automation technologies will result in a more favourable environment with more women being able to enter the industry as their needs are better catered for (James, 2018; Minerals Council, 2017:4).

1.4.2 Economic imperatives

The mining and metals industry is a vital part of the South African economy and has been described as the "flywheel of the economy" that keeps the economic wheels turning and promotes higher and more inclusive growth. In support of this argument, the National Development Plan (NDP) of South Africa places a responsibility on the mining sector to provide a positive socio-economic contribution to the economy at large, with the sector earmarked to play a large role if South Africa is to achieve its economic growth as well as development and transformation targets as set out in the NDP. Furthermore, more than half of the priorities listed on the NDP can be addressed through leveraging the industry as a whole, and thus its strategic importance coupled with that of the ferroalloy sector cannot be understated (Baxter, 2016:15; Mineral council of South Africa, 2018a:1-9).

The South African mining and metals industry is the fifth largest mining industry in the world and is an integral part of the economy and the social fabric. Moreover, the ferroalloy sector is an important part of the South African mining and metals sector with an installed capacity of more than a hundred furnaces providing direct employment to tens of thousands of people. However, despite the very large capital base and infrastructure needed for mining, international commodity producers still have a certain degree of flexibility when choosing within which geographic locations to operate and how to spread operations throughout their value chain. As pressures keep mounting on South African producers, some unwanted divestment is taking place with producers moving operations elsewhere or at best extracting the raw ore in South Africa while moving the downstream parts of the value chain abroad, such as beneficiating, smelting and metal recovery (Theron & Volk, 2015:363).

The South African economy in its current form cannot afford further divestment and needs to encourage more inclusive value chain creation, thus there is now a very real imperative to transform the local industry through innovation to remain globally competitive and attract international investment. Therefore, it is important to better understand the drivers that will increase technology adoption with the goal of formulating a strategy to reverse this negative trend and facilitate transformative change leading to competitive advantage. Ultimately, it is hoped that the metals industry will be set on a new course and a step change will be realised through innovation (Bryant, 2016:1).

1.4.3 Innovation imperatives

Currently, there exists an innovation imperative to gain a competitive advantage through fundamental and drastic changes beyond the realm of traditional incremental improvement. Transformative change through disruptive innovation is needed to set the industry on a new course and to reverse current negative trends. The hope is to create a step change in the industry to regain a competitive advantage and to ensure the survival of the ferroalloy sector in South Africa. However, by all accounts, producers are not likely to radically change their approach towards innovation in the near future (Bryant, 2016:1; Lane & Beier, 2015).

Therefore, the argument can be made that it is incumbent on technology companies and service providers to move the industry forward by partnering with producers to drive innovation and to maintain R&D funding. Future economic progress depends on whether producers will be able to stimulate innovation growth and adopt associated technologies to their benefit. Moreover, although the mining and metals sector is conservative and resistant to change, it is still considered to be a rational investor driven industry. Therefore, as with all investments, a clear and sound business case must be presented to producers to facilitate the adoption of new and innovative products, processes and technology. Although there are examples of innovative products in isolated plants, generally speaking, technology companies and service providers have failed to win the trust of producers and have also failed to cross the chasm from the early market into the mainstream market. Therefore, the marketing implications around innovation need to be better understood and a better narrative must be communicated to producers (Theron & Volk, 2015:364-365; Visser, 2017a:3).

1.5 PROBLEM STATEMENT

"We need to do it differently. We need a better way. We need to innovate ... If we don't start to bring innovation back … the major diversified companies will be subsidiaries of General Electric or some other conglomerate that still has innovation in their vocabulary."

Bryant (2016)

Ferroalloy producers in South Africa are typically slow to innovate and adopt new technology. This problem is not unique to mining and metals, since navigating the technology adoption life-cycle and promoting innovation are often quite difficult in any sector, even if the innovation presents clear and obvious benefits. Moreover, many new products do not diffuse successfully into the marketplace and end in failure. Therefore, a common problem faced by many organisations and technology companies alike is how to increase the rate of technology adoption and to ensure that viable technologies successfully diffuse into the market given the premise that these innovations will potentially be beneficial to the target producers and, ultimately, to society as a whole (Monitor Deloitte, 2016; Rogers, 2003:1,83,213).

Compounding the problem, the South African ferroalloy industry is under extreme pressure to innovate due to the sustained negative influences of external market forces coupled with internal structural challenges within the industry.

(I) External forces include price volatility, increased demands from local communities, power supply issues, degrading national infrastructure and increased onerous regulation from government with corruption also playing a role.

(II) Internal structural challenges include increased difficulty to exploit existing resources primarily due to diminishing ore grades, rising input costs and resistance to change in the industry.

It can be argued that the underlying economics and structure of the ferroalloy sector typically result in low levels of innovation due to the conservative nature of producers, because of aversion to risk and the fact that commodities are sold at low margins, implying that there is not a great deal of free cash available to spend on innovation during market downturns. There is merit in these arguments, however, given the clear innovation imperative in the industry, it must also be true that potential technology products and innovations are not commercialised effectively nor are they marketed correctly to producers (Moore, 2014; Murphy & Walker, 2018:4-8; Odendaal, 2018).

1.5.1 Cost pressures on industry and dwindling reserves

The overall business landscape in the metals market has changed significantly in the last decade. Historically, growing demand from developing countries coupled with high commodity prices and relatively low input costs created an environment where inefficiencies were tolerated and the status quo was not questioned, resulting in the well-worn and culturally accepted mining mantra of “we’ve always done it this way.” These abundant years created a false sense of security for producers and contributed to an industry that is now inefficient and stuck in technology stagnation. Therefore, cost overruns have become quite common and leaders in the metals industry must rethink their approach towards R&D and technology adoption with the understanding that innovation in the metals sector is fundamentally different from innovation in other industries (Leach, 2014:3).

Many of the easily accessible, high-value ore bodies around the world are in the process of being mined out. Furthermore, the number of new world class reserves that are being discovered is diminishing. As production continues at current deposits, mines become deeper, more dangerous and more expensive as ore bodies become more challenging to exploit. This increases input costs and has a negative effect on the profitability of operations. Moreover, ore grade declines as high value deposits are mined out, negatively affecting beneficiation and smelting recoveries downstream. As average grade declines, a point is reached where it is no longer economically feasible to process the existing ore bodies with conventional methods and technologies. Further compounding the problem, producers must navigate increased safety and environmental regulations imposed by government. In short, the "easy money" is gone and generally, the low-hanging fruits have already been picked off (Murphy & Walker, 2018).

Producers are now beginning to look at previously undesirable areas for mining operations. A good example is the Northern regions of Canada's "ring of fire" which are only accessible during summer months due to frigid climatic conditions. Consequently, producers now face the dilemma of whether to continue exploiting existing deposits at declining grades and increasing cost, or to move operations by taking up new sovereign risk elsewhere in more inhospitable regions or politically unstable countries with known ore reserves. In either case, producers must innovate and adopt new technology and pyro-metallurgical processes to remain competitive. Producers are now faced with the following scenarios (Foss, 2013; Swanepoel, 2009):

(i) Extend the life of existing mines as ore grades decline;
(ii) Exploit complex deposits that were previously not economically viable to extract; or
(iii) Develop plants and operations in previously inaccessible regions such as the arctic.

All these options point towards a clear imperative to innovate, since existing technologies are becoming redundant and not achieving these objectives. Therefore, a clear imperative exists within the industry to change current models and to adopt new technology to increase productivity, safety performance and inclusivity on all levels.

However, many producers are choosing not to embrace the innovation imperatives and are still on record with strategies of extreme cost-cutting. Therefore, they are tackling the problem by further cutting operational costs in the hope of relieving the pressure on already strained profit margins. The ferroalloy industry has long been stuck in this sustained cost-cutting mentality, lacking a long-term view on technology investment, which will ultimately have a negative impact on business sustainability in the region (Odendaal, 2018; Whyle, 2016).

1.5.2 Lack of spending on innovation and research and development

Typically, producers fall into the trap of focussing on short-term cost reduction at the expense of a long-term strategy and development initiatives with capital improvement projects being amongst the first to be discarded. Mark Cutifani, CEO of Anglo American, is one of the most influential voices to raise concern around the lack of innovation and the slow rate of technology adoption in the industry. In 2014, spending on innovation in mining and metals was one-tenth that of the petroleum industry. Moreover, whenever commodity prices are under pressure, producers cut back further on R&D and new technology adoption (Leach, 2014:1-4; Odendaal, 2018; Whyle, 2016).

Globally, mining and metals are facing an innovation deficit with a definite and sustained decrease of investment in technology development, specifically of the disruptive type. The South African industry is no different with the lack of innovation also causing producers to lose market share internationally given rising input costs. Historically, innovation in the South African industry has been driven by government and industry-supported research programmes; however, mismanagement and a lack of executing on stated NDP initiatives have led to many of these research facilities closing in recent years as observed by former minister of science and technology, Derek Hanekom. Moreover, historically speaking, producers and equipment manufacturers also maintained independent in-house R&D programmes, typically up to the 1990s. However, most of these in-house programmes have now also been closed down (Bartos, 2007:154-156; Creamer, 2017; Swanepoel, 2009; Yameogo, 2015:54).

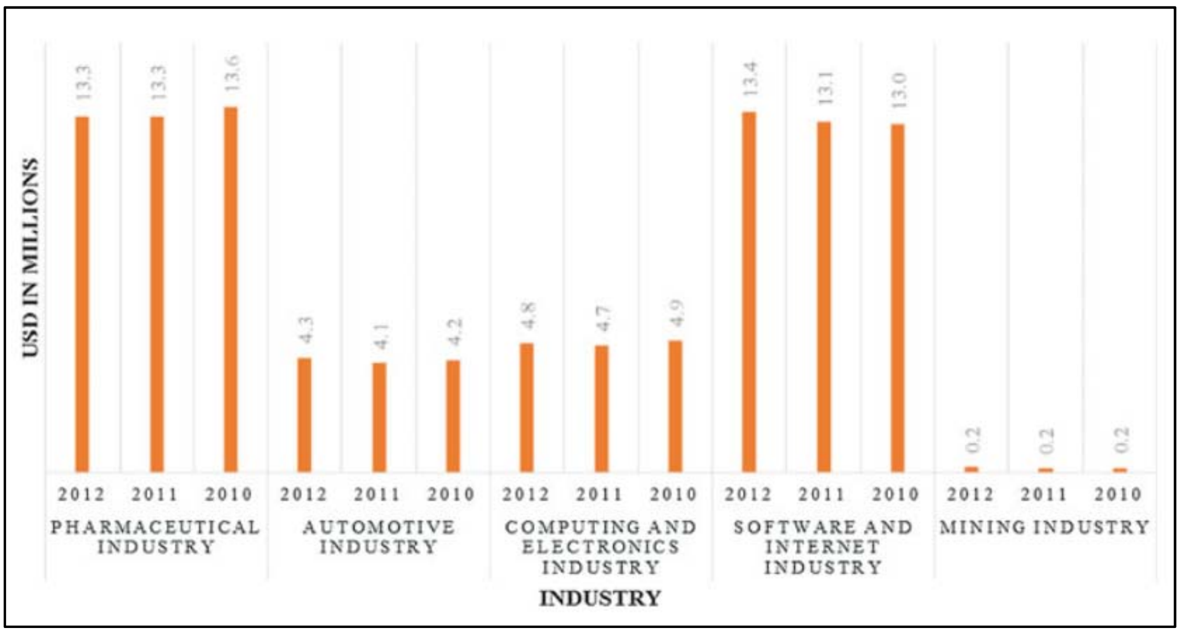


Figure 1-1: Average R&D intensities per industry operating within South Africa

Source: Theron & Volk (2015:374)

This problem is clearly demonstrated in Figure 1-1, which compares the R&D intensity, defined as the total amount being spent on R&D expressed as a percentage of total revenue. The mining and metals industry, represented by the big diversified producers such as Anglo America, Rio Tinto and BHP Billiton, is compared to four of the most innovative industries. The results demonstrate that R&D intensity in the mining and metals industry is less than that of other comparable industries, even though the large diversified producers would be expected to have available cash-flow and ongoing R&D programmes in place. Furthermore, a clear relationship exists between R&D intensity and price-to-earnings (PE) ratio, with a resultant reduction in PE ratio as R&D intensity declines. Therefore, it can be argued that investors in the market are already punishing mining producers for their lack of long-term investment in innovation and technology (Theron & Volk, 2015:364).

State-owned minerals research body, Mintek, has repeatedly called for increased investment in R&D specifically related to mining and metals technologies and practices in South Africa. Moreover, the MCSA has also identified the importance of improving productivity and reducing cost pressures on local producers by actively promoting innovation and R&D, with the MCSA allocating roughly 10% of their annual R35 million budget in 2017 towards related initiatives. However, although it is a step in the right direction, this money is only a drop in the bucket. Therefore, producers also need to be encouraged to spend their own money on innovation, R&D and appropriate technologies. Ultimately, producers are the key decision-makers that have to embrace innovation, thereby adopting relevant technologies and innovative practices that may be created (Baxter, 2016; Mineral council of South Africa, 2018b; , 2018a; Swanepoel, 2009).

1.5.3 Resistance to change on the part of the producers

The final and perhaps key part of the problem is cultural resistance to change within the industry. Key decision-makers in the industry tend to be reserved in nature and are characterised by low personal adaptability. Moreover, operators have earned a reputation of being technically conservative, traditional, overly risk averse and resistant to change – all of which contribute to poor adoption rates of new technologies (Bartos, 2007:149; Johnson, 2016; Shook, 2015).

Many believe that the multitude of challenges inherent to mining and metals coupled with ongoing low margins have created a generation of inward-looking and self-reliant mining executives and managers who fail to fully appreciate and grasp the benefits of innovation and new technology. This phenomenon has created an industry that is closed off and believes it has little in common with other industries, resulting in a significant lack of collaboration with other industries and curtails thinking outside the box. Moreover, these same managers often do not have a good understanding of the technology development process and are hesitant to partner with service providers and technology companies during a product development phase. These individuals often resist any form of change, especially innovation, with a sense panic and therefore miss the fact that there is always potential opportunity coupled to innovation (Bryant, 2016:6; Leach, 2014:9).

1.6 RESEARCH OBJECTIVES

The primary research objective is clearly stated. In order to achieve this objective, several detailed secondary objectives were formulated that each contributes towards fulfilling the primary research objective of the study.

1.6.1 Primary objectives

The primary objective of this study is to identify the cardinal variables that affect the rate of technology adoption and therefore the likelihood for successful innovation diffusion into the South African ferroalloy industry given the existing operational, environmental and social constraints.

1.6.2 Secondary objectives

To achieve the primary objective of the study, the following secondary objectives were identified with reference to the South African ferroalloy industry:

- (i) Complete a literature study on the diffusion of innovations with a specific focus on the variables that affect the rate of technology adoption into the market.
- (ii) Gain an understanding of the mechanisms behind the successful diffusion of an innovation, thereby appreciating how it effectively penetrates the market, crosses the innovation chasm and gains mainstream appeal.
- (iii) Complete a literature study to better define the context of this research, including the behaviour and preferences of potential adopters working in the industry.
- (iv) Investigate the broader working environment of potential adopters, including an overview of the specific market constraint and dynamics.
- (v) Investigate and define the cardinal variables that have the most significant effect on increasing the rate of technology adoption and the likelihood of successful diffusion of an innovation into the broader mainstream market.
- (vi) Complete empirical research by engaging with individuals in the industry to test the applicability of the theoretical framework; and
- (vii) Comment on what elements would be required for a successful, targeted marketing strategy designed to persuade potential adopters to make an adoption decision when faced with applicable new technology.

Ultimately, the combination of these objectives will inform a strategy to promote innovation diffusion in the ferroalloy industry by better appealing to the requirements and motivations of producers and end-users. Therefore, technology companies, service providers and consultants will be able to formulate a targeted marketing campaign with the hope of increasing the diffusion of innovations thereby crossing the innovation chasm into the mainstream ferroalloy market

1.7 RESEARCH METHODOLOGY

1.7.1 Description of overall research design

The approach used to complete this study and the overall research design is presented graphically in the form of a flowchart in Figure 1-2.

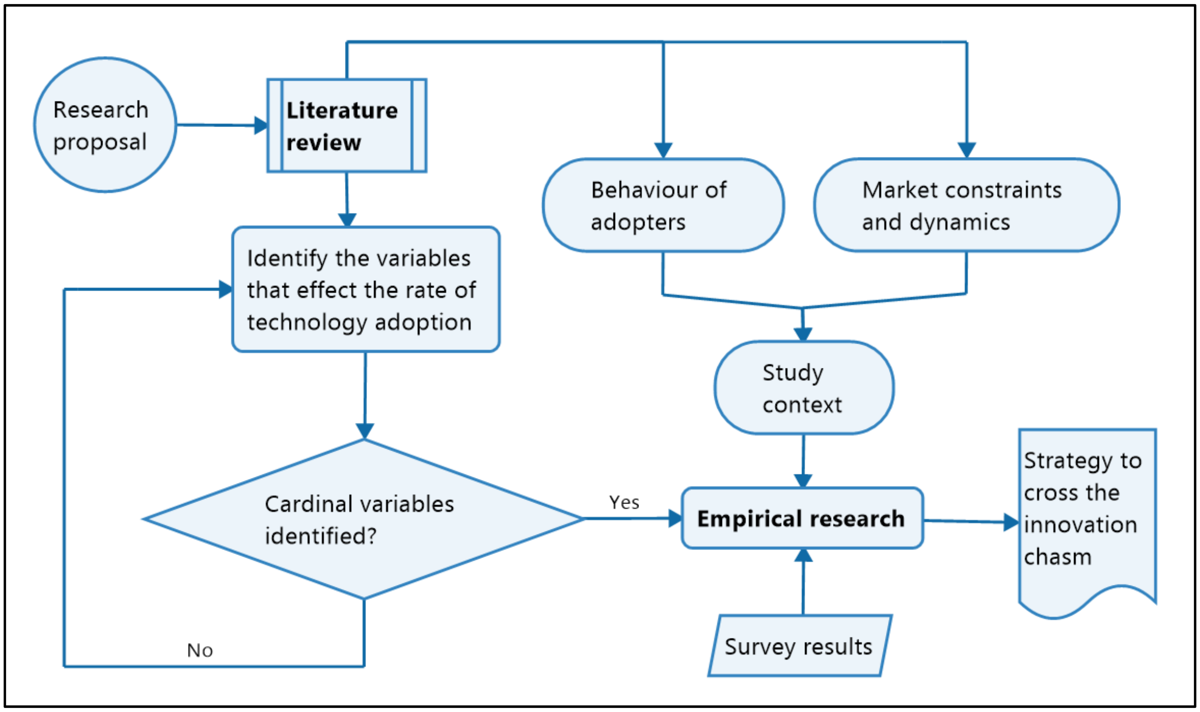


Figure 1-2: Research design

This empirical study was executed in the following sequential steps:

(i) A literature review was completed on diffusion of innovations with a specific focus on identifying the variables that affect the rate of technology adoption and promote successful diffusion of an innovation into a new market. Furthermore, the context of the study was considred including the general behavioural traits of potential adopters coupled with the working environment, market constraints and market dynamics in the South African ferroalloy industry.

(ii) During the literature review, a judgement was made as to whether the cardinal and overriding variables that have the largest effect on the rate of technology adoption in a new market have been identified. The literature review was continued untill these variables were adequately identified.

(iii) Following the literature review, empirical research was conducted with an analysis of primary data based on survey questionares received from respondents working in the South African ferroalloy industry; and

(iv) Conclusions were drawn which informed a targeted marketing strategy designed to assist technology providers and engineering firms to cross the innovation chasm.

1.7.2 Literature and theoretical review

A literature review was conducted on the diffusion on innovations within the context of the South African ferroalloy industry. (Refer to Figure 2-1 detailing all the topics and sub-topics that were considered during the literature review.)

EbscoHost and Google Scholar platforms were used to search for and retrieve information. Furthermore, existing subscriptions to online web-based mining and engineering articles were also referenced. Sources used in the literature review include:

(i) Journals and written publications;
(ii) Published books;
(iii) Relevant dissertations and mini-dissertations;
(iv) News articles;
(v) Internet articles and websites; and
(vi) Opinion pieces published on the internet.

(Refer to section 1.7.4 defining the limitations and of literature sources and research.)

1.7.3 Empirical research

To accomplish the research objectives of this study, empirical research was conducted. The target population was comprised of individuals working in the ferroalloy industry with a specific focus on downstream operations including sintering, smelting and alloy recovery.

These individuals were segregated into two groups as follows:

(i) Senior employees working directly for ferroalloy producers; and
(ii) Consultants, service providers and technology providers that service the ferroalloys producers.

A convenience sample of the entire population was used, and individuals were approached to participate in the study who were known to the researcher and willing to engage in the research.

A quantitative research approach was followed with an electronic survey questionnaire used to gather data. From the literature study, relevant questions were formulated and put to respondents via the survey and the collected primary data was evaluated by means of statistical analyses to correlate variables and draw conclusions from the target population. The results of the data analyses were then used to establish whether different marketing approaches should be developed to approach the different adopter groups and whether the views of the two different population groups differ.

1.7.4 Limitations

(i) Sources

All literature and theory used in this study are limited to sources that were readily available on the internet and in South African libraries as of the 30th September 2019. Sources posted after that date were not considered during this study.

(ii) Literature review

It was not be possible to consider all the variables that affect technology adoption in this study, due a lack of resources and available time required to complete such a mammoth study. Therefore, the pareto principle was followed in this research, wherein only the cardinal or primary variables that have been shown to have the largest effect on the rate of technology adoption and the prediction of successull innovation diffusion were considered.

(iii) Research

During this study, exploratory research was conducted on innovation and the adoption of new technology and was limited to the individuals working in the South African ferroalloy industry at the time. Furthermore, the focus of the study is the back end of the value chain, which includes sintering, smelting and alloy recovery plants. These individuals are described in section 1.7.3.

1.8 LAYOUT OF THE STUDY

The author endeavoured to maintain a golden thread throughout the final dissertation to present a consistent argument. This mini-dissertation is divided into four chapters, as presented graphically in Figure 1-3.

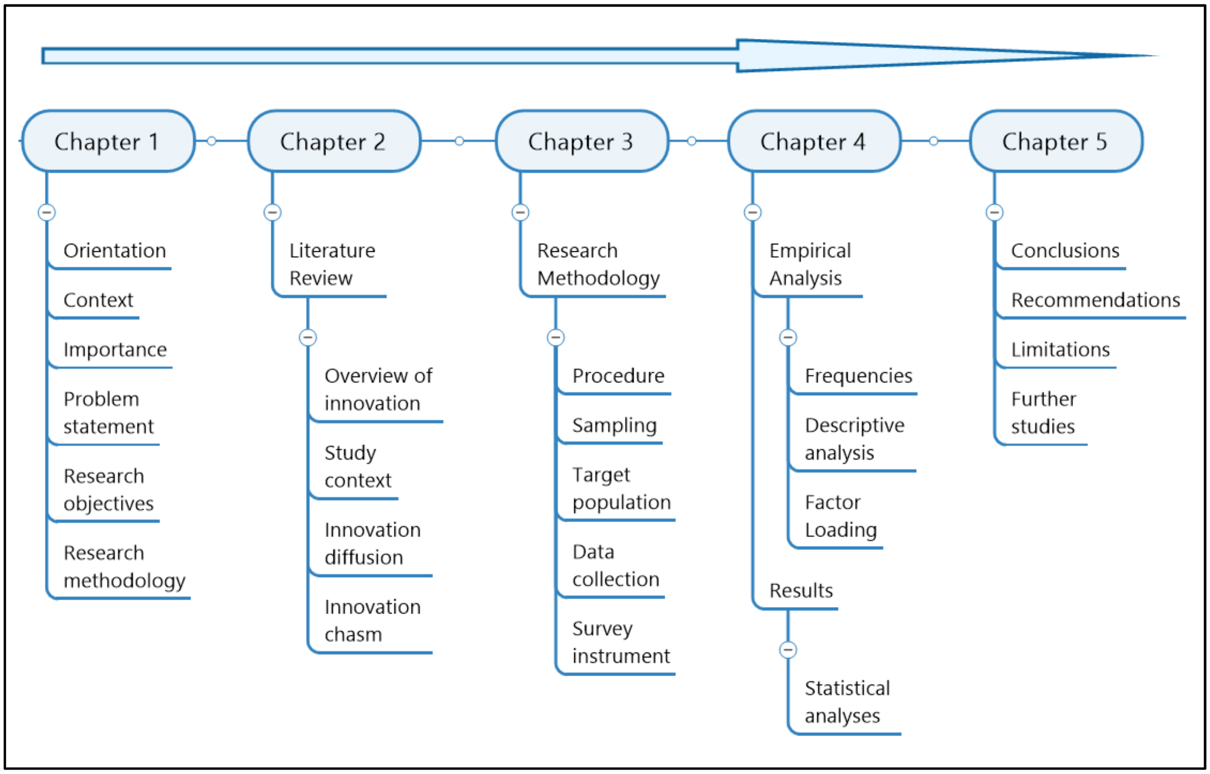


Figure 1-3: Structure and logical layout of the study

(i) Chapter 1: Orientation and problem statement.

This chapter sets the scene for the rest of the study. The background, context and causal factors of the study have been discussed. The importance of the research in increasing the available body of literature was demonstrated while the problem and its impact were also clearly defined. Finally, a brief overview was presented on the research design and the layout of the document.

(ii) Chapter 2: Literature review

This chapter presents the results of a literature review that includes research on the characteristics of the metals industry globally and in South Africa, the ferroalloy industry globally and in South Africa, available technology and the state of innovation within the industry. Finally, an overview of the mechanisms behind the diffusion of innovation coupled with various technology adoption models and potential market segmentation strategies are presented.

(iii) Chapter 3: Research methodology

This chapter presents the detailed research methodology, including sampling methods, details around the research questions that are used, data collection and the target population for the research.

(iv) Chapter 4: Empirical analysis and results

This chapter presents the results obtained from the empirical analyses, including the rationale behind the data analyses. Moreover, the statistical approach used to interpret the data coupled with the results is discussed.

(v) Chapter 5: Conclusion and Recommendations

This chapter presents the conclusions and recommendations that are likely to increase the rate of adoption of new technology when presented to metals producers based on the literature review and empirical investigation done during this study. Finally, recommendations for further study are also presented.

1.9 CONCLUSION

The South African ferroalloy industry at large lags behind other industries when it comes to innovation and has consequently suffered from international divestment. Technology, automation and information have the potential to radically transform the industry in what is a globally competitive market. Moreover, innovation has the potential to reduce the required people- and power intensity while increasing production intensity, therefore reducing inputs and maximising outputs.

The ultimately goal of future mining and production initiatives would be to establish a long-term strategy to drive innovation and the adoption of new technology sustainably within the industry. This will allow producers to move away from existing largely variable processes that are inherent to changing mining conditions and variable ore grades, which require daily intervention towards an era where mining will look more like a known and well-understood manufacturing process (Lane & Beier, 2015).

1.10 CHAPTER SUMMARY

The South African ferroalloy industry is currently in a crisis and is faced with a large innovation deficit coupled with an inherent resistance towards change on the part of producers. These factors have created a rigid industry that is losing market share internationally and one that is heavily reliant on external market forces to remain profitable. Moreover, producers are forced to reconsider outdated business models and embrace their corporate social responsibility by creating wealth for their shareholders through social, environmental and economic imperatives. These imperatives can only be met by aligning operations towards a vision that also embraces positive change with one of the key drivers for change being innovation and the adoption of new technology into the industry.

Given the low rate of technology adoption within the ferroalloy industry, this study sets out to better understand which variables related to a given innovation would improve its rate of diffusion into the market. The intent is that when following the recommendations from this study, technology companies, consultants and service providers will have more success in marketing new technology to producers, thereby creating a more innovate industry and increase global competitiveness.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The objective of this literature review is to review the attributes of an innovation that will increase its rate of adoption and the likelihood of successful diffusion into the South African ferroalloy industry by examining the following overarching themes in a literature study:

(i) Overview of innovation;
(ii) Industry overview;
(iii) Diffusion of innovations;
(iv) Crossing the innovation chasm; and
(v) Rate of adoption if innovations.

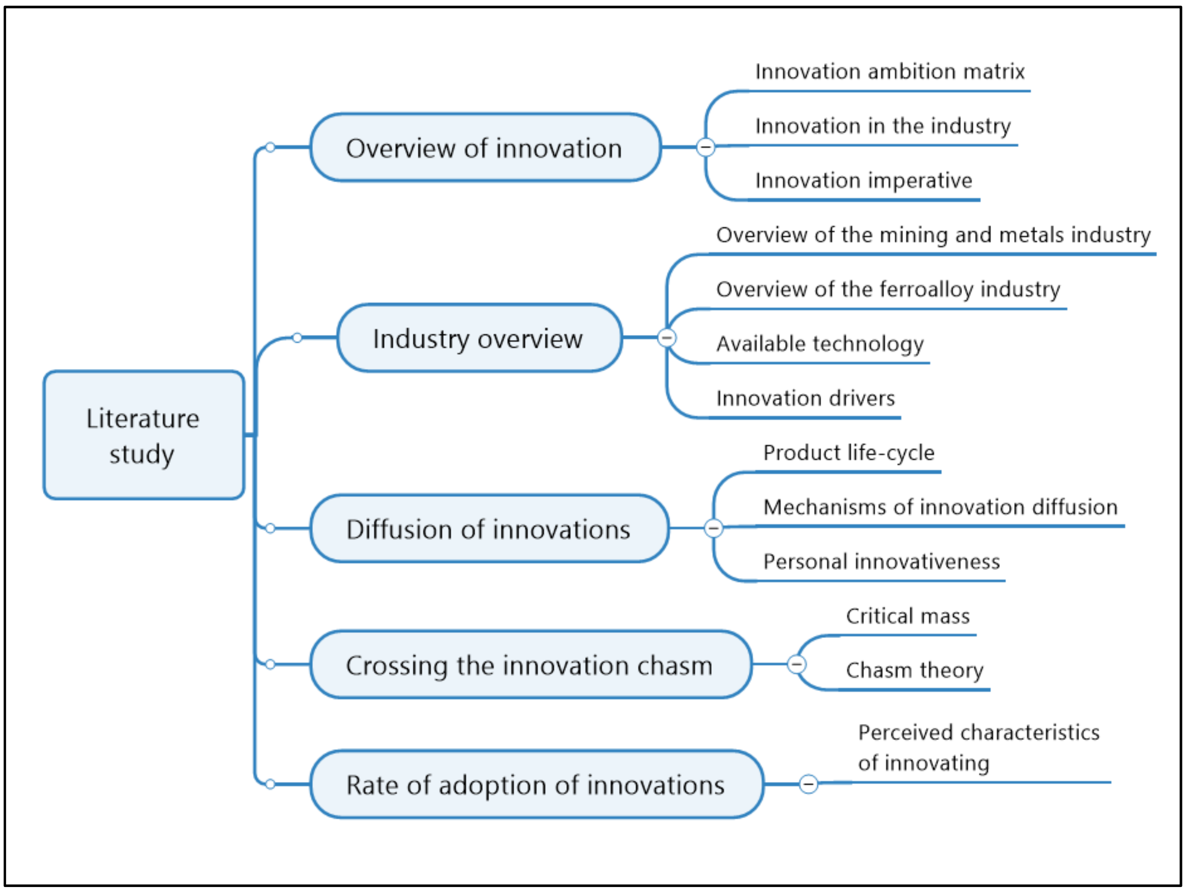


Figure 2-1: Layout of the literature study

These themes are sequentially ordered with relevant sub-themes logically grouped together as presented visually in Figure 2-1. This flowchart presents the outline of the literature study.

(Please refer to section 1.6 and Figure 1-2 for a complete list of research objectives and an overview of the research design.)

2.2 OVERVIEW OF INNOVATION

"Technological possibilities are an uncharted sea. There is no reason to expect slackening of the rate of output through exhaustion of technological possibilities."

Schumpeter (1942)

2.2.1 Innovation definitions and discussion

Innovation is a very broad term that refers to a new idea, method or product that, if implemented, demands the change or restructuring of existing ways of operating and doing things. It can be defined simply as "a novel creation that adds value" (Nagji & Tuff, 2012:6).

Expanding the definition, Christensen (2016:xix) coined the term disruptive innovation, thereby differentiating between different types of innovation as follows:

(i) Sustaining innovation or technologies improve the performance of established products within existing markets or value networks and are characterised by incremental improvement. In a given industry, most technological advances are sustaining in nature.

(ii) Disruptive innovation or technologies create a new market or value network by disrupting the existing market and eventually displacing current market leaders. These technologies are typically cheaper, less complex and simpler to use than established alternatives. In the short term, adoption may result in inferior performance; however, the performance of these products typically improves with further development as the technology matures and grows (Hendricks, 2016).

The concepts of sustaining and disruptive innovation are further divided into core, adjacent and transformational innovation, as presented in Figure 2-2. The horizontal axis represents the increasing novelty or inventiveness of an offering and the vertical axis represents the novelty or newness of the markets being targeted.

The different types of innovation presented by Nagji & Tuff (2012:7) can be described as follows:

(i) Core innovations refer to small incremental improvements on existing products and technologies. A typical example is enlarging a specific piece of equipment to increase throughput, which is something the ferroalloy industry has done well historically;

(ii) Adjacent innovations refer to leveraging technologies and products that already perform well in other industries into the ferroalloy market. A typical example would be to leverage drone technology to facilitate safe and quick site inspections; and

(iii) Transformational innovations are truly revolutionary and game-changing since they involve a radically new technology demanding fundamental change. A typical example would be to adopt a new smelting technology, thereby fundamentally changing furnace operation.

Core innovations are analogous to sustaining innovations and transformational innovations are analogous to disruptive innovation. Furthermore, the new category of adjacent innovation shares characteristics with both core and transformational innovation since it involves leveraging a technology that already works well elsewhere into a new market, in this case the ferroalloy market (Nagji & Tuff, 2012:7).

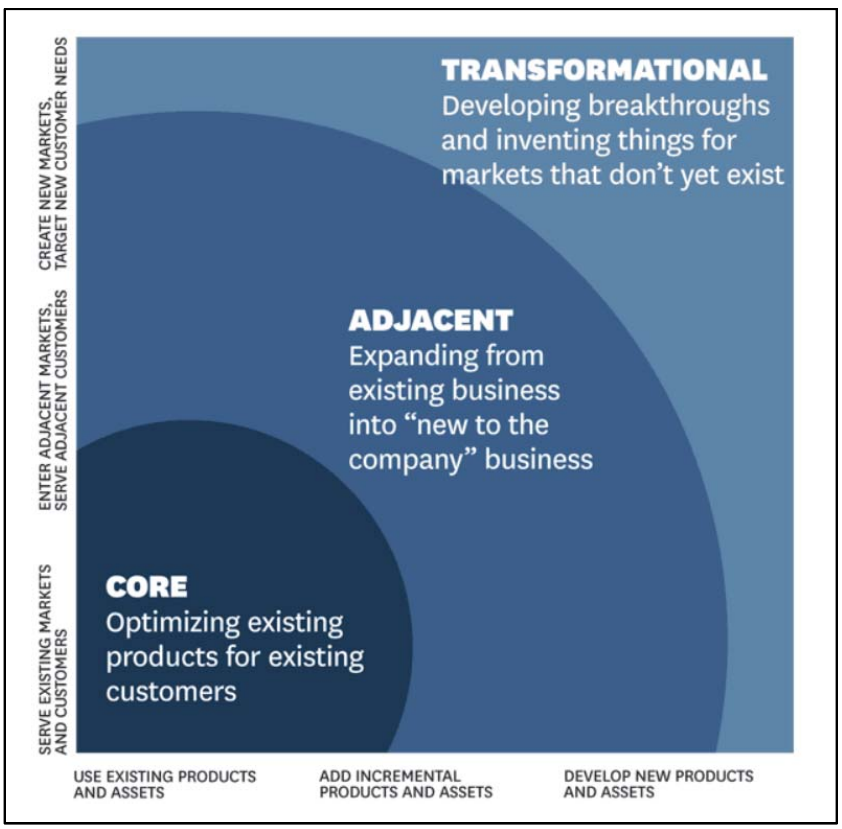


Figure 2-2: Innovation ambition matrix

Source: Nagji & Tuff (2012:7)

It should be clear that innovation is a very broad term that means many different things to many different people. Since the goal of this study is to better understand the factors that contribute to the rate of uptake of all available innovations and new technology, innovation is defined as first proposed by Rogers (2003:12) as:

> "an idea, practice, or object that is perceived as new
> by an individual or other unit of adoption."

From this definition, it is important to recognise that the innovation may not be new to the market, but if the idea, practice or object seems to be new to the individual it will be classified as an innovation. Therefore, this definition includes the full range of innovations as described above and presented in Figure 2-2.

It should also be understood that implementing an innovation may have unintended consequences or may not add value initially, and thus many producers justly view any potential changes as a risk (Nagji & Tuff, 2012:6).

2.2.2 Overview of innovation in the mining and metals industry

Innovation is inherently unpredictable since it requires changing current practices, equipment or operations which can be very disruptive if a metallurgical process is already working well. Moreover, the deployment of new technologies introduces an additional technical risk that can make technology adoption unattractive since the resultant unit performance may be negative, especially with truly disruptive technologies. Therefore, producers often reject new technologies despite the prospect of very real future benefits due to the industry's proclivity towards risk mitigation. However, suffering through short-term teething problems to reap long term rewards is often necessary to ensure sustainable operations (Christensen, 2016).

Despite major innovations and structural changes during the last generation in transport, health care, financing, retailing, oil and gas and information technology, amongst others, the mine and smelter of today looks very similar to what it did 50 years ago. Essentially, rocks are still being pulverised and hauled away and ore is still being smelted with traditional submerged arc processes utilising much of the same equipment that has been in use for decades. In contrast, a modern electric vehicle is vastly superior to a motor vehicle manufactured in the 1960s, advancement in medicine has enabled patients to be effectively treated for diseases that were incurable a mere generation ago and the gains made in information technology and high-tech industries have been remarkable (Bartos, 2007:149; PWC, 2017:49; Shook, 2015; Theron & Volk, 2015:364; Visser, 2017a).

The mining and metals industry lags behind comparable industries in adopting new technologies, despite a clear imperative to innovate. Further expanding on the problem statement in section 1.5, contributing factors towards the innovation deficit and the slow rate of innovation diffusion in industry are as follows:

(i) Cost pressures on industry and dwindling reserves;

Due to the fluctuating commodity price (refer to section 2.3.2), operating environment and structural constraints (refer to section 2.3.3), the need to pay off large investments in terms of plant and equipment (refer to section 2.3.5) and more recently cost-saving initiatives, there is a resistance on the part of producers to further compound risk by introducing additional technology risk into an operation (Christensen, 2016; Shook, 2015).

Producers are reluctant to alter a metallurgical process that is working well despite it being sub-optimal, since a positive cash flow is prioritised to pay off debts and provide returns to shareholders. Therefore, if a process, technology and equipment are well understood, there is an inherent reluctance towards change, especially if an operation is making a profit. Therefore, if a superior technology is available with a high probability of increasing performance but there is a slim chance that it may fail, the technology will often be discarded for existing processes and known technology since the outcomes are better understood (Christensen, 2016; Shook, 2015).

Due to their inherent aversion to risk, producers have focused primarily on less risky core innovations to ease cost pressures, often reverting to tried and tested technology but with minor changes. Subsequently, improvements focused on increasing throughput, essentially “business as usual” but on a bigger scale are accepted and even encouraged during favourable commodity price cycles. However, this historic focus on primarily increasing throughput has resulted in conditions where adjacent- and transformational innovations have been ignored, with many pertinent technologies not able to cross the innovation chasm and attain mainstream adoption. Due to the historic drive to increase scale, fixed-cost contributions are now quite low on smelting plants and bigger is not necessarily better anymore (Bartos, 2007:154; Leach, 2014:5).

Moreover, the scarcity of resources is becoming an increasing issue, with once easily accessible ore bodies becoming harder to liberate. The inability to achieve the required product grade initially projected is a good incentive for innovation; however, it is typically too late in the operation’s life-cycle to recover once that happens (Lane & Beier, 2015:1-2; Theron & Volk, 2015:375).

(ii) Lack of spending on innovation and research and development

Overall, R&D expenditure in the industry is extremely low, as demonstrated in Figure 1-1. Furthermore, disruptive innovation has been very rare historically with continuous improvement initiatives typically focused on core innovations only. Moreover, even adjacent innovations that have proven to be successful in other industries are typically not embraced (Nagji & Tuff, 2012; PWC, 2017:49; Theron & Volk, 2015:364; Visser, 2017b).

Since new technologies are not required for producers to continue operations in the short or even medium term, they typically do not have a pressing incentive to embrace innovation and R&D. It can further be argued that the underlying economics and structure of the industry as discussed in section 2.3.3 also promote low levels of innovation (Foss, 2013).

Finally, many producers choose to be fast followers as opposed to first movers, thereby attempting to reduce risk and minimise resource allocation to development projects that may be unattractive in the medium to long term. This is a very pragmatic and potentially even a good approach given the right circumstances. However, the risk is that a fast follower can miss the boat in terms of missing disruptive technology including patents that are locked in.

(iii) Resistance to change on the part of producers

Large organisations are typically characterised by unwieldy bureaucracies which are structured to provide stability and continuity; however, these organisations are inherently inflexible and struggle to create and sustain an environment that is conducive to technological innovation. Consequently, large metal producers also struggle to create an internal environment that nurtures innovation and must rely heavily upon external technology companies and their products for innovation (Rogers, 2003:149).

Therefore, a significant barrier to innovation is a resistance to change within the industry with key decision-makers tending to be reserved and characterised by low personal adaptability. Moreover, metal producers have received a reputation of being technically conservative, traditional, overly risk averse and resistant to change which all contribute to poor adoption rates of new technology (Bartos, 2007:149; Johnson, 2016; Shook, 2015).

These factors contribute to the phenomenon wherein it is common to find the same plant and equipment in place at an operation for more than 20 years. At times, it is only when certain technologies are discontinued that producers are forced to make any changes. Therefore, very real concerns exist around the metals industry's ability to absorb new technologies (Foss, 2013).

Johnson (2016) further argues that it is preferable to sacrifice the optimal solution in order to adopt a less favourable technical solution, if it will facilitate full engagement from the employees involved. Therefore, successful technology adoption and innovation must consider not only processes, equipment and technology, but should ensure that people are engaged, from low levels to senior management. Nonetheless, producers are typically hesitant to adopt new technologies and technological change is often difficult to deal with, with "business as usual" being preferred (Johnson, 2016).

Industry commentators and analysts often point the finger at the inflexibility and poor decision making of senior industry executives who are blamed for creating an industry that does not actively pursue innovation. However, it can be argued that the structural makeup and operating realities of the metals industry breed producers that are often technically conservative and risk averse. Christensen (2016) further argues that the very factors and good decision-making that allowed producers to achieve dominance in certain areas are the ones that are preventing them from embracing disruptive technology, since by definition it will disrupt existing operations and reduce performance, at least in the short term (Bryant, 2016:4,10; Christensen, 2016; Shook, 2015:2; Whyle, 2016).

It should be noted that other industries attempt to overcome this problem by creating small independent units within the larger organisation that are responsible for "skunkworks" projects, which include research and development coupled with a mandate to drive the organisation towards future innovation. However, metal producers are not known to follow this approach, and many have reduced or eliminated internal project departments following cost control initiatives. Therefore the imperative now rests on technology companies to move the mining sector forward (Rogers, 2003:149).

Producers are starting to appreciate that innovation is a key to survival, and the innovation imperative has taken hold in industry. Specifically, innovation is required beyond a level of basic cost control or economies of scale and producers need to start making step changes within their operations and embrace disruptive innovation. The premium for innovation has become crucial in what is a very fast changing global landscape, therefore the lack of R&D investment and consequential slow rate of technology adoption in the mining and metals industry needs to be challenged. Inevitably, disruptive change will start to affect the mining industry more frequently and operators that do not adopt new technologies and adapt to the times will go under (Lane & Beier, 2015:1-2; Theron & Volk, 2015:375).

2.2.3 Overview of innovation in the South African ferroalloy industry

In line with mining and metals, the ferroalloy industry is also considered as innovation laggard and is characterised by a slow rate of technology adoption. There is not a well-entrenched culture of innovation within the industry, and producers are reluctant to spend money on innovation and R&D, while also being hesitant to adopt new technologies. Moreover, innovation initiatives typically lack clear directives or goals, which at best results in a sub-optimal use of resources and at worst in a proposed innovation that does not necessarily solve a real problem or add value to the target industry. However, innovation has become a buzzword in industry today as producers recognise the imperative for change, although it may not be obvious how to drive that change (Johnson, 2016; Lane & Beier, 2015).

Innovation for the sake of innovating does not necessarily add value and initiatives should be directed towards sensible goals. Shook (2015) proposes that for innovation initiatives to add value, they must directly serve the needs of the target producer, with successful innovation achieving a direct and tangible benefit in any of the following ways:

(i) Generating profit and creating value for shareholders and/or stakeholders;
(ii) Improving the safety of employees and reducing risk; or
(iii) Minimising and reversing the environmental impact of operations.

These tangible benefits can be attained by producers through the adoption of a technology product, installation of a piece of equipment, implementation of a business process or revisiting a metallurgical process.

Nagji and Tuff (2012:7) found that few organisations have a strategy around how to allocate resources towards the different types of innovations for future development (refer to Figure 2-2). Moreover, they concluded that industrial manufacturers with a rough resource split of 70% core-, 20% adjacent- and 10% transformational innovations outperform their competitors and achieve significantly better share price performance. Furthermore, Hendricks (2016) argues that the same innovation strategy is relevant for the South African mining and metals sector, and by extension, the ferroalloy industry (Hendricks, 2016; Nagji & Tuff, 2012:8).

That implies that at least 10% of a typical ferroalloy producer's R&D resources should be targeted towards transformational or disruptive innovation, which will also stimulate and support long-term thinking. However, South African producers have focused almost entirely on core innovations through continuous improvement initiatives with a specific commitment towards increasing the scale of equipment and operations (Bartos, 2007:154; Leach, 2014:5).

2.2.4 Innovation imperative in the South African ferroalloy industry

Moreover, producers neglect funding for innovation management programs with companies lacking a future vision for their operations. This short-term thinking is at odds with the fourth “purpose” pillar of the 4P business model (refer to section 1.1) and explains why producers are facing sustainability challenges. Therefore, it is critical for a producer to manage its innovation portfolio actively, closely and deliberately. The absence of such a framework leads to a steady decline in business, a destruction of long-term value and clearly is one of the reasons that the industry now finds itself in difficulty (Hendricks, 2016; Nagji & Tuff, 2012:8; Whitchurch, 2016:223–224).

The argument has been made that the ferroalloy industry’s purpose is not to be a technical leader, but its main imperative is to provide the raw materials and resources needed by society. Conversely, the counter-argument can be made that the innovation deficit has become so large that South African producers have no choice but to close the innovation gap or face closure in today’s highly competitive landscape. Therefore, there is a strong imperative on producers and technology companies alike to embrace further technology adoption, thereby achieving sufficient levels of diffusion to cross the innovation chasm as described in section 2.8 (Moore, 2014:25; Shook, 2015; Whyle, 2016).

By implication, innovation can confer great benefits to a company; however, innovation also increases the uncertainty and risk associated with current and future operations. Furthermore, innovation in ferroalloys is fundamentally different than that for other industries due the inherent operating conditions, market forces and structural realities of the industry, which are discussed in sections 2.3 and 0 (Shook, 2015; Whyle, 2016).

2.3 OVERVIEW OF THE MINING AND METALS INDUSTRY

Metals are important building blocks for our modern society and are the key elements in many essential products today. Smart technologies, infrastructure, urban development, clean energy, modern buildings, eating utensils, personal hygiene and cosmetic products, amongst others, would not be possible without these raw metals (Baxter, 2016:7-12).

However, despite the clear need for metals, global commodity prices have been under strain for close to a decade now and the high prices achieved in the early to mid-2000s have not made a sustainable comeback. The result is that producers, throughout the commodity spectrum, have been forced to revaluate the way in which they do business or face shutting down operations. The ferroalloy sector is no exception, with many of the hardest-hit metal commodities in the past decade being ferroalloys (Baxter, 2016:28).

Obvious drivers of lower ferroalloy prices are strained market conditions due to reduced steel demand and problematic macro-economic conditions in the international market. These factors coupled with the typical operating environment and constraints inherent to industry are discussed further in this chapter. However, an emerging trend of product dematerialisation (refer to in section 2.3.1) is often overlooked when considering factors that influence, and often reduce, the demand for metals.

2.3.1 Product dematerialisation leading to reduced commodity consumption

A change in commodity demand profiles is affecting mining and metals, with concepts such as “decoupling” or “dematerialisation” starting to skew long-held assumptions of commodity supply and demand curves that have been trusted for decades. Traditionally, producers have depended on the fact that the growing world economy and population would keep demanding more and more resources, thus assuming global demand will continue increasing at a known rate with their primary concern being to maximise profits while navigating volatile commodity price cycles. However, the developed world is starting to move away from an outdated industrial model of “ever increasing demand” towards a more circular economy that is focused on efficiency and an information-driven economy (Ausubel, 2015:3; Rollins, 2016; Tupy, 2012:1-3).

Moreover, the demand for numerous commodities is being decoupled from population in developed countries, wherein the intensity of the use of resources decreases despite a growing population. A typical smart phone (Figure 2-3) is an example of how a single innovative product has reduced the resource burden on society by consuming less raw material and energy to produce more goods. This concept of dematerialisation translates into a smaller demand for commodities and a reduction in energy per unit of GDP that is created. In typical free market fashion, inputs are gradually minimised while outputs are maximised, thus extracting more value from less material. The consequence is that the long-accepted model of supply and demand as a function of population is beginning to break down, which has a direct impact on the ferroalloy industry (Ausubel, 2015:8; Rollins, 2016; Tupy, 2012:2).

Furthermore, the concept of a circular economy, wherein redundant finished goods are recycled with the underlying raw materials being reused, is becoming more popular and financially attractive. Therefore, metal producers are increasingly shifting away from the traditional model of extracting primary resources towards operating in secondary recycling and scrap markets. This ongoing shift will likely open the door for smaller players and new technology to enter the market. However, society is still very far removed from an effective circular economy characterised by limited waste generation and true sustainability. Moreover, significant and fundamental changes are required in economic frameworks, governance structures, corporate social responsibility and human behaviour before there will be a marked change in ferroalloy consumption patterns (Eric, 2018:25–28; Oliveira, 2017).

In developed countries, as the population keeps growing, the intensity of use of raw materials and resources keeps falling, with Asian countries projected to follow the same pattern of resource use as observed in the United States of America from the 1990s onwards (Ausubel, 2015:8; Rollins, 2016).

Figure 2-3: The innovative smart phone demonstrating dematerialisation with less resources consumed to produce more
Source: Tupy (2012:4)

These factors combine to make it quite difficult for commodity producers to project accurate demand curves in the medium to long term and create a compelling argument that the current supressed price for ferroalloy products is primarily due to an oversupply into the market that was not foreseen by producers. Therefore, a very clear innovation imperative is emerging wherein producers must transform operations to become more efficient in their internal production processes if they are going to be cost-competitive (Ausubel, 2015:8; Rollins, 2016).

2.3.2 General factors that affect commodity demand and price

The successful diffusion and wider adoption of new technologies and associated products have a significant effect of the demand profiles of the underlying commodities that are consumed during the production of these products. Moreover, ongoing improvements to existing products often reduce the demand for certain input commodities as products become more streamlined, while the launch of a truly disruptive technology has the potential to dramatically affect global demand profiles. Subsequently, many traditional markets are falling away completely such as those for telephone books, typewriters or newsprint (Ausubel, 2015:8; Creamer, 2019:1–13; Rollins, 2016; Staffell *et al.*, 2019:463).

Furthermore, demand and commodity prices can also be influenced by a multitude of external market forces, including, amongst others, scandals, market sentiment, political manoeuvring, stock levels, investment decisions, supply disruption and even trade wars. The ongoing trade dispute between China and the United States of America is a recent example of a major cause of price volatility in the global ferroalloy market that is creating significant uncertainty and making it difficult to predict future price trends (Hogue, 2019; Narayanan, 2019; Papp *et al.*, 2008:23).

These changes in demand can typically not be anticipated by producers, and as the rate of change and global innovation increases, it becomes more difficult to predict future market trends. Moreover, the perceived value of commodities fluctuate as analysts and economists try to make sense of current trends and predict future value (Marketline, 2018a:17).

Producers can do very little to influence most macro-economic market conditions, nor can they stop the impact of new disruptive technologies on commodity demand profiles. Therefore, producers are inherently price-takers exposed to prevailing market conditions, shifts in demand and indexed commodity prices. It is often difficult and costly to repurpose the production output of an existing operation, and thus producers on the high end of the cost curve are sure to feel the pressure when the price of their commodity product is depressed. Ultimately, the cost of production is a primary driver for the industry as responsible operators want to avoid being exposed, losing money and potentially closing down operations during unpredictable commodity downturns (Papp *et al.*, 2008:22-24).

2.3.3 Operating environment and structural constraints of the mining and metals industry

Mining and metals is a unique and often challenging industry. The structural constraints of the industry and the dynamics that producers face on a day to day basis should be understood before a critique can be made on the slow rate of innovation and the conservative nature of operators, as discussed in section 1.5. Moreover, these constraints and operating conditions, as listed below, are equally relevant to the ferroalloy sector which is a subset of the broader mining and metals industry and are also specifically relevant to the South African geography.

The following factors and trends affect nearly all producers and demonstrate the high levels of uncertainty and risk inherent to operations:

(i) Producers are exposed to inherent uncertainty within the ore body that is being exploited

The economic outcome of a potential mining project is primarily contingent on the viability of the targeted resource and whether it can be practically extracted, beneficiated and smelted in the long term. Therefore, much depends on the quality and grade of the ore in the ground. Initial test work on any ore body generates a proposed mine plan and production schedule that feed into a financial analysis to justify the cost of plant and equipment based on future cash-flow predictions. It is, however, practically impossible to accurately measure the exact size, composition and future mass flow of the ore at every point in the process. Ore resources typically present as heterogenous, solid-state ore seams that are often inconsistent. This is in stark contrast to the oil and gas industry where mixing occurs naturally in the ground with test work generally being representative of the entire resource (Gholamnejad & Osanloo, 2007:177; Morley *et al.*, 1999:293; Shook, 2015).

Consequently, a significant risk is associated with long-term mining projects, even with well-defined ore bodies. Since initial test work might not be representative, producers have imperfect knowledge of the ore body and upfront resource and reserve estimates often prove to be incorrect. It is not possible to know exactly what one will get once full-scale mining starts, nor is there a guarantee that the metallurgical processes selected will be optimal or even produce the metal yield expected (Gholamnejad & Osanloo, 2007:177; Morley *et al.*, 1999:293; Shook, 2015).

(ii) Operations are typically very large with mining and metals being a very capital-intensive business

Mining requires major investment with large amounts of initial and sustaining capital needed for plant, equipment and infrastructure. These funds are typically garnered from banks and investors via loans, since the scale of investment is often too large to self-fund. This creates an environment where proven, conventional technology is often preferred despite being sub-optimal, since getting the needed funding with unproven technology is more challenging. Banks and other loan providers are hesitant to add an additional technology risk onto existing market, country and project risks (Leach, 2014:4; Shook, 2015:1-3).

Also, the industry is characterised by large monthly operational expenditures as part of normal business. Therefore, positive cash-flow is needed early on in any project to keep operations going and pay back loans. Subsequently, the luxury of time to learn how to adapt to a new technology is often not available as cash returns are required early on in a project's lifecycle (Leach, 2014:4; Shook, 2015:1-3).

(iii) Producers are price takers within a volatile commodity market

Metal products are sold on the open market based on a reference price for a certain chemical composition and sizing fraction, thus there is limited opportunity to differentiate the product and producers are essentially trading with pure commodities. In addition, producers have very little influence in setting a selling price and are effectively beholden to market conditions largely driven by supply and demand and external market forces as discussed in section 2.3.2 (Bryant, 2016:1-3,10-12; Leach, 2014:4; Mineral council of South Africa, 2018a:4).

Furthermore, the metals market is extremely volatile with large price fluctuations often being the norm. In the last decade alone, commodity prices have traded at both historic highs and historic lows. Also, metal prices have experienced greater than average historical volatility since 2000, thus creating further unwanted variability and uncertainty in the market as neither producers nor consumers can accurately project future prices. A recent cause of significant price volatility is the impact of international trade wars which was not foreseen by most economists (Hogue, 2019; Narayanan, 2019).

There is still some debate whether metal prices (i) follow a typical cyclical "boom and bust" model, (ii) whether there is a constant upward trend in a "sawtooth" type super cycle due to a long-term increase in demands or (iii) if primary demand will actually decrease, as discussed in section 2.3.1. However, even when assuming the best-case "sawtooth" model, there are still severe, sudden and unexpected price dips and the market is characterised by constant disruption and volatility (Bryant, 2016:1-3,10-12; Leach, 2014:4; Mineral council of South Africa, 2018a:4).

(iv) Operations are often located in remote areas and workers are typically exposed to extreme hazards;

People and equipment in the industry are typically exposed to harsh working conditions and extreme hazards. Manual processes are common and much of the work still requires direct involvement, therefore injuries are common and fatalities remain high. Most large producers have adopted an attitude of striving towards zero harm through safety interventions and reducing the exposure of workers to hazards, which is a stated innovation driver (refer to section 2.11). However, operators often still revert back to largely ineffective low-level administrative controls to mitigate risk (Bryant, 2016:6; Jamasmie, 2013:4; Shook, 2015:1-3).

(v) Industrial relations are often challenging with local communities placing high demands on operators

Since operations are typically very large requiring a hefty labour force, the industry has the potential to provide employment to local communities and to inject cash into supporting businesses and local infrastructure. Subsequently, governments and local communities, especially in developing countries, are increasingly relying on large producers to stimulate local economies and to become the engines of growth, often imposing onerous employment and procurement regulations onto operators (BMI, 2017:48).

In the South African context, government has put forth legislation that compels producers to comply with certain social, labour and procurement targets in their immediate operating vicinity. Achieving these targets is not always practical or even possible. However, with local government often reneging on their duties, private producers become an attractive vehicle for social and economic upliftment, specifically in remote areas. Therefore, the burden has started to fall squarely onto producers to uplift local communities in addition to their primary business of metal processing and smelting.

Stakeholder demands will likely continue increasing with relationship management of local communities becoming paramount. Moreover, local communities are increasingly raising environmental concerns and demanding a reduction in the impact of operations near their homes.

(vi) Diversity of the workforce is becoming an important metric at all levels of the organisation, from control room operators to board level;

Producers are faced with increased calls to diversify their employee base to improve business performance. Subsequently, inclusivity regarding gender, race and ethnicity will be key future metric against which companies will be evaluated. In the South African context, there is specific focus on including more women into the workforce through the promotion of STEM (science, technology, engineering and mathematics) subjects, thus opening doors to technical fields such as mining and metals. Furthermore, technology can assist women in completing repetitive tasks that require brute strength as discussed in section 1.4.1 (James, 2018; Minerals Council, 2017:4; Ndlovu, 2018).

(vii) Talent shortages and an ever-increasing skills gap are putting pressure on operators

Skilled labour shortages are an ongoing concern throughout the industry with a widening talent gap, even in first world countries, as the workforce ages and young people are drawn to more attractive industries. In addition, organised labour and unions typically have goals and objectives that are not aligned with those of producers leading to conflict, strikes and even unrest. This is certainly the case in the South African jurisdiction (Jamasmie, 2013:4).

(viii) Access to key resources such as energy and water are becoming more difficult

In the South African context, the cost of energy is consistently higher than inflation with distribution also becoming increasingly unreliable (refer to section 2.4.5). Also, water is becoming an increasingly scarce resource with many producers being forced to re-evaluate their operations and potentially change existing process to reduce the amount of water required during processing.

Given the challenging operating environment and industry constraints within what is a volatile, low-margin market, it becomes apparent that producers are exposed to a high degree of risk and uncertainty. Therefore, the inherent conservative nature of the industry is better understood and can be viewed as a rational response to the factors listed above. In short, the operating environment does not facilitate high rates of technology adoption, nor is it conducive to high individual innovativeness (refer to section 2.6.4), with producers being hesitant to embrace disruptive innovation (Foss, 2013).

Furthermore, the combination of these factors forces producers to accept sub-optimal prices to maintain positive cash-flow, keep operations going and honour loan agreements. Therefore, even when commodity prices are depressed, plants typically still operate attempting to push high production volumes and dilute fixed costs. A short-term approach of “sweating the assets” and embracing a culture of extreme cost is the result (refer to section 2.4.5). However, operating with this mindset for extended periods has resulted in a destruction of value and a lack of spending on R&D and innovation (Bryant, 2016:2; Visser, 2017a).

2.3.4 Overview of the mining and metals industry worldwide

The mining and metals industry is a key contributor to the global economy and the primary source of the commodities required by modern day society to produce higher value finished goods, products and technology. Furthermore, the industry is responsible for a vast number of direct and indirect jobs, thereby supporting local communities across the globe and injecting investment into locations that are often remote. The iron and steel segment dominate the global mining and metals industry with 61.4% of the total industry value being attributed to this sector in 2017. Moreover, the ferroalloy market is closely associated with the iron and steel market. (Refer to section 2.4 for further discussion on ferroalloys see Marketline, 2018:1–37:16).

Following the commodity super cycle which led to a price boom in the 2000s, there was a sharp and relatively short down-turn in metal prices during the global credit crunch of 2008 and 2009 which was followed by a period of recovery, but ultimately prices fell drastically from 2013 onwards. Also, for the largest part of the current decade metal prices have been depressed globally when compared to the highs that were achieved in the 2000s. Stagnation in the Eurozone and a slowdown in demand from China as it entered the “new normal,” characterised by a lower economic growth rate contributed to a reduction in global metals demand. However, many other external macro-economic and political factors in global markets also contributed to these price variances and will continue to impact future prices (PWC, 2019:5).

Traditional “cash-cow” type operations have become less and less profitable with declining ore grades reducing productivity and rising input costs increasing the cost of production. Bryant (2016:2) goes as far as arguing that there has been a large-scale destruction of value in mining and metals over the last 15 years and that the industry is in dire need of transformation. When considering the poor relative performance of the mining and metals industry in recent years as compared to other sectors (refer to Figure 2-4), it is clear that there is merit in this argument (Bryant, 2016:2; PWC, 2019:5).

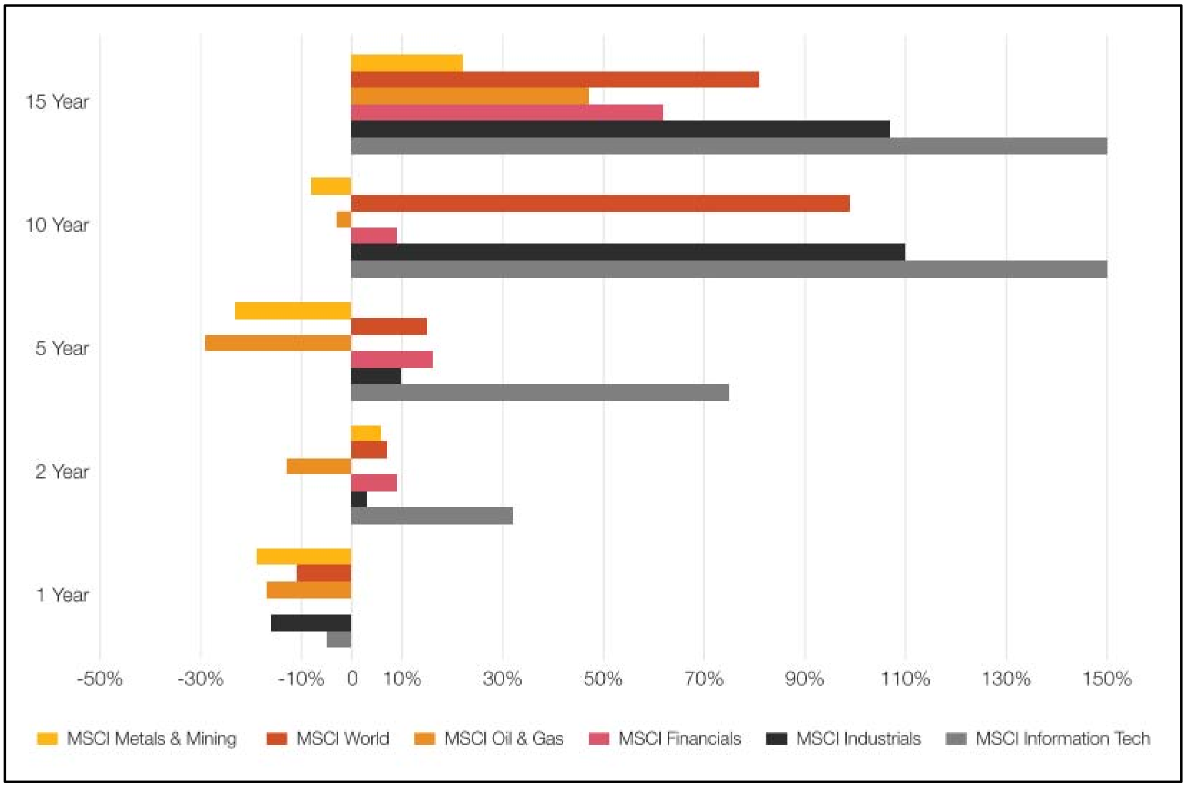


Figure 2-4: Relative historical performance by sector based on total market capitalization as of 2018

Source: (PWC, 2019:5)

PWC recently issued a report detailing the performance of the world's 40 largest mining companies by market capitalisation. Figure 2-4 presents the growth in terms of total market capitalisation of the mining and metals industry when compared with other comparable industries over selected time periods, with the mining and metals industry only achieving marginal growth in terms of market capitalisation over a fifteen year window (PWC, 2019:4-5).

Moreover, mining and metals is the poorest performer when compared to comparable industries such as oil and gas, with the total market capitalisation actually declining in both a five and a ten-year window. A large contributing factor to this poor performance is metal prices that have been depressed for extended periods, certainly for longer than most analysts predicted, and increased price volatility. Consequently, producers have typically struggled to make profits and realise adequate investor returns in the last decade (Deloitte, 2019:67; Dwyer et al., 2011:49–58:57).

Even though the performance of mining and metals improved on the back of higher commodity prices in 2018, investors and other stakeholders did not respond positively and key metrics such as market returns and valuations remain low. Therefore, market sentiment is not in favour of the major producers with many analysts stating that the industry is yet to demonstrate that it can responsibly create sustainable value for all its stakeholders. Furthermore, dividend yields have actually been on par with the oil and gas and technology sectors since 2011; however, investors have snubbed the industry with the poor performance in share price a clear indictment on the attractiveness of the industry. Subsequently, most commentators hold an unfavourable or indifferent perception on the mining and metals brand (PWC, 2019:4-5).

2.3.5 Operating strategy of the mining and metals industry worldwide

The industry has struggled to adjust to long periods of sustained low metal prices and rising input costs. Many argue that this points towards an inflexible industry that is still following outdated business models which may have worked in the early 2000s but have failed to adjust to current realities. Also, fast-changing market conditions are putting pressure on producers and exposing shortcoming with the “business-as-usual” approach (Bryant, 2016:2).

Producers have embraced a ubiquitous low-cost strategy of producing the highest possible volumes at lowest possible cost while also embracing extreme cost-cutting initiatives. This strategy has left many producers exposed since their profitability is primarily based on external commodity prices with no room left to manoeuvre if the asking price drops below their cost of production (Bryant, 2016:2).

Subsequently, long-term investment, R&D and further capital expenditure become difficult to justify once the commodity price is depressed or during periods of exaggerated volatility. In essence, the short-term strategic response becomes a self-fulfilling prophecy with operations eventually losing value in the medium to long term. Conversely, a good argument can be made that long-term investment is needed exactly when times are difficult to promote sustainability (Bryant, 2016:1-3,10-12; Leach, 2014:4; Mineral council of South Africa, 2018a:4).

Given the increased pressure on producers and the fast-changing operating environment, mining and metals companies will benefit from a shift in focus by changing their strategic approach to develop differentiated business models that drive long term value and wealth creation, as opposed to the old driver of low-cost only which has been shown to destroy value in the long term. Therefore, the outdated strategy of simply increasing the scale of operations has likely come to an end. The prevailing thought is that metal producers should strive towards increasing value in all aspects of their business. This means embracing a modern 4P business model, as discussed in section 1.1, with a focus on overall wealth creation and sustainability. Redefining the traditional drivers for success will force the industry to change the way it is doing business at a fundamental strategic level.

It is fair to assume that innovation and the adoption of technology are key elements that facilitate this shift in thinking. Indeed, this change in mindset may already be long overdue.

2.3.6 Overview of the mining and metals industry in South Africa

South Africa is a mineral-rich country with an abundant supply of commercially exploitable ore deposits characterised by high concentrations of various minerals. Due to the inherent mineral wealth of the country coupled with the visionary leadership of many early industrial pioneers, a strong mining and metals industry was created to extract and beneficiate minerals during the last century. Furthermore, due to the historic low cost of electricity and various government incentives a strong pyrometallurgical base was also established which includes the downstream furnaces, refineries and processing plants required to cover the entire metals value chain and deliver finished goods to market, a true “pit to port” offering. Given this level of investment and commitment, the South African industry emerged as a global player in the last century. Despite a contraction of the industry in recent years, at least 18 different types of metal commodities were produced in more than 60 pyrometallurgical plants within South Africa in the last decade (Steenkamp & Basson, 2013:667–676:667).

Given its proud history and large installation base, South Africa is considered as the primary mining player within the sub-Saharan African (SSA) market. It is home to the largest mining sector in the region coupled with one of the most sustainable, ample and diverse ore reserves globally including, but not limited to chrome, platinum, gold, manganese, silicon, ilmenite and iron ore. The mining industry is a notable source of employment and an important contributor to the South African economy, thereby generating wealth for society. As of 2016, the chamber of mines of South Africa estimated that the mining industry was directly responsible for the following stimulus expressed as a percentage of the total economy (Baxter, 2016:19-20):

- (i) Foreign direct investment (15-25% of total foreign investment);
- (ii) Private investment (20% of total private investment);
- (iii) Mineral exports (30-35% of total exports);
- (iv) Government revenue (6-8% of total taxation income);
- (v) Gross domestic product (7.7% contribution to total GDP); and
- (vi) Employment with 1.4 million direct jobs in the mining sector in 2015 (8-15% of total employment).

South Africa is still viewed as having a lucrative mining industry, recently being ranked as the third most attractive country in SSA for investment based on a risk-reward score derived from multiple metrics as plotted in Figure 2-5. However, it should be noted that SSA's mining and metals sector is also the region with the highest risk globally. Therefore, South Africa was only ranked 31st out of 61 countries on the global risk-reward index (BMI, 2017:36-52).

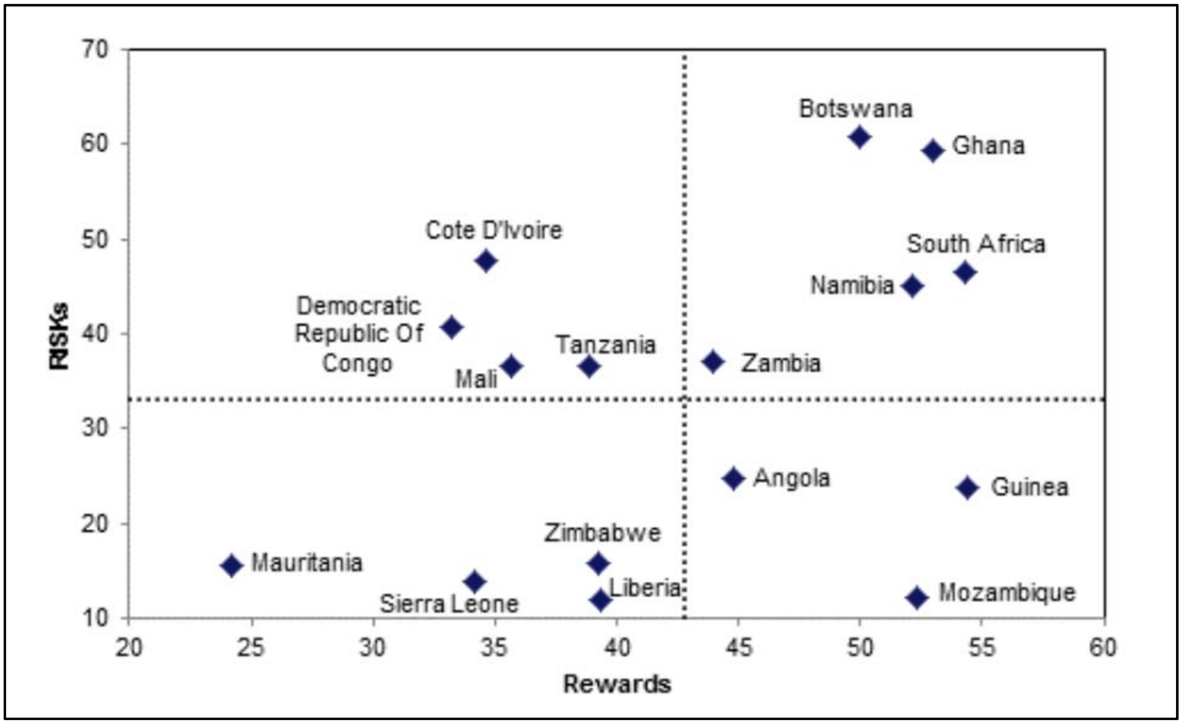


Figure 2-5: Mining risk to reward index for sub-Saharan Africa

Source: (BMI, 2017)

Figure 2-5 displays a graphic plot of the risk-reward index showing potential rewards on the horizontal axis and potential risks on the vertical axis. A higher score indicates a more attractive market. The primary factors that are positively impacting South Africa's reward rating are as follows:

(i) Highly developed mining sector with the largest installed base in SSA and a strong competitive landscape including a variety of major and minor players;

(ii) Above average infrastructure development;

(iii) Low country risk; and

(iv) Economic openness with a superior banking and financial services sector.

As discussed, its sheer installed capacity and the abundance of natural resources alone make South Africa an attractive destination for mining investment; however, there are also very real risks associated with potential investment. More specifically, the primary factors that are negatively impacting South Africa's risk rating are as follows:

(i) An increased regulatory burden associated with the new mining charter which will drive up compliance costs and further dictate ownership and procurement rules;
(ii) Political risks, including policy uncertainty and high levels of government intervention;
(iii) High levels of government corruption;
(iv) High labour costs and incidents of labour unrest;
(v) High energy costs coupled with power supply uncertainty; and
(vi) Low mining and metals sector growth rate.

The primary issues can be demarcated as "country risks" that are mostly political in nature and typically a result of poor governance, thus creating uncertainty regarding the future of the nation. These conditions have led to a decrease in investor confidence, adversely affecting the forecasted growth rate and investment in the sector (BMI, 2016:42).

In summary, the mining and metals industry in South Africa has both significant positive and negative factors associated with it, which will ultimately dictate future investment and operational requirements. However, it should be noted that the current trend is negative, with ongoing divestment coupled with a contraction in market volume due to internal country dynamics, external market forces and macro-economic conditions.

2.3.7 Performance of the mining and metals industry in South Africa

Refer to Figure 2-6 displaying total industry production per year in a five-year period with the total tonnes produced on the first vertical axis and the rate of change per year plotted on the second vertical axis. A total market volume of 254 million tonnes was achieved in 2017, which represents a reduction in volume based on a compound annual rate of change of 0.6% over the period from 2013 to 2017 (Marketline, 2018b:10).

Furthermore, in terms of total market value, the industry hit an all-time peak of US$48.8 billion in 2011 based on revenues from the aluminium, iron & steel, precious metals, coal and base metals markets. This figure is corrected for historical exchange rates (Marketline, 2018a:7-10; Theron & Volk, 2015:363).

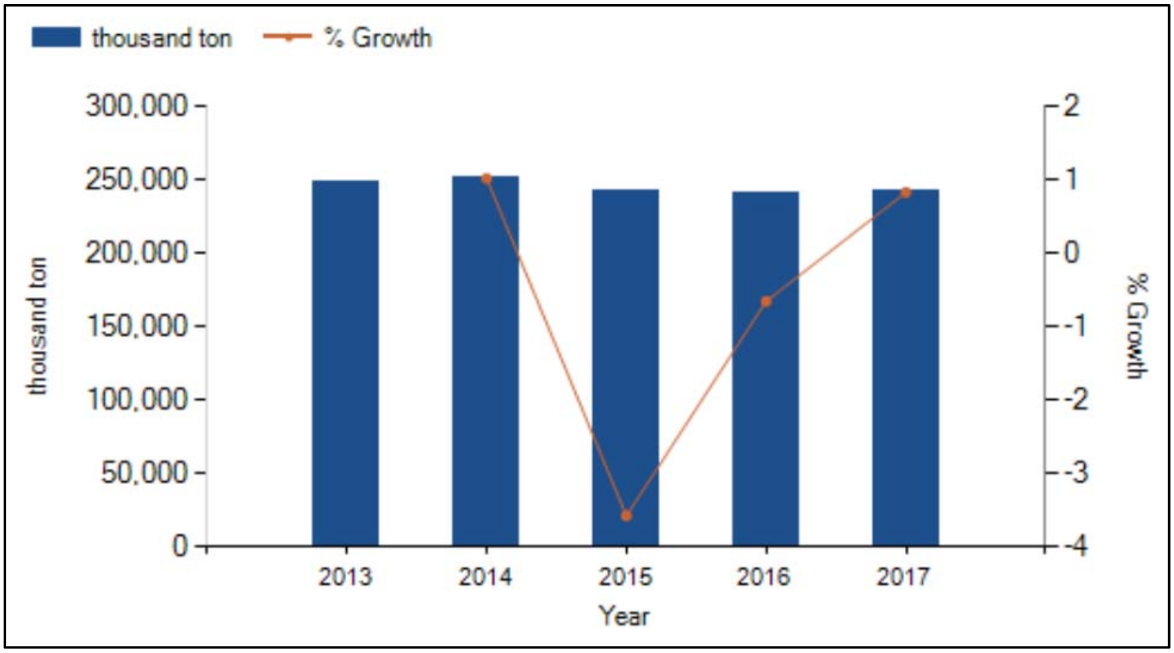


Figure 2-6: Market volume of the South African metals and mining industry in thousand tons produced

Source: Marketline (2018a:10)

However, the South African mining and metals industry has been in steady decline ever since. The actual five-year compound annual growth rate (CAGR) did not come close to the projected CAGR of 8.1% that was expected back in 2011, with the market actually contracting over the period. Many years were marked by large contractions, with an overall market value reduction of 12.8% and 6.3% reported in 2014 and 2016 respectively. Moreover, current projections of market value now forecast a further reduction of 1.5% in the next five-year window from 2017 to 2022. Refer to Figure 2-7 displaying total market value on the first vertical axis and the rate of change (or rate of contraction in this case) on the second vertical axis (Marketline, 2018a:7-10; Theron & Volk, 2015:363).

The result is that the projected market value in 2022 is less than the peak value that was achieved in 2011, thus resulting in a projected contraction of the market over an eleven-year window. This performance in South Africa confirms the argument presented by Bryant (2016:2) in section 2.3.4, claiming that there has been a destruction of value in the global mining industry since the early 2000s. Therefore, the need for a change in thinking and operating models in the industry becomes more necessary (Bryant, 2016).

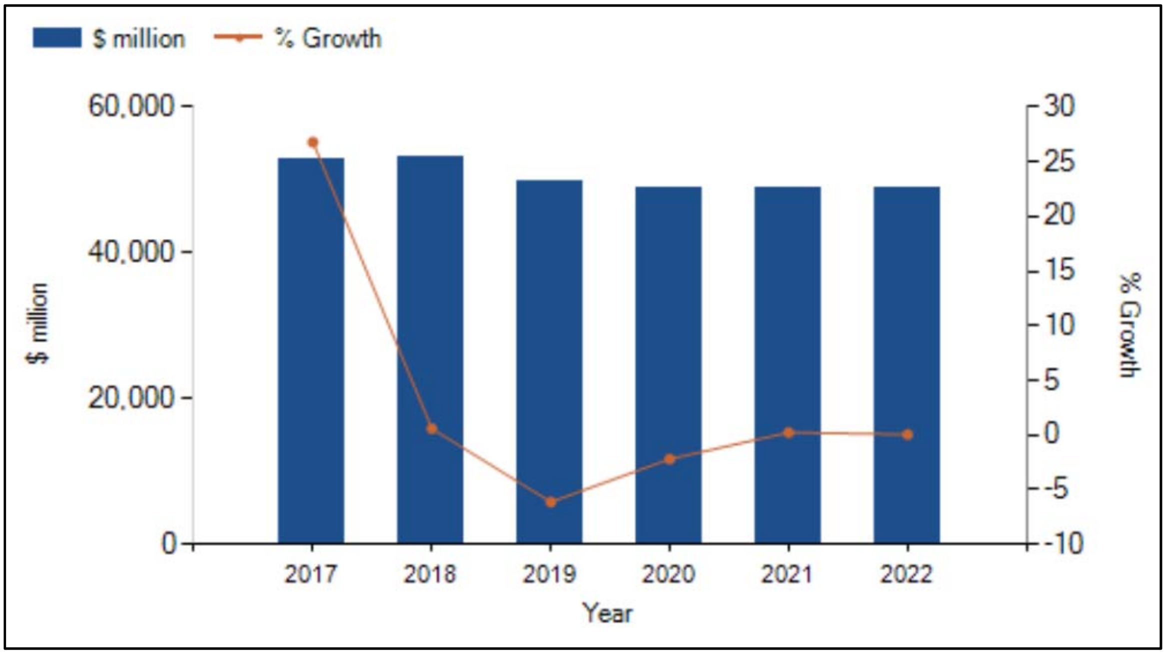


Figure 2-7: South African metals and mining industry value forecast in millions of US dollars
Source: Marketline (2018:9)

In summary, market sentiment points towards a South African industry that is very much at a cross roads as industry investors are faced with uncertainty in the medium to long term. Currently, major producers are in a difficult position with many companies choosing to divest out of the country to mitigate their risks. Typically, the upfront mining and beneficiation activities remain in the country, since the ore must still be extracted out of the ground, but the downstream smelting and refining steps at the back end of the value chain are moved abroad.

Subsequently, the overall market trend is pointing towards a contraction in operations and ongoing divestment at least in the short to medium term. However, divestment may be a poor choice in the long term as there may be an opportunity cost associated with missing out on future rewards should the industry turn around. Therefore, a case can also be made for operators to maintain and even expand operations within the country to position themselves for future gains.

It is expected that the South African mining sector will continue to face persistent challenges, mainly due to low commodity prices, retrenchments, energy supply issues, further divestments by producers and labour unrest. However, despite very real challenges and risks, South Africa remains an attractive destination for mining based solely on the potential rewards offered should the country resolve some of its many internal problems. In support of this view, when taking all factors into consideration South Africa’s risk-reward index (RRI) rank is still third out of sixteen countries in the sub-Saharan African (SSA) region in terms of mining investment (BMI, 2016:7).

2.3.8 The role of innovation in industrial relations and corporate social responsibility for the mining and metals industry in South Africa

Pressure is constantly exerted on producers by trade unions to increase the monthly wages and benefits of workers, with many of the demands often being unrealistic such as unions calling for a doubling of wages for unskilled workers. Current wage hikes and potential future wage hikes increase pressure on operating margins and drive a wedge between workers and producers, who are not willing or often unable to consent to the demands of unions. Subsequently, to alleviate the financial pressure caused by wage increases, producers have reduced the total number of employees in industry as part of cost cutting measures and “sweating existing assets” (BMI, 2016:20).

This trend is not unique to South Africa, since large international producers have also reduced head counts. However, in the South African context this trend is also inflaming the current inequality problem and may compromise long-term operational sustainability as a lack of knowledge transfer programmes will only increase existing skills gaps. Conversely, the counter-argument can be made that producers are reducing head counts to improve the safety of employees by removing them from high-risk working situations through automation (BMI, 2016:20).

Regardless whether the motivation is one of reducing cost or of improving safety, a trend is emerging where some progressive producers are starting to streamline operations by replacing ”many minimum wage jobs” with “fewer higher skilled jobs”. This gradual change coupled with an overall reduction of employees can only be sustainable and effective if labour is assisted in terms of technology adoption and if the ever-present skills gap is addressed.

The implication for the industry is that cheap labour in South Africa is soon becoming a thing of the past. Moreover, the combination of increasing wages, safety concerns, labour unrest and a growing skills gap is supporting the business case for further automation and technology adoption. However, the qualification is that sufficient skilled labour should be available to enter these higher skilled jobs with innovation potentially being a vehicle to uplift the labour force.

2.4 OVERVIEW OF THE FERROALLOY INDUSTRY

2.4.1 Ferroalloy: definition and use

The term ferroalloy is a collective noun that refers to various alloys of iron combined with one or more elements such as manganese, chromium, silicon and so forth. It is fundamentally an intermediate product that forms part of the larger metals supply chain. Ferroalloys are primarily utilised as raw materials that are added to steel melts during the manufacturing process of iron and steel to (Eric, 2014):

(i) Impart distinctive qualities to the final iron or steel product, such as improving the mechanical properties of the steel or improving corrosion resistance; and
(ii) Aid in steel refining as well as the desulfurisation or deoxidisation of the steel and to control inclusions.

The main ferroalloys listed in alphabetical order are (Eric, 2014:477; LPI, 2019:1):

(i) Ferrochromium (FeCr);
(ii) Ferromanganese (FeMn);
(iii) Ferromolybdenum (FeMo);
(iv) Ferronickel (FeNi);
(v) Ferrosilicon (FeSi);
(vi) Ferrotitanium (FeTi);
(vii) Ferrovanadium (FeV); and
(viii) Ferrotungsten (FeW).

Ferroalloys can be further classified into two groups, the bulk (major) ferroalloys and the minor (noble) ferroalloys, with bulk ferroalloys representing by far the largest portion of global production. The equipment and pyrometallurgical processes required to produce the different types of bulk ferroalloys are similar, with all of them making use of large furnaces. Minor ferroalloys are a relatively small portion of global production and are primarily used for speciality applications and will not be considered as part of this study.

2.4.2 Ferroalloy industry worldwide

Since the iron and steel industry is the primary consumer of ferroalloys, the performance of the ferroalloy industry is closely related to the demand for iron and steel, with commodity prices historically correlated for both markets. Ferroalloys are used in lesser amounts in other markets to produce cast iron and nonferrous alloys and more recently in the manufacturing of batteries. Globally, the leading ferroalloy producing countries are Brazil, China, Kazakhstan, Russia, South

Africa and the Ukraine, with a worldwide annual peak production of 43 million tons recorded in 2010. A peak production in steel and stainless steels was recorded in the same year. Production has declined in subsequent years due to less favourable conditions in leading world economies (Eric, 2014:477; LPI, 2019:1).

An accurate record of the global installed base of ferroalloy furnaces is not available. However, best estimates indicate an installed base of more than 1,500 ferroalloy furnaces globally. Furthermore, the size, age and level of sophistication of operational furnaces vary significantly, ranging from small, basic furnaces built in the 1940's to large, modern, integrated furnaces that dwarf the capacity of older units (Nelson, 2014:40).

However, the essential components, technology and production techniques have not changed fundamentally for more than 70 years, with ferroalloy products still primarily produced by smelting raw materials in electric arc furnaces. Eric (2018:25–28:6) criticises the apparent lack of technological progress in the ferroalloy industry and specifically critiques the industry for

(i) Being poorly integrated into the overall product value chain;
(ii) Operating with outdated processes and installations;
(iii) Requiring large amounts of electrical energy; and
(iv) Producing large amounts of carbon dioxide that contribute negatively towards climate change (Eric, 2018:25–28; Oliveira, 2017).

Subsequently, production is still very energy-intensive and heavily dependent on the grade of ore used. Therefore, the availability, reliability and cost of electricity and the quality and cost of feedstocks are key considerations for producers given current technology. In addition, input costs are very variable with raw materials and electrical power being the largest cost contributors, with power cost typically in the range of 25% to 55% of the total cost of production, depending on regional power pricing and the commodity in question (Biermann *et al.*, 2012:301–308:302).

2.4.3 Business drivers and innovation focus for the ferroalloy industry

The typical ferroalloy producer's primary motivation is to operate at the lower end of the cost curve, with an ongoing drive to reduce cost of production being a key feature of the industry. The key objective of lowering costs is quite rational when offering a commodity product into a competitive market. However, one has to question the continuing desire of producers to focus on reducing overheads and fixed costs, as this contribution has a relatively small impact on total cost of production and following many years of focus any further improvements will only result in marginal benefits (Biermann *et al.*, 2012:301–308).

Nelson (2014:46-47) compares the installed capacities and commissioning dates of ferroalloy furnaces over the last 90 years and makes the point that there has been a steady increase and progression of furnace capacity over time with the clear emergence of mega-scale furnaces becoming the new norm in the industry. A plethora of smaller furnaces still exists, with their main advantage being the flexibility to quickly enter and exit production and even swing production between different commodities based on market conditions. However, despite the increase in scale, the electric furnaces of today are very similar to those from yesteryear. This is an indication that innovation has taken place predominantly at the core level with incremental advancements only. Therefore, there is a clear lack of adjacent or transformative (disruptive) innovation in the industry (Eric, 2014:6; Nelson, 2014:46-47).

It seems that many producers have become insular in their approach towards innovation and technology adoption and are collectively falling into the trap defined by Christensen (2016) as the innovator's dilemma, wherein, despite making apparently logical and competent decisions by following principles that worked in the past, producers are losing market share and are destroying potential business value. Following this rationale, sound decisions which may have been situationally correct given past circumstances are now causing producers to lose their position of market leadership and could ultimately lead towards failure without strategic adjustment. Ultimately, most producers have failed to cross the innovation chasm and are very much reliant on external factors for survival (Bryant, 2016:2; Christensen, 2016:xvii).

In the absence of benefitting from adopting new adjacent or disruptive technologies, external factors overwhelmingly dictate the position of various producers on the cost curve. Therefore, one of the few levers left to large producers is to consider the location of their assets, with producers typically evaluating the trade-off between having more integrated operations close to raw materials or close to market to save on logistics costs versus building plants in regions with low cost power agreements, as inexpensive power is of the few competitive advantages available to producers operating with current technology (Biermann *et al.*, 2012:301–308:302).

These findings confirm the argument that the industry has historically focused on increasing the scale and throughput of operations (refer to section 2.2.2 and 2.3.3), with the primary goal being to dilute fixed costs. However, Nelson (2014:46-47) argues that a producer's ultimate goal should be profitability, therefore productivity and operational intensity should take precedence over sheer furnace size for future development. This argument advocates embracing disruptive innovation and adopting technology and processes capable of reducing the large variable cost burdens through working towards positive change. Furthermore, when considering cost cutting initiatives, a longer-term and more sustainable re-engineering strategy is preferable and its development demonstrates that the industry recognises the limitations to the short-term reactive focus (Johnson, 2016; Nelson, 2014:46-47).

2.4.4 Ferroalloy industry in South Africa

South Africa is a mineral rich country (refer to section 2.3.6) that also has extensive deposits of economically extractable ore reserves suitable to produce various ferroalloys. In terms of ferroalloy production, South Africa is in an enviable global position with an abundance of the following raw materials:

(i) The largest concentration of land-based manganese ore in the world, used to produce ferromanganese and silicomanganese. More than 80% of the world's known reserves are located in South Africa (Basson *et al.*, 2007:8; Steenkamp & Basson, 2013:667–676:667);

(ii) The largest reserves of chromite ore in the world, used to produce ferrochrome. More than 75% of the world's known economically extractable reserves are located in South Africa (Basson *et al.*, 2007:8);

(iii) Significant reserves of vanadium, used to produce ferrovanadium. More than 30% of the world's known reserves are located in South Africa (Basson *et al.*, 2007:9); and

(iv) Significant reserves of quartzites used to produce ferrosilicon and silicon, although this is quite a common mineral globally.

A strong ferroalloy industry was established during the last century, with South Africa emerging as a leading supplier of bulk ferroalloys to the global market. Historically, its competitive advantage was attained primarily due to

(i) An abundance of natural resources;

(ii) The historic low cost of electricity; and

(iii) A relatively inexpensive cost of capital.

The combination of these factors created optimal conditions for the production of ferroalloys, and subsequently South Africa has a large installed production base, including more than a hundred furnaces (Basson *et al.*, 2007:6; Mahony & Baartman, 2018:1).

However, a clear trend has emerged in the last decade wherein the beneficiation of the raw ore and smelting of the ferroalloy product is moving abroad primarily due to rising input costs, uncertainty around government policies and labour unrest. More specifically, unfavourable economics due to the increasing electricity cost and lower commodity prices have hit the industry hard. Therefore, subsequent divestment has been taking place in the ferroalloy industry with many global producers exiting the market, which has resulted in the closure of multiple furnaces in the last five years. Consequently, South Africa is increasingly selling its raw ore into the global market for further processing and mothballing existing production units at the back end of the value chain (Steenkamp & Basson, 2013:667–676:667).

Despite ongoing challenges and an ever-shrinking employment base the Ferroalloy Producers Association (FAPA) of South Africa in a recent letter to president Ramaphosa stressed that the industry is still responsible for about 18 500 direct and 129 000 indirect job opportunities. FAPA further argued that the industry adds value to local ore, which is a central concern of the policy framework of government, and coupled with the obvious economic benefits and retention of the workforce, the industry should be supported for the good of the country (Slabbert, 2019; Steyn, 2019).

FAPA members include most of the large ferroalloy players in the South African market, including Samancor Chrome, Glencore, Richards Bay Minerals, Assmang. South 32, Silicon Smelters, Transalloys and SA Calcium Carbide. The only notable player that is not referenced in FAPA press releases is Ferroglobe.

2.4.5 Challenges facing the ferroalloy industry in South Africa and cost-cutting initiatives

Faced with the ongoing challenge of rising input costs and lower commodity prices, producers have long been focussed on aggressive cost-cutting initiatives. Subsequently, a mentality of cost-cutting, above all else, has become deeply entrenched within the South African ferroalloy industry characterised by a strategy of "first wave" and "second wave" cost cutting, which was developed from 2012 onwards (refer to Figure 2-8). These strategies have generally been focused on short-term gains, or quick-wins, requiring the least amount of effort and resources. However, the majority of these initiatives are non-sustainable – examples are cancelling projects, stopping exploration, reducing head count and "sweating assets" through reduced maintenance and increased throughput (Odendaal, 2018; Whyle, 2016).

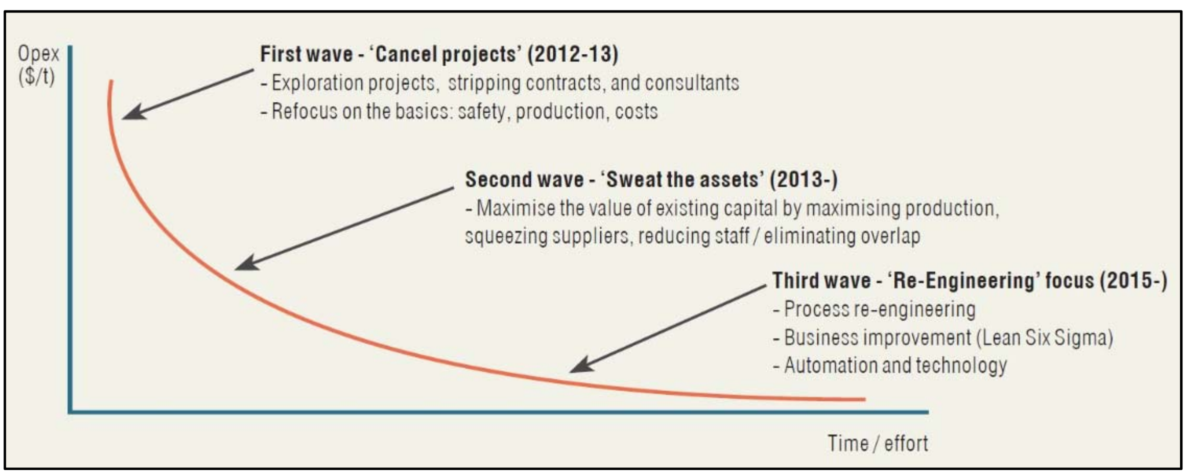


Figure 2-8: The three waves of cost cutting in the mining and metals industry
Source: Johnson (2016)

This thinking has resulted in a destruction of long-term value and made it increasingly difficult to embrace adjacent and transformational innovations, and this is increasing the innovation chasm in the industry. The recent emergence of a more sustainable re-engineering approach to reduce operating costs is a positive development. However, many producers have not embraced this approach due to an inherent resistance to change, or simply due to no longer having the required resources available to drive these innovation initiatives. In short, the industry has been focussed on saving its way out of trouble as opposed to innovating its way out of trouble (Bryant, 2016:4; Dibrov, 2015:93; Moore, 2014).

This short-term strategy is not sustainable in the medium term and in recent times many operations have closed down, including ASA Metals, Machadodorp, Richard's Bay Alloys, International Ferrometals, Hernic Ferrochrome, Silicon Smelters and Siltech, amongst others. Furthermore, no new furnaces have been built in the last five years with only three new ferroalloy furnaces being erected in the country in the last ten years. Despite an understanding that change is needed and with the industry now recognising that innovation and technology adoption are required to facilitate this change, the industry is caught in a downward spiral wherein funds are not available or not being allocated to South African operations (Mineral council of South Africa, 2018a:23).

Most operational producers have already reduced operational costs as far as possible and cut overheads to the bone. Subsequently, producers have little room left to manoeuvre and have become heavily reliant on external factors for survival, such as a strengthening commodity price coupled with a weaker currency to boost returns on exports. Capital expenditure is generally very low, and since producers have taken the approach to "sweat their assets" they are generally hesitant to further increase risk by investing in innovations and new technologies.

2.4.6 FAPA initiatives in the ferroalloy industry in South Africa

"If there's one thing the industry does not have, it is time."

(Motloung, 2019), Chairperson of the Ferroalloy Producers' Association (FAPA)

To counter what will likely be an inevitable and slow decline towards obscurity if the status quo persists, FAPA have started an initiative titled, "Save the South African Ferroalloy industry." The aim of this is initiative is to get alignment from local industry, relevant stakeholders and government towards implementing practices and policies that will benefit the industry and allow it to regain its international competitiveness. Moreover, FAPA members and industry experts alike believe that thousands of industry jobs are at risk and that the industry in its current state will not survive without significant changes. Raising input costs, which primarily manifest as increases in electricity price, raw material cost and wage expectations from labour, coupled with the looming introduction of carbon taxes by government haves led many industry leaders to raise serious concerns publicly (Slabbert, 2019; Steyn, 2019).

The chairman of FAPA recently cautioned that the industry has already ran out of time since it has generally reached the end of ongoing and vigorous cost-cutting campaigns (refer to 2.4.5) with almost no scope left for further cost reductions. Even more concerning, some industry leaders have gone on record stating that the industry will not be able to survive for more than two years in its current form. This is indeed a damming report, and it should be clear that FAPA is taking a very aggressive and even desperate stance in an attempt to return to profitability (Slabbert, 2019; Steyn, 2019).

Probably the single most salient challenge facing the ferroalloy industry at present is the rising cost of electricity, which has exceeded inflation for the last 10 years. Ferroalloy producers are significant power consumers with the industry's total electricity consumption accounting for at least 10% of the total power supplied to the grid by Eskom, the state power utility. Eskom has recognised the importance of retaining their key industrial consumer (KIC) base and even proposed implementing a specific tariff for the KIC segment in 2018. However, this tariff was not rolled out and, on the contrary, the electricity price has consistently increased at above-inflation rates. The result is that South Africa's traditional competitive advantage of providing low-cost electricity to international producers has been completely eroded. Moreover, the electricity supply has also become unreliable (Mahony & Baartman, 2018; McKay, 2019:8).

Therefore, South Africa has transitioned from a country with one of the lowest electricity prices globally in 2009, to one of the highest today with the current cost of electricity exceeding that of many developed countries. Eskom is charging local producers between $65 to $70 per megawatt-hour. Comparatively, similar smelters are charged between $40 to 45 per megawatt-hour in the United States of America and $45 to $50 in Spain. At the low end of the range, electricity prices in France are less than $35 per megawatt-hour for industrial metallurgical users, with developing countries such as Kazakhstan and Malaysia charging producers even less while still providing dependable power supply to their customers (Slabbert, 2019).

Given current costs, the electricity contribution to total cost of production is enormous, ranging anywhere from 30% to 55%, depending on the specific ferroalloy produced. Yet again, a very clear problem emerges, demanding innovative approaches towards improving energy efficiency with a clear directive emerging to challenge the status quo and embrace disruptive innovation. Some producers are adopting waste heat recovery technologies; however, others are choosing to maintain the status quo by moving operations abroad and building new smelters in developing regions with low cost power such as Malaysia and even Brazil (Steenkamp & Basson, 2013:667–676).

The FAPA chairman commented, in January 2019, that should the new 15% price increase requested by Eskom be granted, it will result in a large contraction of the ferroalloy industry and Eskom will ultimately loose many of its clients. Mr. Motloung further commented that there was "simply no more place for any digit increases as the industry has already gone through vigorous cost-cutting measures including retrenchments." To the great dismay of the industry, the South African regulator then approved an average price increase of 13.87% which came into effect in April 2019, and which was again way above inflation. Moreover, Eskom is seeking further price increases for 2020, over and above what has already been sanctioned, which could result in an increase of 16.6% in April 2020. With further above-inflation energy increases expected and the introduction of a new carbon tax in 2020, cost pressures are increasing on what is already a stressed industry (Eskom, 2019:2–3; McKay, 2019:8; Steyn, 2019).

2.5 AVAILABLE TECHNOLOGY AND INNOVATION DRIVERS IN THE FERROALLOY INDUSTRY

The fourth industry revolution is currently a buzzword in industry with the promise to incorporate the best elements from the digital world into the physical nuts and bolts plant and equipment environments to streamline, optimise and even disrupt existing operations. Therefore, the upcoming digital revolution has the potential to radically transform the industry and add tremendous value to ferroalloy producers if these technologies can indeed cross the innovation chasm and garner appeal and adoption within the broader the mainstream market (Hermanus, 2017:813; Moore, 2014)

The concept of utilising historic data coupled with predictive data analytics to optimise value and gain insights into operations is a key future trend in industry. Concepts such as the "digital twin," that creates a digital smelter able to mirror the inputs and outputs from a real-world installation, promise better outcomes through an advisory system to support operators with decision making. Furthermore, machine learning, open platforms and the internet coupled with integrating sensors into real-world applications can support decision-making throughout the entire value chain from pit to port. This level of integration was impossible prior to the development of digital platforms and associated visualization tools (Deloitte, 2018:4-5).

Closely linked to advancements in the digital space is the ongoing trend to automate existing operations by mechanising repeatable tasks and hazardous physical operations by removing employees from the danger. Automation also has the potential to increase quality and productivity by reducing human variability and error. In short, given enough time and commitment technology has the potential to increase operational output intensity while reducing human, capital and energy intensity (Deloitte, 2018:4-5; Hendricks, 2016).

Despite the relatively low expenditure on innovation and R&D by producers, there is still a multitude of high-value, viable technologies and equipment available in the marketplace. Further examples include enhanced drilling machines, renewable energy sources, autonomous vehicles and aerial drones. Many technologies have interesting applications specific to the industry that were not necessarily foreseen during the development phases of the technology. It is common for further applications to emerge as an innovation diffuses into the market and becomes better understood (refer to section 2.8.3). For example, the use of aerial drones has evolved to include a variety of applications that require quickly traversing ground which include general monitoring of activities, measuring the volume of a resource, fault detection on electrical networks and even to check whether there are any people in the vicinity of a blast (Hendricks, 2016; Murphy & Walker, 2018).

The innovation imperative for ferroalloys further requires embracing crossovers with other industries, thereby adopting relevant technologies that cut across sectors. A multitude of potential technologies is available that have been successful implemented in other industries with the potential to find a new home within ferroalloys with modification. These technologies could potentially be adopted and further developed in the ferroalloy market and have the potential to create significant value (Hermanus, 2017:813; Jacobs & Webber-Youngman, 2017:637–648).

There is not a shortage of ideas, only a failure to execute the right ideas and an inherent resistance to change in the industry. Although initial teething problems are expected, technologies exist that have the potential to transform what has traditionally been an insular and inward-looking industry. However, there is inherent risk associated with any type of change, and many producers fear losing value in the short term due to a new technology not being well understood, which makes it difficult for technology companies to cross the innovation chasm and penetrate the mainstream market with their products (Johnson, 2016; Lane & Beier, 2015).

2.6 OVERVIEW OF DIFFUSION OF INNOVATIONS

2.6.1 Diffusion definitions and discussion

The theory of diffusion of innovations aims to better explain how and why new ideas, practices and technologies are adopted by individuals, organizations or cultural groups. This theory was first promulgated by Rogers and is based on work done in over 5000 research studies that have built on the literature. More precisely, the study of innovation diffusion relates to better understanding and defining the mechanisms, factors and processes that influence the uptake of specific innovations or new technologies into a target market. Diffusion is essentially the communication between individuals and communication towards individuals about a new idea or innovation with the intent to reduce the inherent uncertainty around the innovation (McCann, 2007:36).

Rogers (2003:5-7) defines diffusion as:

> "the process in which an innovation;
> is communicated through certain channels;
> over time;
> among the members of a social system."

From this definition we can conclude that there are four primary elements necessary for the diffusion of an innovation:

(i) The innovation itself, which for the purposes of this study is analogues to a technology product available in the market;
(ii) The communication channels through which messages related to the innovation travel to individuals, be it through mass media or interpersonal relationships;
(iii) The time it takes for an individual to either adopt or reject an innovation from the first instance they receive knowledge of that innovation; and
(iv) The social system through which the diffusion occurs.

The diffusion process is very complex with many variables affecting the ultimate degree to which an innovation penetrates the target market. Moreover, the speed of the diffusion process and the shape of the diffusion curve also depend on these variables. For the purposes of this study, we are interested in the cardinal or primary variables that affect the speed of diffusion, better known as the rate of adoption of an innovation or new technology product to the market. Diffusion researchers and marketing scholars have long been interested in predicting the rate of adoption of a new product into a market and more importantly understanding what factors increase or decrease this adoption rate (Bohlmann *et al.*, 2010:741–760:742)

Diffusion involves social change and requires communication between participants to share information and reach a mutual understanding. Therefore, the diffusion process is highly dependent on the perception of potential adopters within the market. In fact, the perception of an individual towards a particular innovation is more important than the actual objective performance of that innovation and thus perception drives the decision to adopt or not to adopt. Moreover, diffusion scholars purposefully attempt to measure the perception around an innovation and not the performance of the innovation itself to infer future rates of adoption (Cundy *et al.*, 2014:1522–1526:1522; Moore & Benbasat, 1991:192–222)

Subsequently, the individual characteristics and preferences of potential adopters influence the diffusion process and an individual's perception towards a given innovation is often the governing factor when deciding whether it should be adopted or not (Lamb *et al.*, 2015:328).

2.6.2 Innovation decision process

"As much as change is about adapting to the new, it is about detaching from the old."

Burt (2000)

Before we turn our focus on the factors that predict and affect the rate of adoption of innovations, the process through which an individual goes to reach a concrete decision on whether to either adopt or reject an innovation must first be understood.

Typically, individuals do not make impulse decisions to adopt new innovations or technology products. When learning of an innovation they first seek new information to further clarify the proposition to reduce the inherent uncertainty that is coupled with any new innovation. Moreover, an individual's decision to adopt an innovation can be described as a process that occurs over time involving several sequential steps as presented in Figure 2-9. These steps are heavily influenced by the communication channels through which potential adopters are able to learn more about an innovation at each step in the process (Rogers, 2003:168-169).

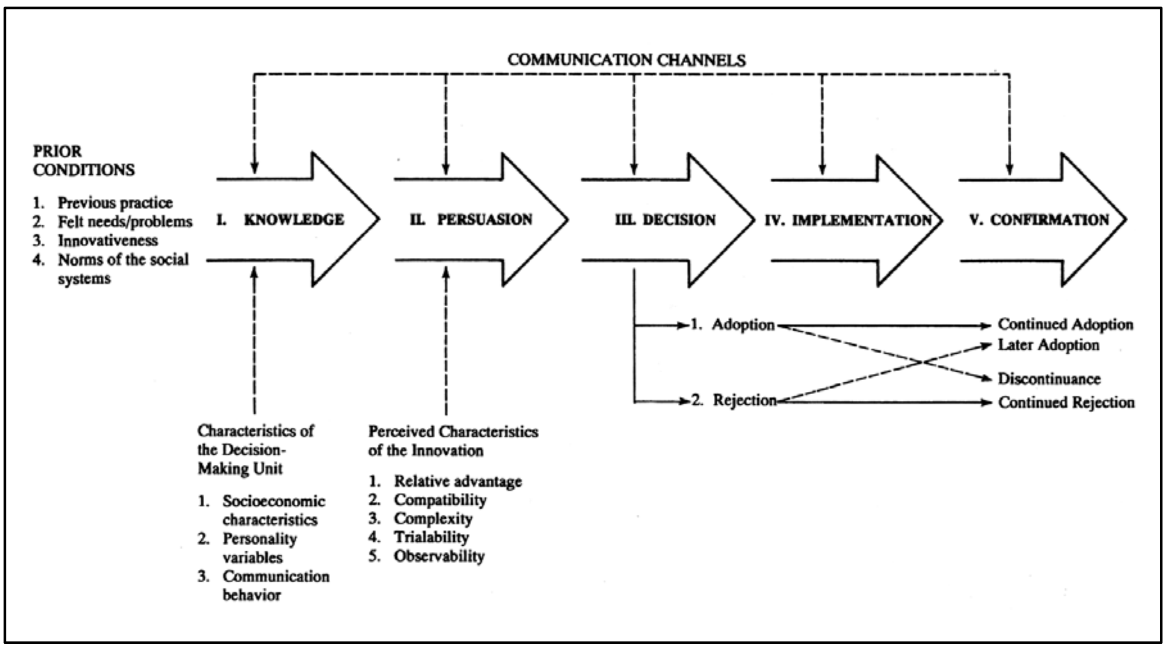


Figure 2-9: A model displaying the five stages in the innovation decision process

Source: **Rogers (2003:170)**

Using this model as basis, Rogers (2003:169-205) defines the innovation decision process as:

> "the process through which an individual passes;
> from first knowledge of an innovation,
> to a decision to adopt or reject,
> to implementation of the new idea
> followed by confirmation of the decision."

Further expanding on this definition and the model presented in Figure 2-9, specific focus will be given to the first three stages in the model, since the objective of this study is to identify the cardinal variables that influence the adoption decision, therefore effecting the rate of adoption and increasing the likelihood of successful diffusion. The implementation and confirmation stages are not relevant to the objectives of this study. The relevant stages can be expanded on as follows:

(i) Knowledge stage (precontemplation)

The first step towards adoption is gaining knowledge about the innovation with the intent to reduce the uncertainty around the consequences of adopting, thus better defining potential advantages and disadvantages. It is important to note that the existing predispositions of individuals influence their behaviour and response towards external innovation messages, regardless of the objective attributes of the innovation. Moreover, the norms of the social system play a large role in forming an individual's initial view of an innovation.

The most common approach companies take to create awareness around an innovation is through mass media channels or personal selling. Subsequently, individuals with a higher socio-economic status and more access to communication channels, such as conferences, publications and change agents are generally the first to learn of the innovation. Therefore, individuals that first come into contact with an innovation can typically be classified as the early market (innovators and early adopters) (Rogers, 2003:205).

(ii) Persuasion stage (contemplation)

The individual then forms a favourable or unfavourable attitude towards the innovation as their knowledge on the innovation increases. This stage is characterized by an emotional response that is much more subjective than the typical cognitive approach used during the knowledge stage. Individuals attempt to interpret the messages that they received related to the innovation and attempt to sort these into credible and false messages based on their own interpretation. Subsequently, they form a general perception about the innovation based on amongst others its perceived attributes or characteristics.

The typical individual will then seek to reinforce their opinion within their social system, checking whether their thinking is in line with the opinion of their peers. Therefore, the subjective opinion of their peers, which is often based on their own personal experience with the innovation, is more convincing and accessible to the individual than objective facts. At this step in the process the influence of interpersonal networks and personal selling become more important than mass media channels.

(iii) Decision stage (action)

The individual then engages in actions either to adopt or reject an innovation. Rejection of the innovation can be active in that the individual considers it and chooses not to adopt it, however it can also be passive wherein the individual does not even consider the use of the innovation although it may be appropriate to their situation. This is barrier that can be crossed by a change agent.

Ultimately, the rate of innovation adoption is based on the cumulative decision by individuals to adopt or to reject new innovations. Moreover, the rate of adoption drives the cumulative market penetration of specific innovations and products.

2.6.3 Resistance to change

Innovation resistance is a well-documented phenomenon that creates conditions which slow down the diffusion of innovations. This is typically due to negative psychological and social reactions towards change by individuals. Moreover, certain organizational environments and bureaucracies create conditions wherein individuals actively resist change. Therefore, these barriers have to be crossed and it often takes time for social groups to adapt to new ideas and innovations (Dibrov, 2015:93).

Producers often fall into the trap of focussing so much on daily operations and in getting the most out of already installed equipment that they don’t strive to innovate and improve their operation in the long run. Moreover, due to the risk-averse nature of producers, any available capital investment is typically spent on the expansion of current capacity, essentially a case of business as usual on a larger scale. This lack of vision and long term strategy often leads to an acceptance of the status quo and an inherent resistance to change (Theron & Volk, 2015:364-365).

2.6.4 Personal innovativeness

Rogers (2003:5-7) defines innovativeness as:

> "the degree to which an individual;
> is relatively earlier in adopting new ideas;
> than other members in a social system."

From this definition we can conclude that personal innovativeness is a relative measure of human behaviour with the potential to predict an individual's response to a given innovation. Moreover, personal innovativeness is a normally distributed personality trait that informs the likelihood of a person adopting what is perceived to them as being a new technology. Moreover, individuals with a high degree of personal innovativeness are more willing to change and therefore are much more likely to embrace new products or services (Wells & Nieuwenhuis, 2018:445).

Individuals respond differently to an innovation or technology product based on their personal perception of the product. It is important to realize that a key driver for innovation diffusion is the perception that an individual holds towards a product, and often not the objective properties of the product itself. Therefore, the perceived attributes of a technology product have a greater impact on the decision to adopt than the actual utility of the technology itself. Moreover, these perceptions are based on the specific personality traits, preferences, appetite for risk and social makeup of the individuals (Tanye, 2016:10).

As with many physical attributes and character traits, research has proven that members of a social system can also be effectively categorized according to idealized adopter types with the aid of a normal distribution as demonstrated in Figure 2-10. The mean represents the average innovativeness of the population and from that point the idealized adopter types can be defined as follows (Rogers, 2003:281):

(i) The early majority and late majority each make up one standard deviation of a typical population group, thus 68% or two thirds of all people into a social system fall into one of these two categories.

(ii) The early adopters typically makeup 13,5% of the population and fall between one and two standard deviations away from the mean, thus they are not that far removed from the social norm.

(iii) Innovators are the most innovative type of people, but makeup a small fraction of the population at only 2.5% and fall far away from the mean and accepted social norm, since they possess traits that are more than two standard deviations away from the average of a population.

(iv) Laggards are the least innovative type of people and are typically the last to adopt a given innovation. This includes all people that fall more than one standard deviation away from the norm in a social system.

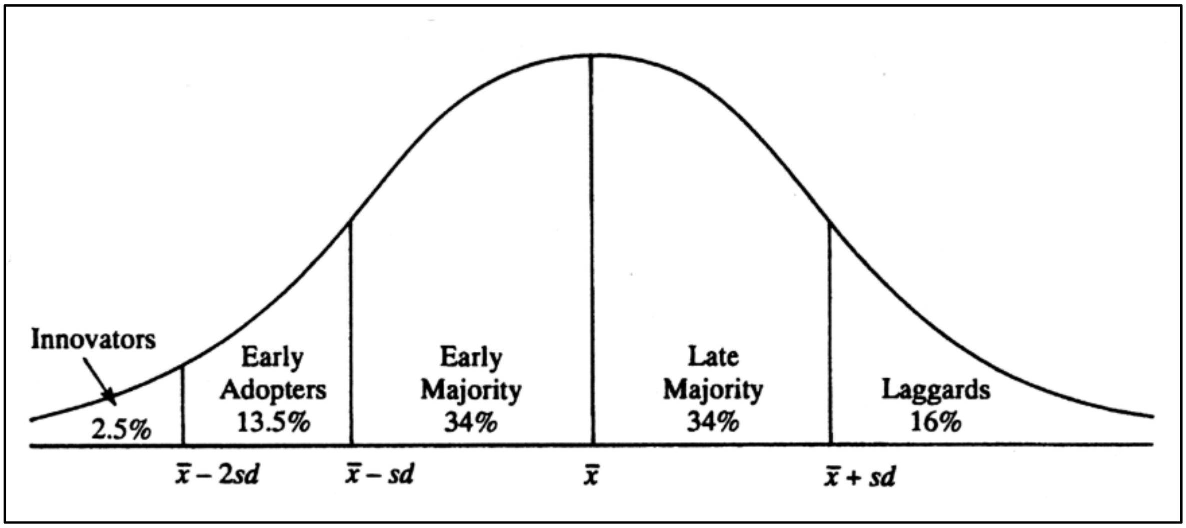


Figure 2-10: Technology adoption life cycle with adopter categories.
Source: Rogers (2003:281)

As discussed in section 2.4, the ferroalloy industry presents many unique challenges that producers are forced to navigate in order to build a successful operation. Subsequently, the inherent conservative nature of producers is likely a rationale response towards high degrees of risk, uncertainty and volatility. Therefore, it is expected that the personal innovativeness of employees working directly for ferroalloy producers will be relatively low. Conversely, the personal innovativeness of technology companies and service providers doing business with producers is expected to be higher since these individuals are constantly promoting new technology products and engaging producers around changes in order to improved their operations (Foss, 2013).

2.6.5 Adopter categories

"Be not the first by whom the new is tried, nor the last to lay the old aside."

Pope (1711)

Adopter categories are assigned based on the personal innovativeness of individuals within a social system, with five idealized categories being the historic guideline that is still used today in order to standardize further diffusion research. Refer to Figure 2-10. These adopter groups have been assigned based on the amount of time that passes before an individual adopts a certain innovation after learning about it for the first time (Tanye, 201611).

When plotting the number of adoptions over time absolute a normal distribution emerges that is then further separated into adopter categories, which makes it very helpful in understanding and classifying the behaviour and response of individuals in the social system. It is important to note that a specific individual may fall anywhere on a continuum of this scale from innovator through to laggard and thus he or she may have characteristics relevant to two adjacent adopter groups However, very real qualitative differences still exist between these different adopter groups, especially when potential adopters are faced with transformational (disruptive) innovations. These changes manifest in terms of product needs, buying behaviour and willingness to adopt (Moore, 201421; Rogers, 2003:281)

The five adopter groups are described in more detail and clearly defined in the section below (Rogers, 2003:270):

(i) Innovators (technology enthusiasts)

These people learn about technology for the sake of technology alone. They are eager to try out new products and ideas almost to the point of it being an obsession. Typically, these people are at the top end of the socio-economic scale and subsequently they are also able to be more active outside of their local communities and are also able to readily interact with people outside of their community and industry, thus they are more worldly and cosmopolitan. They tend to be better educated, have higher incomes, are more self-confident and rely less on group norms and pressures.

However, in terms of a normal population distribution these people represent a small fraction of the population and fall more than two standard deviations away from the social norm. Therefore, they are generally seen as outsiders in the social system and have very little influence on buying decisions and technology adoption of the majority. Innovators are typically the target market during the launch of a new product, which coincides with the introductory stage of the product life cycle. From the perspective of product diffusion, the key role of the innovators is that they are actually willing to change and adopt a new product while also acting as the gatekeepers into the early adopter markets.

(ii) Early adopters (visionaries)

These people adopt relative early in the product's life cycle. When compared to the innovators they typically rely more on group values and norms to make buying decisions. Due to their close affiliation with local groups and communities they are far more likely to influence buying decisions and are often seems as opinion leaders that the mainstream market can turn to for advice.

Early adopters are typically the target market during the late introductory stage or early growth stage of the product life cycle. From the perspective of product diffusion, the key role of early adopters is to influence the majority. Moreover, early adopter see great potential in the technology for personal gain should the adoption prove to be successful and often view the technology as a means to get ahead in their working environment.

(iii) Early majority (pragmatists)

These people adopt an innovation just before half the population has already adopted it and also represent a large part of the population. They are best described as pragmatists that carefully weight up the pros and cons of innovations and new products before making the decision to adopt. Thus, they are likely to collect more information around an innovation in an attempt to evaluate it and display a planned deliberateness in their adoption action as opposed to the impulsiveness that is often presented by the earlier adopters (innovators and early adopters).

They rely strongly on the group for information and are unlikely to be opinion leaders themselves. Therefore, they are typically strongly influenced by opinion leaders, mass media and personal selling by peers. Only once a technology company has gained a foothold in the early majority market they are assured of future diffusion of their innovation and ongoing product sales. However, gaining a foothold in the early majority market is the key challenge in crossing the innovation chasm and this is not always so easy to achieve. Moreover, the sheer size of this market segment promises increased product turnover due to increased sales.

(iv) Late majority (conservatives)

These people adopt an innovation after more than half the population has already adopted. Similar to the early majority they also represent a large part of the population. They are best described as conservatives or even sceptics, that only adopt a new product because most of their friends or peers in industry have already adopted it. Therefore, they rely heavily on existing social norms and as such are heavily influenced by peer pressure. Their desire to conform to the social system drives their need to adopt, since they are in turn pressured by the early majority to complete the adoption process. They prefer to hold on to existing beliefs and ways of doing things.

They tend to be on the lower end of the scale in terms of income and education level. Lamb *et al.* (2015:329) further argues that the late majority tends to be older than earlier adopters, however Rogers (2003:288) refutes this claims and points out that more than half of the many diffusion studies show no relationship between age and adopter level while others show that earlier adopters are both older and younger. The late majority typically depend primarily on word of mouth communication. The late majority are the target market during the maturity stage of the product life cycle.

(v) Laggards (sceptics)

These people are the very last to adopt an innovation. They do not rely on group norms at all, nor are they influenced by their peers. Like innovators, they act completely independently, however as innovators are forward thinking, laggards are very much routed in the past with heavy ties to tradition. The past is their frame of reference and drives their decisions and adoption behaviour, thus they tend to be suspicious of new products and generally resistant to change.

Laggards typically have the lowest socio-economic status from all the adopter groups. Since these people are apparently not influenced by personal selling or marketing messages through advertising, marketers often ignore this segment all together as any effort to reach this audience is viewed as wasted effort. Laggards will often only adopt a new innovation well into its maturity phase or typically during the decline phase of the product life cycle out of necessity.

The key point here is that different adopters perceive innovations is a different way. A marketing strategy can only be effective if an innovation is targeted towards a specific adopter group based on the progression through the diffusion curve. (Moore & Benbasat, 1991:192–222:194).

2.6.6 Diffusion networks and communication channels

The social networks and its structures has a significant effect on adoption rate and diffusion processes. This is logical since diffusion is inherently a social process that requires communication between individuals to drive market penetration. Subsequently, interpersonal channels are important means of changing attitudes and beliefs regarding an innovation, especially during the persuasion stage (Pescher & Spann, 2014:1630–16371631).

Despite the high level of importance of social networks in driving the rate of technology adoption, further discussion is not warranted since the objective of this study is to determine what perceived characteristics should be communicated thought these networks to drive the rate of adoption. It is important to realize that the communication channels are the vehicle that get the information to potential adopters.

2.6.7 Opinion leaders and change agents

Opinion leaders and change agents are present in any social system and play an active role in persuading potential adopters to either adopt or reject a given innovation. Change agents are often humans within the social system, but can also be viewed as an optimal set of conditions that create the incentive to change. Moreover, the socioeconomic status of individuals heavily influences the degree to which they will have contact with change agents and therefore also influences their personal innovativeness (Rogers, 2003:159)

2.7 MECHANISMS OF INNOVATION DIFFUSION AND MARKET PENETRATION

Once an appropriate innovation exists that addresses market needs, even when its benefits are clearly demonstrated, there is no guarantee that it will further spread or diffuse within the marketplace. Moreover, superior technological innovations with obvious advantages do not diffuse themselves into use and most innovations diffuse at a disappointingly slow rate with many never penetrating the market in a meaningful way (Rogers, 2003:7-11).

2.7.1 Product life-cycle and market diffusion

Technology companies depend on the introduction of new products into their existing product mix to stay relevant and remain competitive in today’s fast-changing business environment. Typically, technology companies have a range of offerings with products and services at different stages of maturity and varying degrees of penetration into the target market segment (Lamb *et al.*, 2015:303-305).

Product sales typically follow a predictable curve based on a product’s market acceptance and rate of growth. This curve is known as the product life cycle as plotted in Figure 2-11 and describes the total sales per year over time. The shape of this sales curve for a specific product is dependent on many variables, amongst others the competitive landscape, product category, marketing mix, cost point, customer needs, target industry and external factors such as the economic and political landscape. However, the general trend line is typically similar for a variety of products and thus the curve can be divided into four distinct stages, namely introduction, growth, maturity and decline.

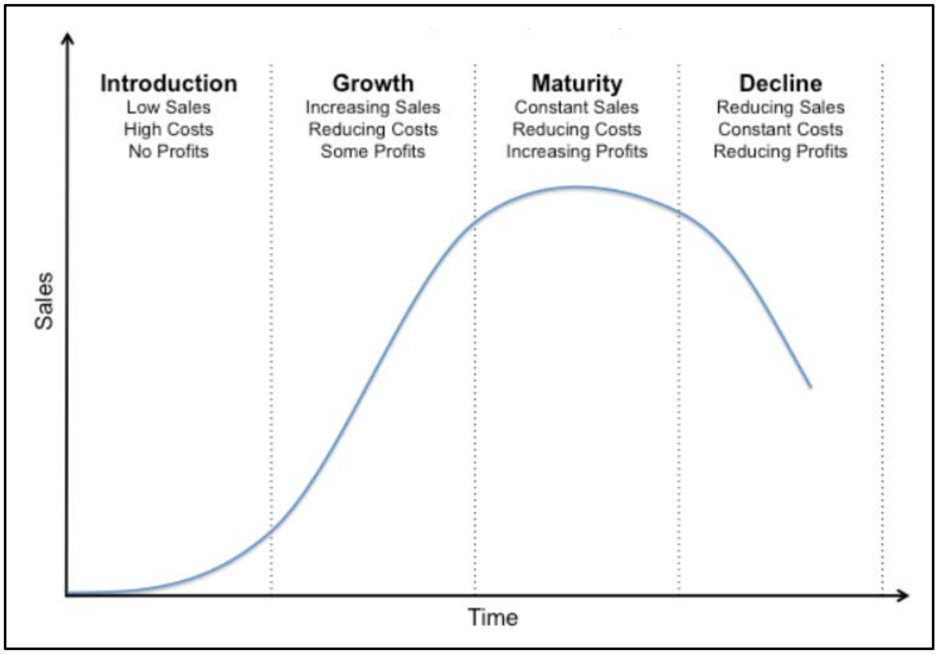


Figure 2-11: The four stages of the product life cycle
Source: Rogers (2003:281)

Based on the annual sales or number of adoptions per year from the product life-cycle the diffusion or market penetration of these products can now be plotted thus creating the classical product s-curve displaying product diffusion in the market as demonstrated in Figure 2-12. The shape of the s-curve is dependent on the amount of time that the product has been available in the market and its associated rate of adoption. Moreover, as a new product penetrates the market and ideas continue to spread or diffuse, adoption rates tend to increase as annual sales increase. Finally, as a product becomes more heavily diffused in the market, adoption rates start decreasing again.

Total cumulative adoption is the dependent variable on the vertical axis which is plotted against time, with time being the independent variable on the horizontal axis. The slope of the curve indicates the rate of adoption at a specific time with the rate of adoption increasing as the slope increases. Once an innovation is completely adopted within the target population or when a saturation point is reached the curve will completely flatten out.

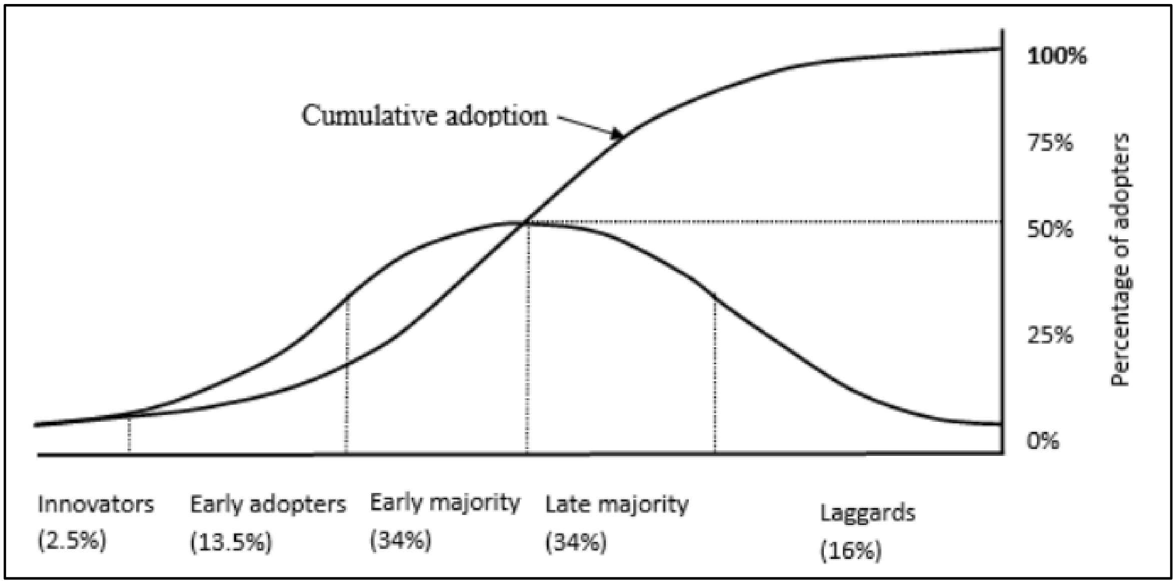


Figure 2-12: Absolute and cumulative rates of adoption plotted over time
Source: Rogers (2003:281)

Technology companies and marketing managers in general have a mandate to predict and more importantly manipulate the rate of adoption of their products entering the market. However, many new products do not attain the level of market diffusion that was initially projected. In fact, most innovations diffuse at a disappointingly slow rate. Compounding this problem, some products are considered unsuccessful and totally withdrawn from the market. Moreover, some 'successful' innovations only ever partially penetrate the target market and may level out at adoption levels of less than 20 per cent of the target population. This is essentially the problem of the innovation chasm, wherein an attractive technology is not able to cross the innovation chasm into the mainstream market and thus it only achieves relatively low market penetration (Lamb *et al.*, 2015:306; Rogers, 2003:83,219).

2.7.2 Mechanism of innovation diffusion and technology adoption

The decision to adopt new technology depends heavily on the adoption decisions of other members in the same social system or population. Therefore, as more people adopt an innovation it lowers the perceived risk for other individuals to change their existing behaviour and practices thus increasing the rate of adoption of that innovation with time. Then once the majority of the population has adopted the innovation, the rate of adoption will again slow down as fewer people are left to be influences. This net result of diffusion is again plotted on the classical S-curve shaped curve graphically representing the diffusion into a target population of an innovation as depicted in Figure 2-12. Note that this plot assumes complete adoption within the target population.

The technology S-curve (refer to Figure 2-12) is analogues with the product life cycle (refer to Figure 2-11) and it should be clear that the highest rate of adoption will occur during the maturity phase of a product, since this time corresponds with the peak annual sales volume. Furthermore, the absolute adoption at a specific point in time is overlaid in a normal distribution onto the technology S-curve as depicted in Figure 2-12, with this normal distribution ultimately creating the s-curve shape for the cumulative adoption profile. Finally, this normal distribution is further delineated into various adopter profiles, from innovators through to laggards, which corresponds to the time taken for individuals to make the adoption decision. Adopter profiles will be further discussed in section 2.6.7.

2.7.3 Bass forecasting model

Technology companies have a vital stake in understanding the mechanisms behind the diffusion of new products within the target market group and ultimately being able to predict future adoption rates, based on product attributes, target market traits and external factors. A key factor in driving product adoption rates is the marketing mix strategy, which includes the split between personal selling and advertising. This phenomenon is described by the Bass forecasting model, which is a seminal work in the field of new product adoption and diffusion that was first used to predict the rate of adoption of consumer durables within a social system. Subsequently, the model has been applied to a wide range of new goods and services and remains one of the most widely utilized theoretical model in marketing today (Bass, 1969:215; Rogers, 2003:83).

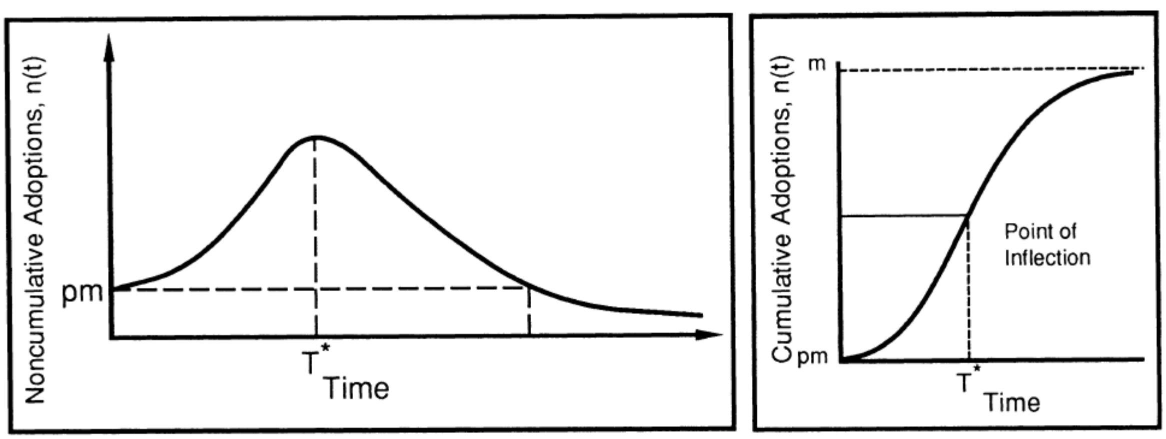


Figure 2-13: Analytical structure of the Bass model
Source: Mahajan *et al.* (1990:1–26:4)

The Bass model attempts to predict the future rate of adoption of an innovation resulting from the efforts of both advertising campaigns and personal selling while also incorporating variables like product price. Therefore, it offers plausible scenarios for the subsequent diffusion of new products into the marketplace. Figure 2-13 demonstrates how the noncumulative number of adoptions over time peaks at the mean (T*), which results in a model analogous to the classical S-curve of cumulative adoption (refer to Figure 2-12). The total market penetration (m) indicates the point at which the market will be saturated assuming all parties have adopted.

Bass (1969) argues that the timing of a consumer's initial purchase is based on the number of previous buyers that also bought that product which validates the point that diffusion is primarily a social phenomenon. It is assumed that potential adopters of an innovation are influenced primarily by two communication channels, namely mass media channels and interpersonal channels which can be defined as follows (Bass, 1969:215; Rogers, 2003:83,208):

(i) Mass media channels include any communication able to reach a large audience rapidly in order to create knowledge and spread information. For ferroalloy producers, these would include journal publications, conferences and the internet. At best, mass media channels can create awareness of a product or technology but will have a small effect on changing existing attitudes (Rogers, 2003:205).

(ii) Interpersonal channels involve two-way communication and an exchange of information between two or more individuals. It is far more effective at dealing with resistance to change or apathy and can even change an existing strongly held attitude that has already been formed by an individual (Rogers, 2003:205).

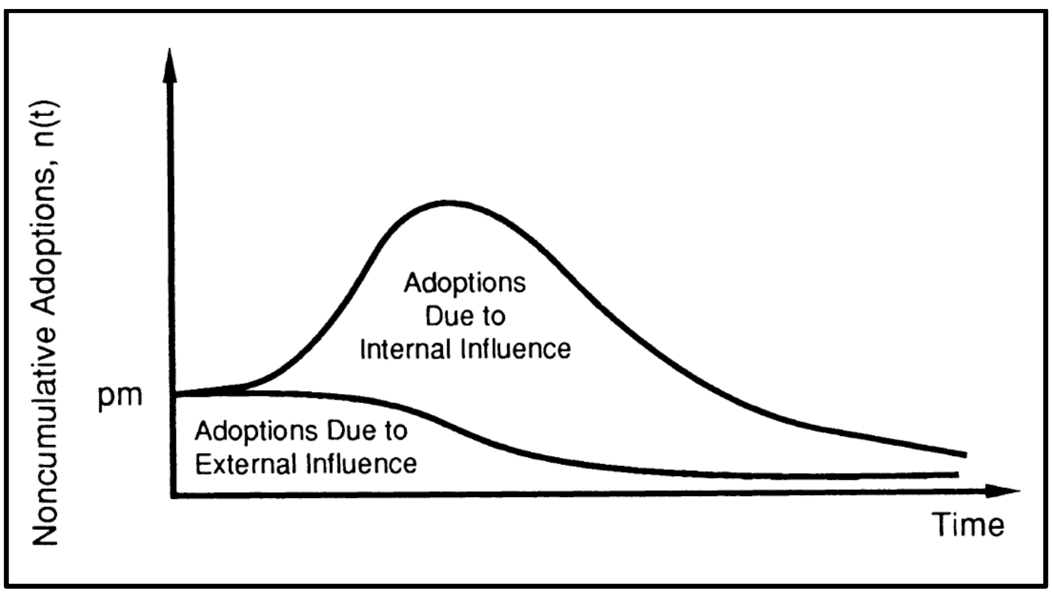


Figure 2-14: Adoptions due to external and internal influences in the Bass model
Source: Mahajan et al. (1990:1–26:4)

The majority of adoptions are due to the influence from internal channels as displayed in Figure 2-14. Later adopter categories are not typically exposed nor affected by mass media communication channels. Therefore, interaction with peers or interpersonal communication channels is far more effective in influencing adoption behaviour for later adopters and laggards (Rogers, 2003:205).

2.8 CROSSING THE CHASM INTO THE MAINSTREAM MARKET

2.8.1 Individual thresholds for adoption and achieving critical mass for market diffusion

Critical mass relates to the point at which further diffusion becomes self-sustaining. In essence, it is a “tipping point” that once reached, diffusion takes off. Once enough individuals or producers have adopted a certain innovation and it has crossed a specific adoption threshold, further adoption is almost guaranteed due to the pressure from adopters influencing the remaining population to also adopt the new technology. This phenomenon is represented graphically in Figure 2-15.The rate of adoption of a given technology is relatively slow, until a critical mass of adoption is achieved at which point the rate of adoption accelerates drastically, which again results in the shape of the classical s-curve of cumulative adoption (Delre *et al.*, 2010:269).

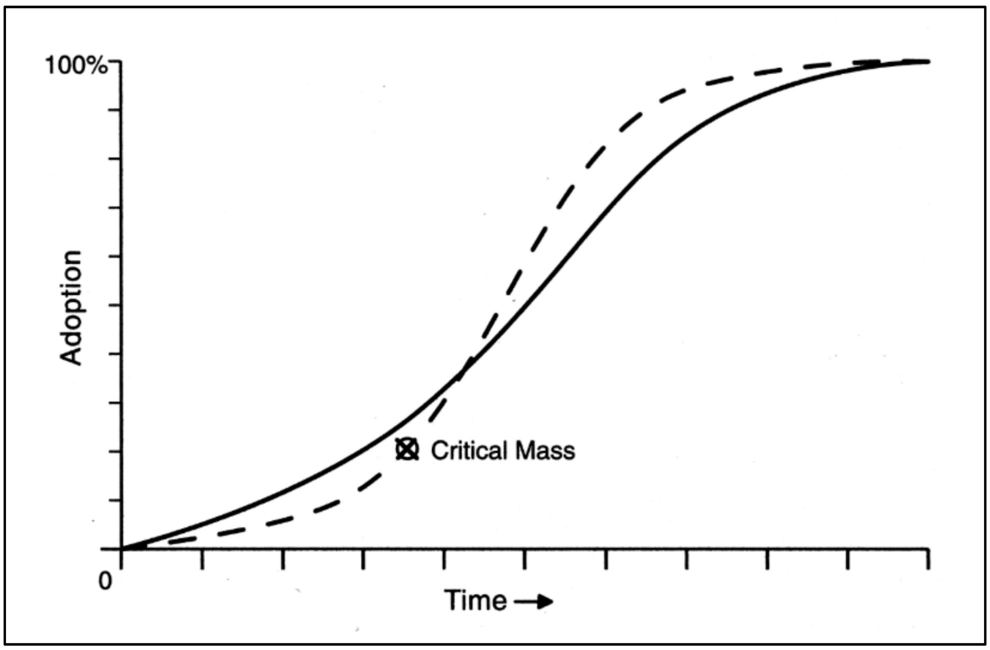


Figure 2-15: Rate of adoption for a typical innovation demonstrating the critical mass necessary for further adoption to become self-sustaining.
Source: Rogers (2003:344)

Since an individual is more likely to adopt a new technology if their peers have adopted it, later adopters are influenced by earlier adopters within the same market. Furthermore, the consensus is that once an innovation has achieved 10% to 20% adoption within a target market, it has achieved critical mass so that an innovation’s further rate of adoption becomes self-sustaining. At this point it is often impossible to stop further diffusion of an innovation, or even a new idea that enters the social consciousness (Rogers, 2003:360).

During the introductory stage of the product life-cycle for a specific new product or service, sales are often slow, with the technology company typically experiencing losses due to a slow rate of adoption as they attempt to penetrate the market. Furthermore, the introductory stage is characterised by the reluctance to change on the part of consumers and producers, which includes a reluctance to change existing suppliers, technology and processes. Generally, the literature is in agreement that an upper maximum of 20% of consumers are actually prepared to be the first to try out new ideas and new products (Lamb *et al.*, 2015:317-318; Mahajan & Muller, 1998:489).

Therefore, technology companies should have this threshold in mind with the primary objective of penetrating a new market to the point where the adoption of their technology exceeds the point of critical mass. Conversely, if a critical mass is not reached for a given innovation, the technology will fail and will not be adopted by the greater market, resulting in a failed diffusion wherein it failed to penetrate the market effectively.

Given the progression of technology adoption through the various adopter categories, it can be concluded that technology companies should target their marketing efforts directly and sequentially towards innovators, early adopters and the early majority in that order. Once a sufficient percentage of the early majority has a given innovation, it will diffuse naturally into the marketplace with little further promotion needed. Therefore, marketing efforts that are directed and targeted at the appropriate adopter group at any given time should increase the overall rate of technology adoption within a given market.

2.8.2 Moore's chasm theory

Building on the technology adoption lifecycle, Moore (2014:25) introduced the revised technology adoption lifecycle wherein he argues that each adopter type is sufficiently unique that "cracks" exist between the different categories and therefore a technology company should customise and direct their marketing effort and product offering to target the pertinent adopter type associated with an innovation's current level of diffusion into the target market. This is an improvement towards taking a common broad brush-marketing approach for the whole market.

The primary concept of a "chasm" in the technology adoption curve separating the early adopters from the early majority has been introduced since these two adopter profiles are considered to have major differences (refer to Figure 2-16). In this plot, the chasm is reached once 16% of the has adopted, however the chasm typically exits anywhere in a range from 10% to 20% of cumulative adoption. The goal of a technology company is then to cross the chasm to bring their innovation into the knowledge of the main market, thereby ensuring further diffusion up the technology adoption curve (Moore, 2014:12).

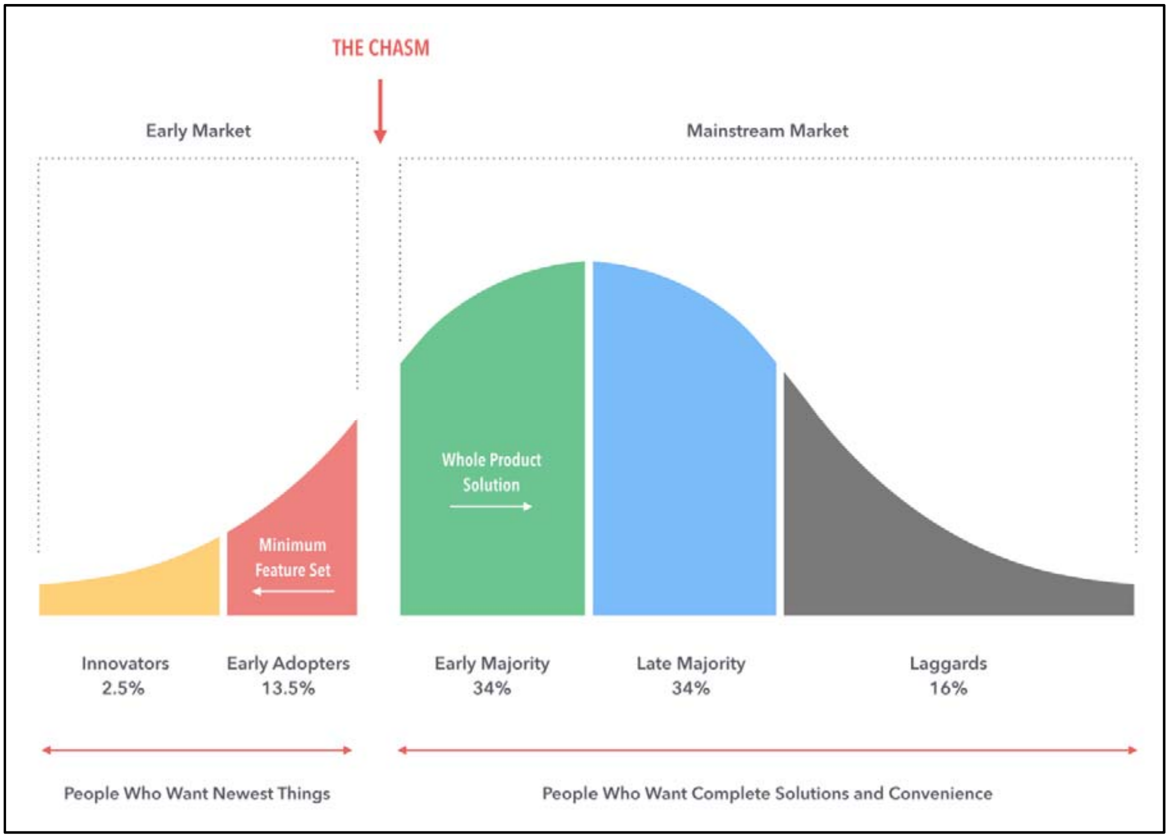


Figure 2-16: Technology adoption life-cycle with adopter categories and the chasm between the early market and the mainstream market
Source: Moore (2014:21)

Based on the similarities between adopter group, these groups are often logically combined as follows:

(i) The early market includes innovators and early adopters; and
(ii) The mainstream market includes early majority, late majority and laggards.

The marketing challenge is lodged in effectively appealing towards the early majority segment of the mainstream market once the early market has been successfully captured. However, this is not an easy task and many technologies have failed to diffuse past the early market stage, never achieving critical mass and mainstream appeal. Hence the concept of the innovation chasm located between the early market and the mainstream market was born with strategies developed to cross the innovation chasm into the mainstream market. Refer to Figure 2-16 (Moore, 2014:21)

Chasm theory further holds that disruptive or transformational innovations are more difficult to push through the adoption curve than continuous or core innovations, since they demand an increased change in the business or change in people's behaviour in order to cross the chasm and sustain the diffusion of the innovation. Conversely, continuous or core innovations that only require small incremental improvements have no chasm since there is little change required and consequently adoption is evident given enough time (Bhattacharya, 2019).

Rogers (2003:282) does not agree with the chasm concept and argues that personal innovativeness is a continuous variable and that no discontinuities exist between different adopter categories, stating that the different adopter categories were initially put forward to make comparisons and further study possible. The argument is further expanded that there are no breaks in the innovativeness continuum and that research does not support the claim of a chasm between the early market and mainstream market as put forward by Moore (2014).

However, the chasm model has had great success and has influenced the fields of marketing and entrepreneurship significantly, thereby providing direction and strategies to technology companies intending to penetrate a new market often resulting in an increasing the rate of technology adoption within that market. Moreover, scholars agree that once a critical mass of diffusion has been achieved, further diffusion will be self-sustaining. Therefore, for the purposes of this study, it is accepted that achieving the point of critical mass in the technology diffusion curve will result in ongoing adoption.

Moore (2014) further argues that crossing from early adopters to the early majority is the most difficult transition to make. At this point, the innovation has not yet achieved critical mass, thus it is critical to gain a foothold in the early majority market to facilitate further diffusion. There is a large distinction between the early market and the mainstream, since the behaviour and response of these two market segments differ. Furthermore, the basis of a technology sale is radically different for these two markets (Sawng *et al.*, 2010:221).

2.8.3 Gartner’s hype cycle

Commentators, analysts and industry experts alike have a poor track record of predicting future innovation and technology trends and their potential impact on markets. The fundamental principle behind the Hype Cycle is that people tend to overestimate the performance or potential of new technologies in the short term and massively underestimate their potential in the long term. Consequently, the market perception around new technology tends to follow a predictable pattern as demonstrated by the Hype Cycle, which is a graphic representation of the maturity, adoption and business application of a specific technology (Bresciani & Eppler, 2015).

The Hype Cycle is a tool created by Gartner to support organisations with evaluation and decision-making related to technology adoption. It attempts to characterise the perceived value of various emerging technologies on a predefined curve as displayed in Figure 2-17 over time, with the vertical axis qualitatively representing current market expectations and the horizontal axis representing time. Therefore, the Hype Cycle attempts to capture the market's perception and anticipation level for a specific technology at a given time (Bresciani & Eppler, 2015).

Market perception is an important external factor that directly affects the rate of technology adoption (refer to section 2.9). Also, the Hype cycle is more interested in the perception of the value of a specific technology by a potential adopter than the technology itself (Bass, 1969; Johnson, 2015).

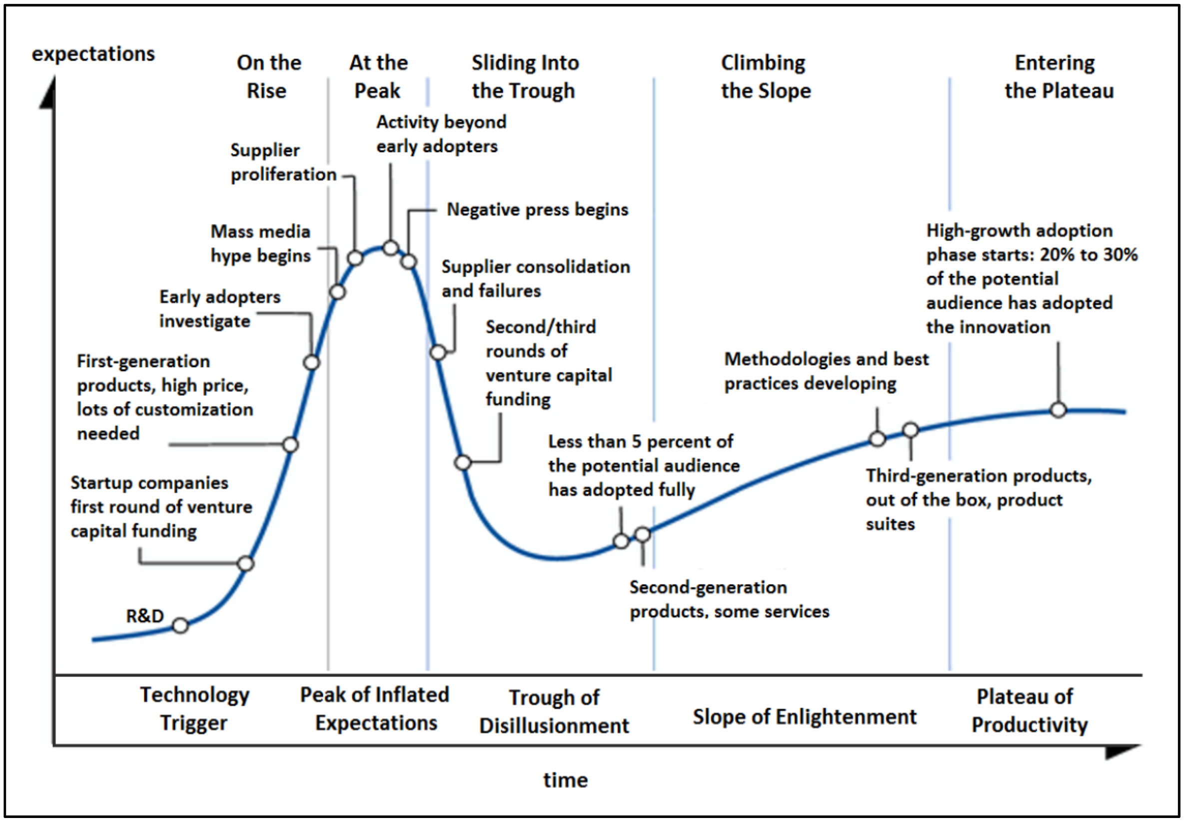


Figure 2-17: Typical hype cycle for a new technology or innovation
Source: **Blosch & Fenn (2019)**

Gartner argues that all new technologies follow a similar path characterised by five distinct stages, so that multiple new technologies can be plotted onto the same curve based on the time elapsed and the development stage of each specific technology. Furthermore, different technologies will proceed through the Hype Cycle at different speeds. The five stage of the Hype Cycle can be described as follows (Blosch & Fenn, 2019):

(i) The "technology (or innovation) trigger" represents the introduction of a new technology, generating excitement coupled with a multitude of future potential applications resulting in unfounded and inflated expectations;

(ii) The ‘peak of inflated expectations’ occurs as unrealistic expectations outweigh current capabilities and the potential of the new technology seems unlimited with funding for further development increasing dramatically;

(iii) The “trough of disillusionment” is marked by commentators, media and the general market losing faith in the technology since it does not live up to the initial hype that was created. This occurs even while the technology is still being adopted into the market;

(iv) The “slope of enlightenment” is characterised by an end to the hype coupled with some real and tangible benefits being gained through the technology and a better understanding of its limitations. Also, the technology keeps improving often in areas not foreseen initially; and

(v) The “plateau of productivity” occurs once the product becomes more mature with benefits and limitations clearly defined. The technology becomes more widely accepted and adopted in certain applications and finds its niche in the market. Moreover, revenue starts to increase dramatically.

The first distinctive vertical peak of the graph is driven by hype and represents how quickly market expectations can increase and then again contract over time, based on projected future values of a given technology, which further demonstrates the difficulty associated with managing expectations during any type of change or transformation event. The second more gradual increase in expectations is based on ongoing engineering development or business maturity and consequently this gradual increase due to value being added to the technology is more sustainable (Blosch & Fenn, 2019; Schreinemakers & Peterson, 2016:1–11).

Gartner’s business model is based on providing insights to potential adopters around the optimal timing for the adoption of a given innovation, which is at the start of the “scope of enlightenment” phase. Therefore, the adopter will not be affected by initial unfounded hype but will be able to adopt selective technologies early enough to gain the technology benefit at a low cost while yielding maximum future benefits from further development and lessons learnt as the product improves. In addition, this is the optimal point where a producer will receive the full benefit at an acceptable level of risk which is a very attractive proposition to the ferroalloy industry (Blosch & Fenn, 2019).

This approach makes business sense as it targets adopting a given technology during the early adopter stage and avoids the pitfalls and uncertainties coupled with a very immature product during the innovator stage of adoption. However, given the pragmatic and conservative nature of the typical ferroalloy producer, very few clients will sign up for new technologies during the early market stage and thus the usefulness of the Hype Cycle to the industry is in question.

2.8.4 Interactions between the Hype Cycle and the cumulative adoption s-curve

The Hype Cycle's "trough of disillusionment" coincides with Moore's "chasm" with both phases occurring at the same time following the release of a given innovation or technology product into the market. Figure 2-18 shows both models plotted on the same horizontal axis, which is time, however the Hype Cycle presents market expectation on the vertical axis while the chasm model presents adoption levels on the vertical axis. Therefore, the "plateau of productivity" represents the start of mainstream adoption since roughly 20% of the target market has adopted at this point. Consequently, the technology has entered the mainstream market and crossed over the chasm into the "scope of enlightenment" with the typical adopter profile now being the early majority (Blosch & Fenn, 2019; Moore, 2014).

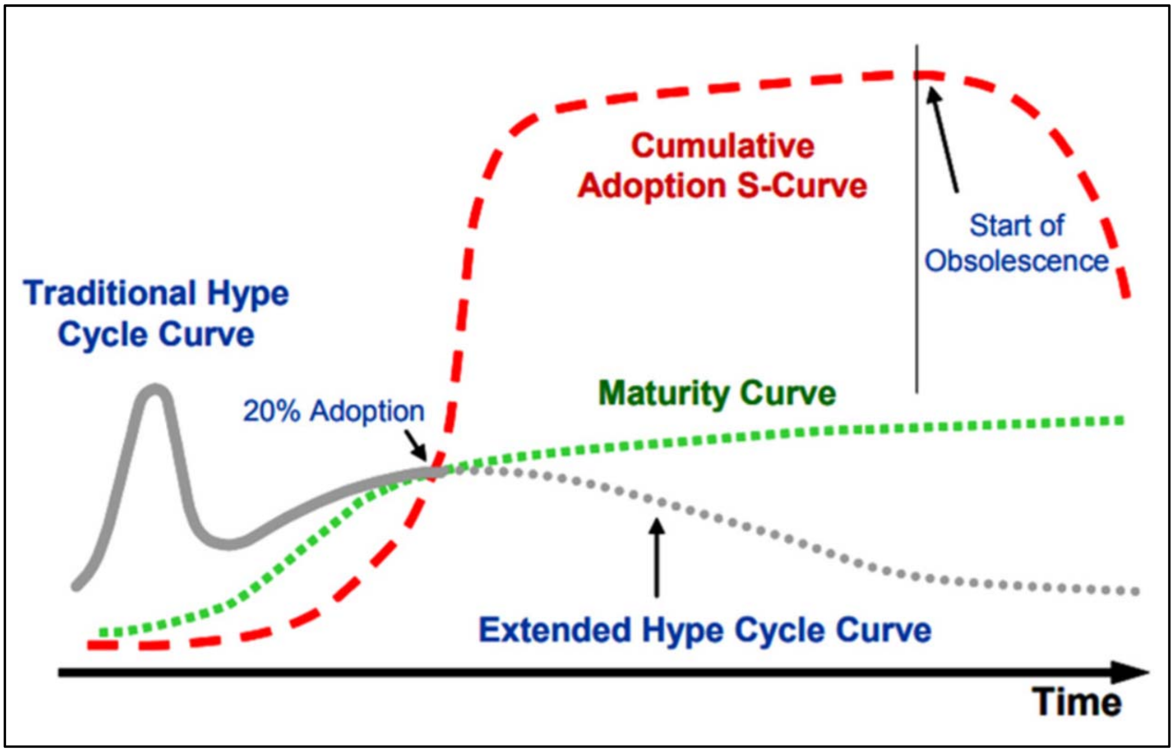


Figure 2-18: Hype cycle and technology adoption lifecycle plotted on a common time axis
Source: Schreinemakers & Peterson (2016:1–11)

2.9 RATE OF ADOPTION OF INNOVATIONS

2.9.1 Variables determining the rate of adoption of innovations

The rate of adoption of an innovation is based on the steepness of its cumulative adoption curve and is the relative speed with which the specific innovation is adopted by individuals interacting within the social system (refer to Figure 2-12).

The following variables determine and influence the rate of adoption of an innovation:

(i) Perceived attributes of innovations;

(ii) Type of innovation decision process;

(iii) Communication channels;

(iv) Nature of the social system; and

(v) Extent of the change agent's promotional efforts

This model is presented in Figure 2-19, with the dependent variable being adoption rate.

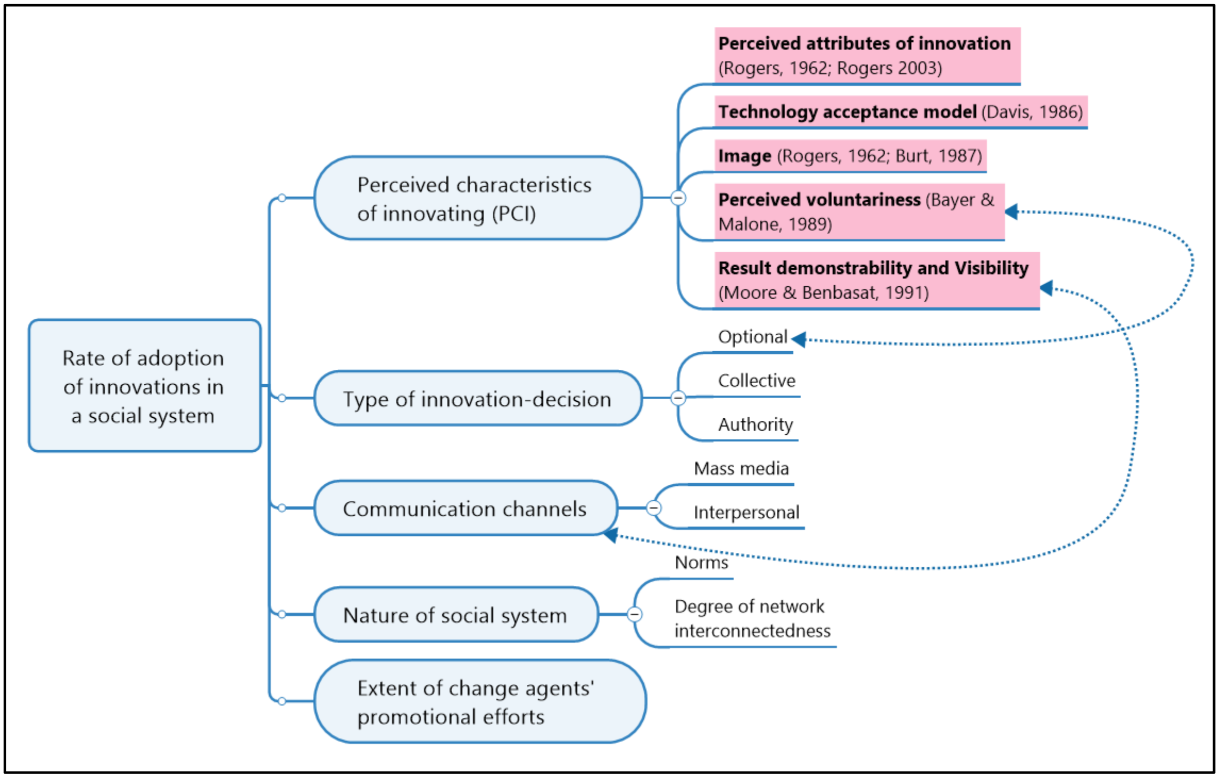


Figure 2-19: Variables determining the rate of adoption of innovations

Source: adapted from **Rogers (2003:222)**

Furthermore, the five variables that affect adoption rate are further influenced by underlying attributes and sub-variables which are lists as sub-headings under each of the five variables. The focus of this research is on the perceived characteristics of innovating (PCI), since these characteristics have the largest impact on adoption rate. It is important to note that the dotted lines represent areas where clear overlap exists between the sub-variables from the PCI and other primary variables affecting the rate of adoption. Therefore, the although focused on the attributes of an innovation, the PCI model also considers factors related to the type of innovation decision and communication channels.

2.9.2 Cardinal variables that affect the rate of adoption of innovations

The perceived attributes of an innovation, which constitute a sub-variable of the perceived characteristics of innovating, has a significant influence on, and define the rates of adoption. Moreover, these attributes can be used to predict the rate of acceptance and ultimately the diffusion of a new product or service. Therefore, the perceived attributes of an innovation can be considered as the cardinal variables that most saliently affect adoption rate and will be expanded upon below (Lamb *et al.*, 2015:329).

In fact, 49 to 87 percent of all variance in the rate of adoption of innovations can be explained by five attributes of innovation as first proposed by Rogers (2003). These attributes relate to the characteristics of the innovation as perceived by an individual. Therefore, the advantage or superiority of an innovation in objective terms is typically a secondary factor with the perception of individuals being more important in determining the rate of adoption (Rogers, 2003:221).

There is a myriad of other variables that also affect the rate of adoption of innovations as presented in Figure 2-19, with some of the most important ones being:

- (i) Type of innovation decision process;
- (ii) Communication channels;
- (iii) Nature of the social system; and
- (iv) Extent of the change agent's promotional efforts

However, for the purposes of this study, the focus remains on the effect of the perceived attributes of an innovation, since these are considered to be the cardinal variables that most heavily influence adoption rate. Also, an effective marketing strategy can be built to communicate these attributes to potential adopters with the intent of influencing their perception. Conversely, technology firms often have limited influence in affecting the other variables such as communication channels or the nature of the social system.

2.10 PERCEIVED CHARACTERISTICS OF INNOVATING

Moore and Benbasat (1991) created an instrument to measure the key perceptions around an innovation by synthesising and combining previous research in the field of innovation diffusion. They coined the term perceived characteristics of innovating (PCI) to describe the model that combines all relevant variables that affect the perceptions of potential adopters towards a given innovation.

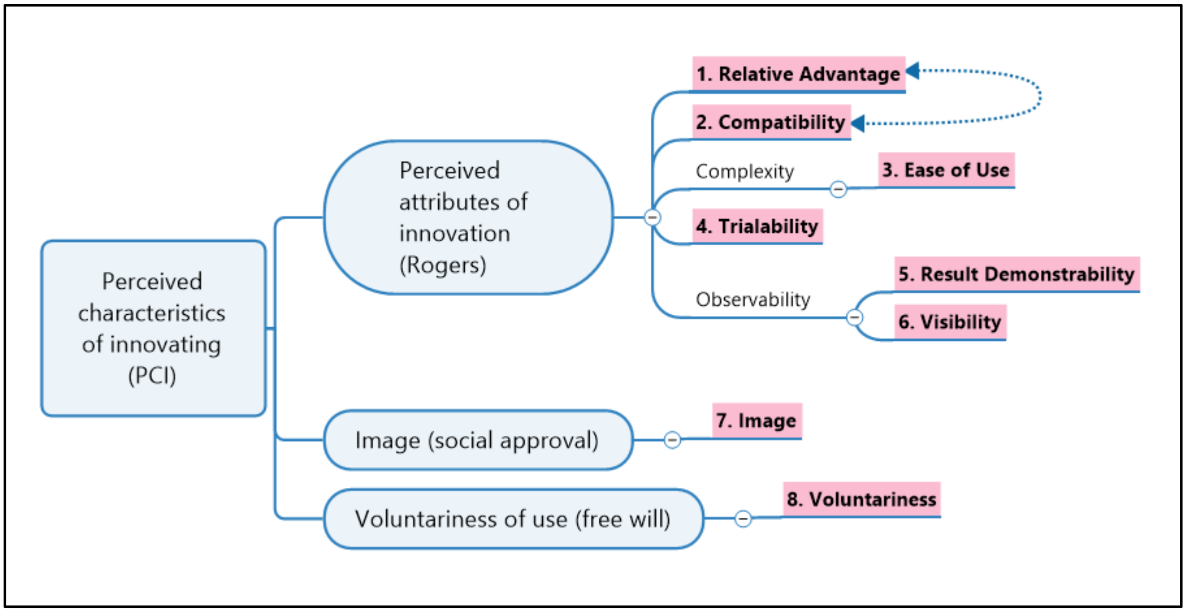


Figure 2-20: Perceived characteristics of innovating

Source: Own

The relationship between "relative advantage" and "compatibility" has been included visually with an arrow, since questions related to these two variables often load to the same factor. However, the two concepts are quite distinct and were also viewed as two separate variables by Rogers (2003). Therefore, both of these variables are retained as separate entities, but it should be noted that they are typically highly correlated in the mind of respondents (Moore & Benbasat, 1991:211)

2.10.1 Development of the perceived characteristics of innovating model

Measuring the perceptions of potential adopters towards innovations has long been a central issue in innovation diffusion research with the development of the PCI model attempting to capture all the relevant variables influencing the rate of adoption of innovations. The research and authors that influenced the creation of the PCI model are presented in Figure 2-19 with the associated field of research also highlighted. Moreover, the development of the PCI is presented visually with the final variables that will be considered during this research being highlighted and presented in Figure 2-20.

Rogers (2003:221) initially proposed only five characteristics of innovations that directly affect the rate of technology adoption, known as the perceived attributes of innovation. These include

(i) Relative advantage;
(ii) Compatibility;
(iii) Complexity;
(iv) Trialability; and

(v) Observability.

Davis (1989) developed the technology acceptance model (TAM) where he proposed two constructs, namely “perceived ease of use” and “perceived usefulness”. The “ease of use” variable effectively replaces the “complexity” variable and can be regarded as the inverse of complexity and is also retained in the PCI model.

Moore and Benbasat (1991) expanded on the “observability” variable since the construct was found to be quite complex, because it measured two distinct factors. It was found that observability is the degree to which innovations are:

(i) Visible to others since innovations that are less observable (or visible) were found to diffuse at slower rates; and
(ii) Communicable to others, since the results of an innovation need to be effectively demonstrated for diffusion to take place.

Image or the social approval obtained by adopting an innovation has long been considered as a key variable in predicting adoption and thus it was added to the PCI model (McCann, 2007:42).

Finally, voluntariness of use, which has clear overlap with the innovation decision process and more specifically whether adoption was optional, was also found to be an important variable and added to the PCI model (Moore & Benbasat, 1991:192–222).

2.10.2 Definition of the perceived characteristics of innovating variables

The word perceived is used with the term intent when referring to the variables or characteristics that affect the rate of adoption. Diffusion research attempts to measure the perception that a potential adopter has with regard to a certain characteristic, since the perceived attributes of a technology product have a greater impact on the decision to adopt than the actual utility of the technology itself. The point has already been made that these perceptions are subjective and influenced by the individual adopter’s personality and view of the world. Moreover, as a given innovation or technology product diffuses further into the market the product becomes better understood and these characteristics becomes more objective with time. The subjective nature and interpretation of potential adopters should be considered when attempting to cross the innovation chasm while the product is still residing at the start of the curve (Tanye, 2016:10).

The following eight attributes of innovation that are considered in this study are described as follows (Moore & Benbasat, 1991:192–222):

(i) Relative advantage

This is the degree to which an innovation is perceived as being superior or better than the idea or equipment it replaces. Relative advantage can assume many forms such as convenience, satisfaction or pure financial benefit. Social prestige or image was previously considered as a relative advantage, but this construct now stands on its own.

During the initial uptake of a product it is challenging to quantify or demonstrate the advantage of the product in a given industry, since little evidence is available to prove that advantage.

(ii) Compatibility

This is the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of potential adopters. Therefore, the existing values and norms of the society play an important role in this variable. Also, the innovation must be seen as being compatible with an existing need and therefore needs to be perceived as having the potential to solve a problem.

(iii) Ease of use (derived from complexity)

This is the degree to which an innovation is perceived as being intuitive to understand or use. This variable is often referred to as “simplicity” in the literature. The more complex an innovation is to understand, the slower its rate of adoption will be, since new potential adopters will need to develop new skills, tools or practices to utilise it. Therefore, the innovation must be perceived as being elegant to ensure uptake.

(iv) Trialability (testability)

This is the degree to which an innovation can be experimented with or tried out on a limited basis prior to adopting it. This action reduces the uncertainty associated with an innovation to the potential adopter. Trialability is specifically important at the early stages of an innovation as a way to mitigate risk, since there would be a lack of definitive evidence related to the performance of the innovation. Moreover, over time and further adoption trialability becomes less important as a well-established reference list is built up coupled with hard evidence and performance data.

(v) Result demonstrability (derived from observability)

This is the degree to which the benefits or results of using an innovation are demonstrable to others and communicated to the target market segment. In addition, it refers to how easily an observer can communicate, articulate and describe the value proposition of a certain innovation to a prospective adopter in order to understand the value on offer.

(vi) Visibility (derived from observability)

This is the degree to which the innovation is visible within the social system with potential adopters being able to physically see it in operation. This visibility stimulates discussions within the social system between peers, thereby increasing awareness about the innovation.

(vii) Image

This is the degree to which the use of an innovation is perceived to enhance or promote an individual's status within their social system. Furthermore, some individuals are quite motivated to adopt an innovation by the desire to gain status and be recognised by their peers.

(viii) Voluntariness

This is the degree to which a potential adopter has freedom of choice to make an adoption decision without being compelled to do so, thus the choice can be made of their free will. Again, it is the perception of being compelled to adopt an innovation that will slow diffusion progress, not the actual act of compulsion in itself.

2.10.3 Relative importance of the perceived characteristics of innovating variables

Although all of these variable play an important role in the ultimate rate of adoption of innovations, relative advantage and compatibility have been found to be the most important factors in explaining and predicting adoption rates (Rogers, 2003:17).

Moreover, relative advantage has consistently been found to be the most important variable, since continually upgrading an innovation's relative advantage and being able to communicate the result effectively have the largest benefit as the adopter profile changes. This is intuitive, since the further one moves along the adoption curve, potential adopters become more pragmatic and focused on practical considerations since they require more evidence to make an adoption decision. Therefore, the quicker a strong base of evidence and references can be built, the faster the consequential rate of adoption can be increased.

2.11 INNOVATION DRIVERS IN THE SOUTH AFRICAN FERROALLOY INDUSTRY

Mining and metals producers surveyed in Africa overwhelmingly concur that innovation is crucial if their companies are to succeed and grow sustainably. Producers further agree that the days of traditional, "business as usual" type operations are numbered, and fundamental industry change is needed to create sustainable shareholder value. In an effort to transform operations, many producers have set aspirational innovation targets with a self-reported goal of directing, on average, 54% of their efforts on adjacent and transformational innovations (refer to Figure 2-2). However, these targets are not being achieved currently with most company resources still assigned to core innovations only. It is clear that producers are starting to recognise the importance of embracing dedicated innovation strategies, but there is still a long way to go before potential game changing adjacent and transformational innovation will cross the innovation chasm and enter the mainstream market (Monitor Deloitte, 20168-12; Nagji & Tuff, 2012).

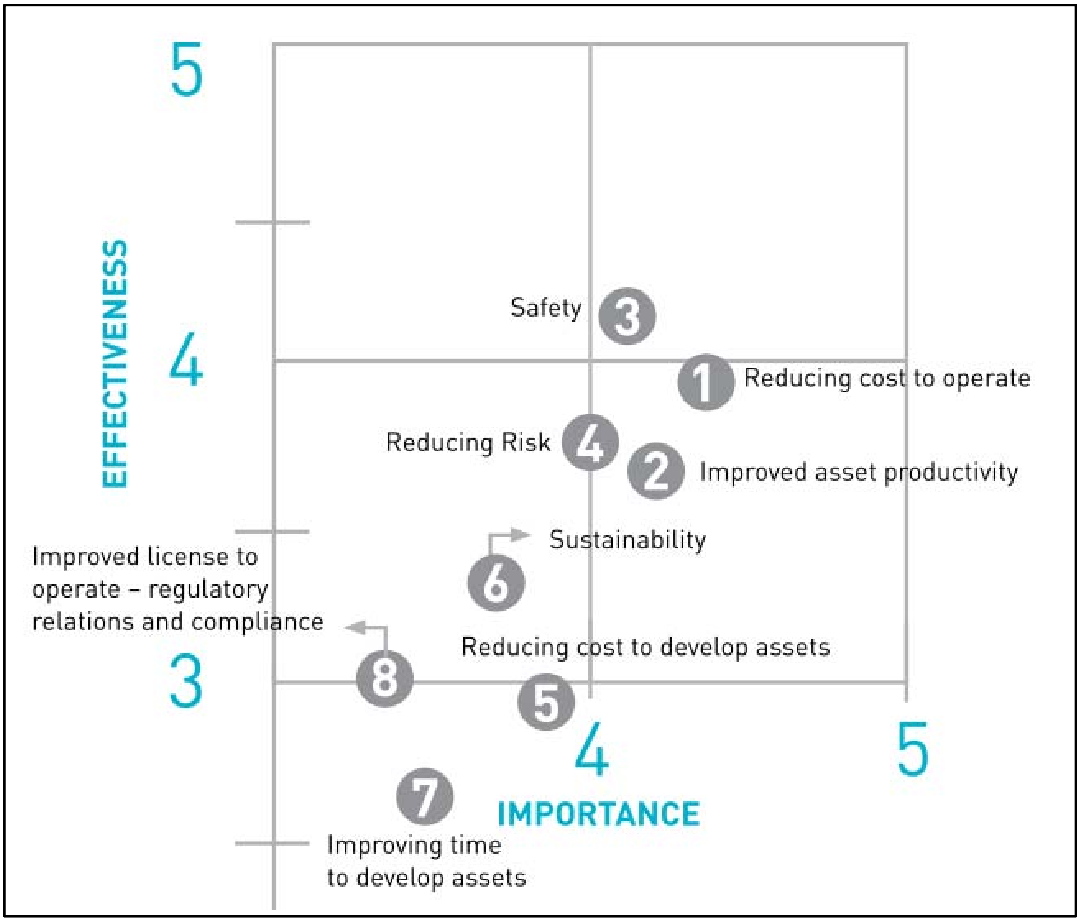


Figure 2-21: Innovation drivers in the mining and metals sector in Africa

Source: Monitor Deloitte (2016:12)

The most important factors that drive innovation in Africa are presented in Figure 2-21, with the industry's view on the relative importance of each factor on the horizontal axis, while the self-reported effectiveness or resultant changes of these initiatives are presented on the vertical axis. Ranked in terms of importance, the top five drivers for innovation are as follows:

(i) Reducing cost to operate due to rising input costs and lower commodity prices;
(ii) Improving the productivity of existing assets to increase margins;
(iii) Improving safety of employees working in hazardous environments;
(iv) Reducing risk which include external regulatory, political, labour and financial forces; and
(v) Reducing cost to develop assets for potential mineral deposits yet to be explored and extracted.

These findings are consistent with the industry's historic mentality towards innovation, with the first four factors falling squarely into the traditional focus areas of "sweating the assets" and reducing risk. Moreover, the top four drivers for innovation in the metals industry were exactly the same across multiple geographies, with analogues in African, Australian, Canadian and Latin American surveys reporting equivalent findings. Therefore, the metals industry as a whole is also focussed on these initiatives and they are not limited to an African context (Deloitte, 2017; Deloitte Touche Tohmatsu, 2016:28; Monitor Deloitte, 2016).

However, despite producers having the intention to adopt adjacent and transformational innovations, they typically continue to pursue traditional methods such as "sweating their assets." The two approaches are at odds with each other, and the logical conclusion is that although producers understand the need for change, they do not know how to bring that change about and often default to their historic approach towards innovation. Therefore, despite these drivers of innovation, listed above, being the focus of producers for many years, the South African ferroalloy industry still finds itself in deep trouble (Hermanus, 2017:821).

Therefore, this historic approach appears to be a self-fulfilling prophecy since any external technology companies or equipment vendors that present an innovation to a producer will be judged according to the criteria presented in Figure 2-21. Therefore, if a service provider presents a technology to a producer that does not, for example, promise to reduce the cost to operate in the short term, it will typically not be viewed positively as the immediate outcome will not be a traditionally accepted driver of innovation.

This thinking limits the industry in its uptake of adjacent and transformational innovations and is clearly at odds with the industry's aspirational innovation goals. Moreover, the point has been made that truly disruptive innovations will actually result in inferior performance in the short term, which is also at odds with the criteria provided by producers for evaluating new innovations. Christensen (2016) perfectly describes this dichotomy in his seminal work aptly entitled "The Innovator's Dilemma." Given this paradox, the question now remains how can the rate of technology adoption and the instances of successful innovation diffusion be increased in an industry that clearly needs it (Christensen, 2016).

When considering perceived characteristics of innovating and assigning specific innovation drivers to each factor, the following characteristics of innovating appear as themes that are common elements to the innovation drivers:

(i) Relative advantage;
(ii) Compatibility; and
(iii) Ease of use.

These findings are subjective since a technology related to "asset productivity," for example, can assume many forms. However, it should be clear that relative advantage is a key factor for almost all of the innovation drivers.

2.12 CONCLUSION

The South African ferroalloy industry is under great pressure due to a myriad of internal and external forces that are economic and social in nature. Furthermore, raising input costs coupled with low commodity prices are putting increasing pressure on what are already thin margins. The point was made that a conservative mindset coupled with a short-term cost cutting mentality has created an environment wherein innovation has been neglected. Therefore, an imperative exists for producers to adopt applicable innovations to become more competitive on the international stage.

Furthermore, it is clear that the industry has failed to create conditions wherein research and development are promoted, and new technologies effectively adopted. Therefore, many operations have not embraced disruptive innovations and they are starting to lose their competitive advantage in the international market. Thus, a need exists for service providers and technology providers to create marketing campaigns that take into account the adopter categories of the producers being targeted. Moreover, the innovation diffusion process needs to be better understood by all parties to facilitate technology uptake.

These type of targeted marketing campaigns should resonate with producers, thereby increasing the rate of adoption of innovations and new technology. In addition, the perceived characteristics of innovating are the primary drivers that affect the rate of adoption and therefore the importance of these characteristics need to be determined for the target audience in order to increase the rate of technology adoption and cross the innovation chasm.

2.13 CHAPTER SUMMARY

A detailed literature study was presented to address all the factors that contribute towards the objective of the study.

An overview of innovation with a focus on the South African ferroalloy industry was provided, distinguishing between different types of innovations and their relevance for the industry. The context of the study was described with a detailed overview of the structural constraints and operational drivers in the mining and metals industry in general, followed by a specific focus on the ferroalloy industry in particular. Moreover, the options around available technologies that can be implemented in the sector were also discussed.

The effect of the personal innovativeness of individuals was discussed in reference to technology adoption patterns and the perceptions that individuals have towards a given innovation. Also, the mechanisms behind the adoption process were discussed, including the sequential steps in that makeup the innovation decision process.

To better understand and define the mechanisms for technology adoption and innovation in the South African ferroalloy industry, an overview of innovation diffusion was presented, including the drivers and variables that affect the rate of innovation adoption. Furthermore, the mechanisms for diffusion of an innovation into a new market, including the potential hurdles that will slow down the diffusion process were discussed. The effect of the innovation chasm in separating the early market from the mainstream market was discussed. Finally, the perceived characteristics of innovating were presented as a means to predict and influence future adoption rates as a strategy to cross the innovation chasm into the mainstream market.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The literature review that was conducted as part of this study (refer to chapter 2), provided an overview of innovation diffusion concepts within the context of the South African ferroalloy industry. Specific attention was given to the behaviours of different adopter types and the need for an innovation or technology that is new to the market to achieve critical mass to cross the innovation chasm and achieve wider mainstream adoption in the market.

The focus of this chapter is on the research methodology that was applied to achieve the research objectives as described in section 1.6.

3.2 PROCEDURE AND SCOPE OF QUANTITATIVE RESEARCH

To accomplish the objectives of this study, empirical research was done focused on the ferroalloy industry in South Africa. Respondents were categorized into logical demographic profiles defining their level of engagement with the industry, employment status, job position, working experience and highest level of education.

Firstly, the study attempted to determine the degree of personal innovativeness within the industry to investigate whether there is a difference in personal innovativeness between different groups of respondents with specific focus on producers versus service providers. Secondly, the study attempted to determine what perceived attributes of a technology or an innovation appeal to respondents that will influence their decision to adopt or promote a new technology or innovation. Finally, the study will attempt to establish whether a relationship exists between different adopter groups and the perceived attributes of innovation they consider important.

This knowledge will inform a market segmentation strategy that can be used to effectively market innovations and new technology to the industry in a targeted fashion. A targeted market segmentation strategy aimed specifically at the early majority will assist consultants, service providers and technology providers to cross the innovation chasm.

A quantitative research approach was followed. Qualitative research was not conducted.

3.3 SAMPLE GROUP AND SIZE

3.3.1 Target population

The target population for this study are senior employees working in the ferroalloy industry that can influence technology adoption decisions. These people have demanding schedules and are not always able to participate in research. Moreover, the ferroalloy community in South Africa is quite large and it would be impractical to obtain a true probability sample that is representative of the entire population for a study of this scope that is not well funded. Therefore, due to the inherent difficulty, costs and preparation required for a probability sample, the decision was made to opt for a convenience sample (Bryman & Bell, 2015:178).

Following a convenience sample strategy, individuals were approached to participate in the study that were known to the researcher and that were willing to engage in the research. Therefore, a targeted segment of the population participated in the research. These individuals were exclusively involved in downstream operations within the overall ferroalloy value chain, including sintering, smelting and alloy recovery. Moreover, the population is relatively homogenous, since respondents are all engaged in technical work for ferroalloy producers within a narrow subset of the broader mining community in South Africa. Furthermore, all respondents are involved in production and engineering related occupations. Therefore, less variation is expected in the study population (Bryman & Bell, 2015:177).

Respondents were categorized into two distinct groups with the following employees targeted for the study:

(i) Senior employees working for metals producers with the ability to influence buying decisions and ultimately technology adoption within their respective departments and companies. These individuals range from supervisor level, working at production facilities, through to top management and executive positions, typically stationed at head office.

(ii) Consultants, service providers and technology providers that service the metal producers with the ability to suggest relevant new technology to the clients and influence potential purchasing decisions. These individuals must be client facing with regular contact and business engagement with clients.

A quantitative research approach was followed, with a survey used to gather data. From the literature study relevant questions were formulated and put to respondents via the survey. The Google Forms platform was used to generate as electronic questionnaire, capture, store and collate all data. Respondents were able to complete the survey electronically via a link to the Google Forms questionnaires and submit their results electronically once the completed the questionnaire.

Respondents were limited to one set of responses only, since it was possible to allow only one response per e-mail address within the Google Forms platform. Therefore, the researcher ensured a consistent repository of information was created and the risk of double counting, wherein one set of responses is counted twice, was avoided.

This primary data was evaluated by means of statistical analyses to draw conclusions from the target population. The results of the data analyses were then used to establish whether different marketing approaches should be developed to approach the different adopter groups.

3.3.2 Response rate

A total of 200 questionnaires were sent out to potential respondents that were known to the researcher. A total of 123 questionnaires were returned of which 122 were found to be valid. One questionnaire was discarded since the respondent selected that he or she had never worked in nor rendered services to the South African ferroalloy industry in the past.

Since the Google Forms electronic platform was used as a vehicle to capture the data, the fields were configured so that a respondent could only select one answer and also had to select an answer for every question to proceed to the next page of the questionnaire. Therefore, the high level of accuracy in completion was expected.

A subsequent response rate of 62% was achieved. Respondents were represented by the following institutions:

(i) Producers employed in various roles at nineteen different operational plants. All of these plants have at least one smelter on the premises;
(ii) Ten different technology companies that work with primary producers to deliver technology and engineering service to the industry;
(iii) Five independent consultants;
(iv) Five service providers offering goods and equipment to the industry.

Non-responses were expected and could have been due to any combination of the following reasons:

(i) The inability of the author to locate respondents due to incorrect e-mail addresses or firewalls blocking incoming e-mails;
(ii) The inability of potential respondents to respond to the surveys due to busy schedules resulting from other work or personal commitments
(iii) Electronic surveys are often viewed as an inconvenience with a low response rate being typical for these types of surveys (Bryman & Bell, 2015:293).

3.4 SURVEY INSTRUMENT

This empirical research study is based on a quantitative method that follows an approach that seeks to precisely measure and analyse the target concept. Moreover, quantitative research is objective and seeks to establish the relationship between theory and research through the analysis of primary data. A measurement instrument in the form of a survey questionnaire was used to gather feedback from potential respondents (Bryman & Bell, 2015:31).

Measuring the perception of potential adopters towards an innovation or new technology has been a core issue in innovation diffusion research for several decades now. Following the publication of "Diffusion of Innovation" by Rogers (2003) in 1962, instruments were created to measure the perceptions around adoption based on the five attributes of innovations (refer to section 2.9.2). However, despite the importance of accurately measuring these characteristics, many historic measurement instruments and scales were found to lack the requisite levels of reliability and validity. Therefore, subsequent studies were completed with the specific goal to produce reliable and valid instruments that would further advance the study of initial adoption and diffusion of innovations (Hurt *et al.*, 1977; Moore & Benbasat, 1991).

The survey instrument used for this study is adopted from previous studies that generated and published survey instruments which were thoroughly tested and scrutinized to prove the reliability and validity of the measurement scales produced. Therefore, it is assumed that the survey instrument used in this study is an effective and useful tool for the study. However, the specific primary data obtained will still be evaluated for reliability (Moore & Benbasat, 1991:192).

The survey instrument used in this research is divided into four distinct sections, to satisfy the research objectives and research design, as follows:

(i) Demographics profile including employment status and experience base;

(ii) Job description and level of engagement in the industry;

(iii) Personal innovativeness based on the instrument initially developed by Hurt *et al.* (1977); and

(iv) Perceived attributes of an innovation based on the instrument initially developed by Moore and Benbasat (1991) and revised by Pallister and Foxall (1998).

Refer to Appendix B to view the actual questionnaire that was sent to respondents.

3.4.1 Practical considerations

The survey instrument that was used for this study is a questionnaire that was sent to all potential respondents by e-mail via with an electronic hyperlink directing users to the Google Forms site.

There are several practical and logistical advantages to utilizing a self-completion questionnaire as opposed to structured interviews. Self-completion questionnaires are cheaper and quicker to administer, there is an absence of interviewer effects and interviewer variability, and finally this tool is more convenient for respondents. Moreover, it is an inexpensive and quick method for collecting data (Bryman & Bell, 2015:192).

3.4.2 Demographic profile and employment section

Basic questions to categorize respondents by age, gender, highest level of education and experience base. It was also established whether respondents are employed directly by a primary ferroalloy producer or employed by a service provider, technology company or consulting entity offering goods and services to producers.

3.4.3 Personal Innovativeness section

This measurement instrument is intended to measure the degree of personal innovativeness of each individual respondent. The measurement instrument was first developed by Hurt *et al.* (1977) and is over 40 years old. Due to its age, the original authors could not be contacted successfully. Their survey instrument was adapted for this research with credit given to the original authors for their work.

3.4.4 Attributes of an innovation section

Moore and Benbasat (1991b:192–222:194) developed an instrument to measure the perception of potential adopters towards new technology and innovations. Although their research was focused in the information services industry, their stated intention was to develop scales that would be generally applicable to a wide variety of innovations, thus all items that were applicable only to their specific scope of research were excluded from the published scales. The short, 25 item, version of the measurement instrument that was published has been adapted for this study. Moreover, this instrument is general enough to be used, with slight modifications, in most diffusion studies with adequate levels of validity and reliability (Moore & Benbasat, 1991:194).

Mr. Gary C Moore passed away in 2012. However, Mr. Benbasat responded to an e-mail request by the author and consented to his survey instrument being adapted for use in this study. Refer to Appendix C for extracts of this correspondence and consent.

3.5 CONCLUSION

The survey instrument used during this research was adapted from existing, robust survey instruments available in the literature. Survey responses received reflect the target population, with all valid respondents being directly associated with the South African ferroalloy industry, either working for a producer or being employed in a service provider role.

3.6 CHAPTER SUMMARY

The research methodology was presented in this chapter, with a quantitative research approach adopted for the study. The procedure that was followed during the research was defined, including the sampling method and the target population. The sampling approach was discussed, with all data gathered via an electronic questionnaire. This survey instrument included questions to determine the demographic profile of respondents as well as the underlying factors that were being analysed.

CHAPTER 4

EMPIRICAL ANALYSIS AND RESULTS

4.1 INTRODUCTION

The research methodology that was applied during this study was presented in chapter 3. Specific attention was given to the procedure used to execute this study and the development of the survey instrument. The focus of this chapter is on the empirical analysis and results obtained from the target population, which includes the investigation procedures, data analyses and results of the research.

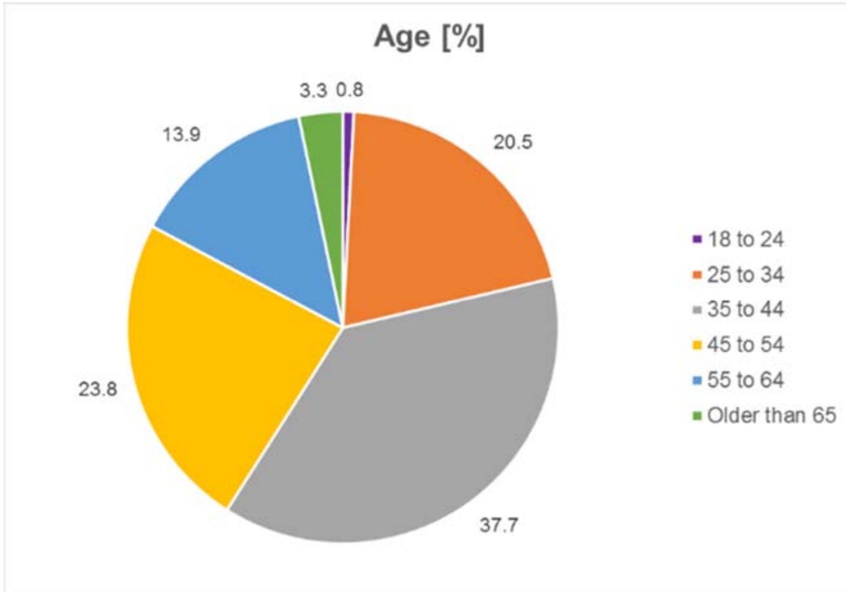
All statistical analyses conducted during the research were completed by the Statistical Consultation Services at the North-West University on the Potchefstroom campus, using the software package SPSS.

4.2 DEMOGRAPHIC PROFILE OF RESPONDENTS

A demographic profile to better classify respondents is presented in this section. Data was collected from a total of 122 respondents who indicated direct involvement within the South African ferroalloy industry. People working in senior roles with the ability to potentially influence technology adoption decisions were targeted as respondents, and therefore an older, senior and more experienced respondent base was expected.

4.2.1 Age and gender profile of respondents

The age and gender distribution of respondents is presented in Figure 4-1. On average, respondents were middle-aged and older, with 78% of respondents reporting to be older than 35 years and 41% of respondents reporting to be older than 45 years.



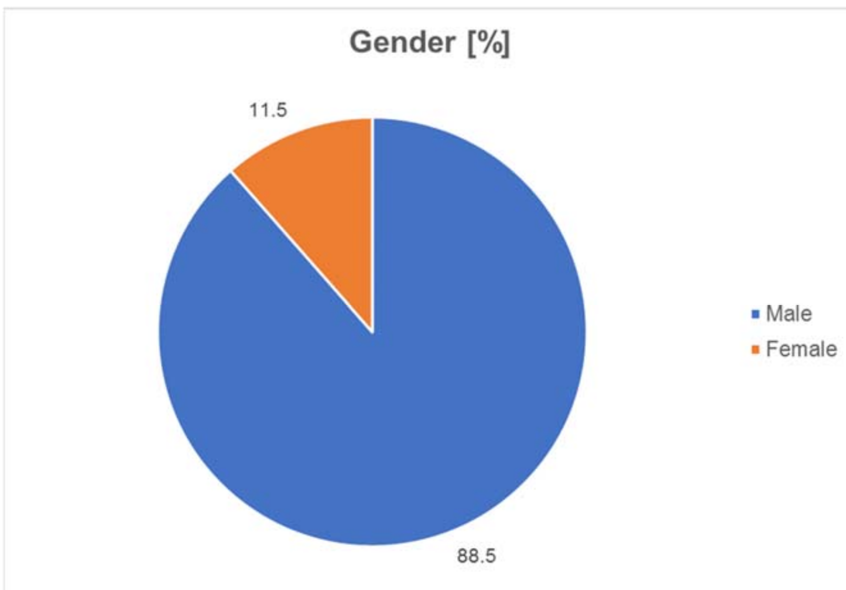


Figure 4-1: Demographic profile of respondents by age and gender

The majority of respondents were male with 108 responses in total, while only 14 females participated in the study. The mining industry in general, including ferroalloys, has historically employed more males than females, and hence these skewed gender results were expected.

4.2.2 Education and working experience of respondents

The highest level of education and level of experience of respondents are presented in Figure 4-2. Respondents are generally well-educated with 60% of respondents indicating they possess a university degree and 30% of respondents having achieved a master's degree or higher. Only 4% of respondents indicated no form of tertiary education. Therefore, this population is expected to have a higher level of personal innovativeness when compared to the average individual, based on their relatively high level of education as discussed in section 2.6.

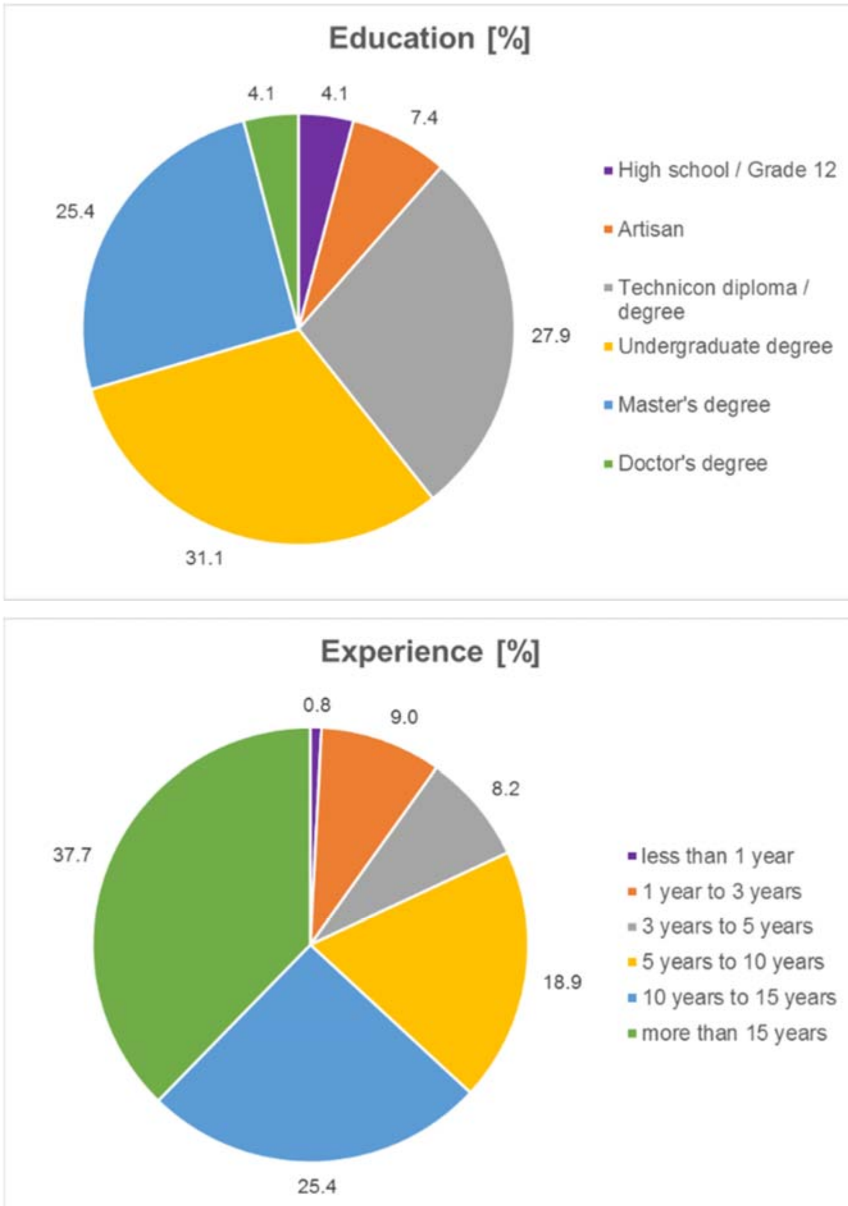


Figure 4-2: Demographic profile of respondents by education and working experience

In line with the finding that most respondents are in their middle years and older, respondents are also relatively experienced with 82% of respondents having been directly involved with the South African ferroalloy industry for more than 5 years and 63% for more than 10 years. Therefore, it is fair to assume that the sample population is well versed in the industry, having spent a considerable amount of their professional lives working in the industry.

4.2.3 Employment position and industry relationship of respondents

The positions to which respondents have been appointed and the services being offered by them are presented in Figure 4-3. In line with previous demographical data, respondents generally occupy senior roles in their respective companies, with 56% of respondents in manager, senior engineer or senior consultant roles or higher.

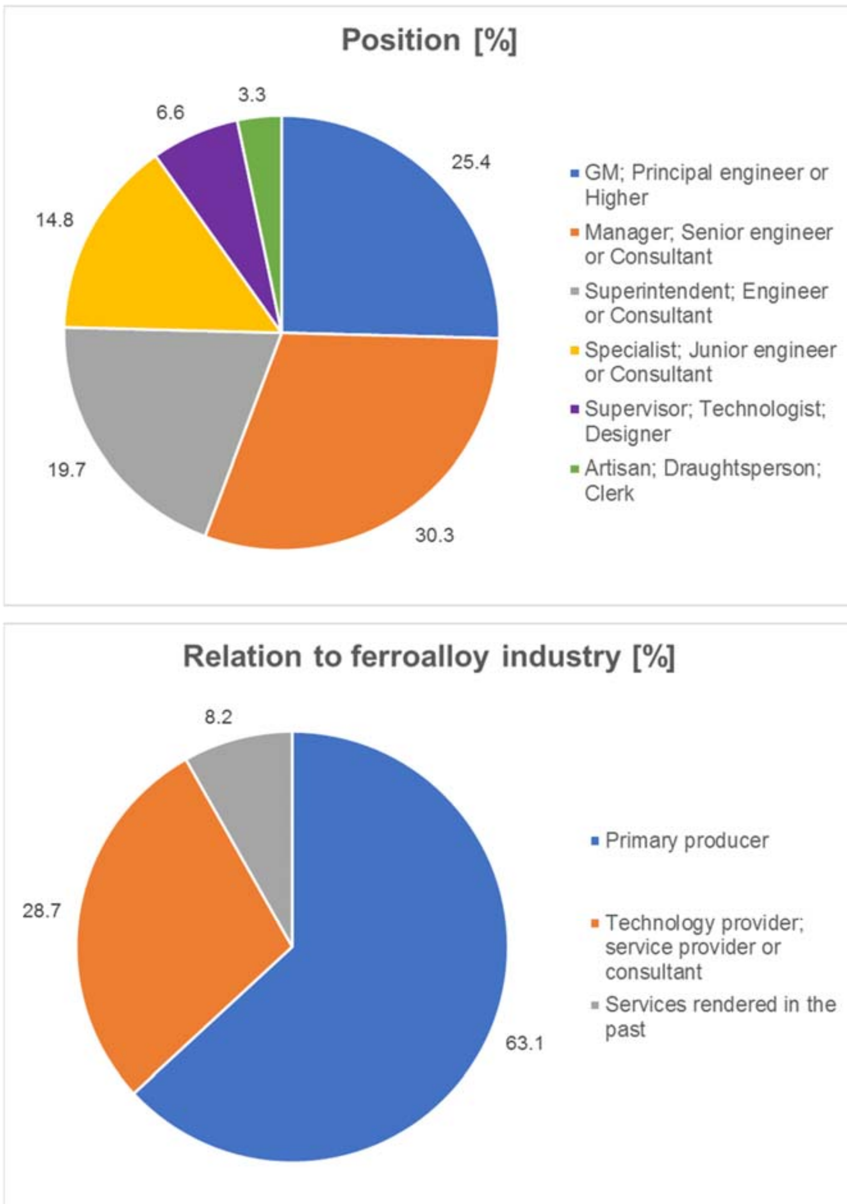


Figure 4-3: Demographic profile of respondents by employment position and category

However, employees at specialist, junior engineer and consultant level also spend a good deal of their time evaluating potential new technologies and innovations. They are often the ones that conduct technology trade-off studies for presentation to top management. Finally, employees at artisan level and equivalent may not work with new technology daily, but certainly have influence in new technology adoption decisions. Therefore, 90% of respondents have a direct role in technology adoption decisions, since they are employed at specialist level and above with the remaining 10% of respondents still able to influence these decisions.

The relation of respondents to the ferroalloy industry is an important distinction that is addressed throughout this chapter. Most respondents work directly for primary producers with 63% of them working to directly support an operational plant. On the other hand, 37% of respondents work as service providers, technology providers or consultants to the industry, meaning that they ultimately deliver professional services to the primary producers.

It should be noted that the group of respondents that rendered services to the industry in the past were also included with second group that offer professional services or technology to the industry. This is a logical grouping, since their companies have offered services to the ferroalloy industry in the past, although they are not doing so at present.

4.2.4 Demographic overview of respondents

The demographic data confirms that all respondents in this study are directly involved with the ferroalloy industry and influence technology adoption decisions. Moreover, most of the respondents are well educated, experienced individuals occupying relatively senior positions within their respective companies.

Therefore, although a non-random convenience sample was obtained, this set of respondents is certainly a relevant population set when considering the subject matter and goal of the empirical research. Also, the respondent set appears to be representative of the target population, although this claim cannot be confirmed since the intent of the research from the beginning was to gather data on a segment of the population by means of a convenience sample.

4.3 OVERVIEW OF STUDY DATA

An overview of the data obtained during the empirical research is presented in this section, with a focus on frequencies and descriptive statistics. The data is presented in two logical sub-sections, delineated as follows:

(i) Personal innovativeness of individuals; and
(ii) Perceived characteristics of innovating.

Data pertaining to the demographic profile and working environment is presented in section 4.2.

A seven-point Likert scale was used as rating scale for all questions pertaining to the sub-sections described above, with each respondent only able to select a single response per question. A respondent was able to select a single response to each question from a minimum value of 1 to a maximum of 7 for each item, based on the following guidelines provided in the questionnaire:

(i) 1: Strongly disagree;
(ii) 2: Disagree;
(iii) 3: Moderately disagree
(iv) 4: Undecided
(v) 5: Moderately agree
(vi) 6: Agree
(vii) 7: Strongly agree

4.3.1 Personal innovativeness

Based on the work done by Hurt *et al.* (1977:61) and Pallister and Foxall (1998:663) in developing a robust survey instrument to measure personal innovativeness, the seven-point Likert scale was therefore selected as rating scale in this study.

Table 4-1 presents the total responses received for each question expressed as a percentage of 122 responses in total. The instrument is made up of 20 questions with both standard and reversed scoring applied as follows:

(i) Questions 1, 2, 3, 5, 8, 9, 11, 12, 14, 18 and 19 utilise standard scoring with a higher score representing more innovative responses. Therefore, a higher level of agreement with the statements coupled with a higher score indicates a more innovative individual.
(ii) Questions 4, 6, 7, 10, 13, 15, 17 and 20 utilise reversed scoring with a lower score representing more innovative responses. Therefore, a higher level of disagreement with the statements coupled with a lower score indicates a more innovative individual.

The questions were reduced into factors (refer to section 4.4), with the primary factor associated with each question also indicated in the table.

Respondents generally indicated a high level of agreement with questions using standard scoring, with a lowest mean score of 5.72, representing agreement to strong agreement with the statements. Moreover, a high level of disagreement was registered with questions using reversed scoring, with a highest mean score of 3.80 but all other scores falling below 3, representing at least moderate disagreement.

Therefore, on average respondents in this data set were found to be quite innovative. This was a surprising outcome, since primary producers in particular have long been viewed as individuals that possess low personal innovativeness and the expectation was that many respondents would typically be classified as late majority individuals or even laggards (Moore, 2014; Rogers, 2003).

Table 4-1: Personal innovativeness: Frequencies and descriptive analyses

#	F#	Question	N	Likert Scale 1	2	3	4	5	6	7	Mean	Std. Dev.
1	A-3	My friends or colleagues (peers) often ask me for advice or information.	122	0.0%	0.0%	2.5%	1.6%	22.1%	45.9%	27.9%	5.95	0.89
2	A-1	I enjoy trying out new ideas.	122	0.0%	0.0%	0.0%	1.6%	18.0%	40.2%	40.2%	6.19	0.79
3	A-1	I seek out new ways to do things.	122	0.0%	0.0%	0.0%	2.5%	14.8%	46.7%	36.1%	6.16	0.76
4	A-2	*I am generally cautious about accepting new ideas.	122	4.1%	23.8%	23.0%	10.7%	19.7%	13.9%	4.9%	3.80	1.65
5	A-1	I frequently improvise (invent) methods for solving a problem when an answer is not apparent.	122	0.8%	0.0%	0.8%	4.1%	27.9%	41.8%	24.6%	5.82	0.97
6	A-2	*I am suspicious of new inventions and new ways of thinking.	122	18.0%	34.4%	14.8%	13.1%	9.0%	9.8%	0.8%	2.93	1.61
7	A-2	*I rarely trust new ideas until I can see whether the vast majority of people around me accept them.	122	16.4%	37.7%	23.8%	9.0%	4.9%	4.1%	4.1%	2.77	1.52
8	A-3	I feel that I am an influential member of the group of friends and colleagues (the peer group) I associate with.	122	0.0%	0.0%	0.0%	6.6%	25.4%	46.7%	21.3%	5.83	0.84
9	A-1	I consider myself to be creative and original in my thinking and behaviour.	122	0.0%	0.0%	0.0%	3.3%	22.1%	46.7%	27.9%	5.99	0.80
10	A-4	*I am aware that I am usually one of the last people in my group to accept something new.	122	30.3%	38.5%	18.0%	3.3%	4.9%	3.3%	1.6%	2.30	1.38
11	A-1	I am an inventive kind of person.	122	0.8%	0.0%	2.5%	10.7%	32.8%	36.1%	17.2%	5.52	1.06
12	A-3	I enjoy taking part in the leadership responsibilities of the groups I belong to.	122	0.0%	0.0%	0.0%	1.6%	18.9%	43.4%	36.1%	6.14	0.77
13	A-2	*I am reluctant about adopting new ways of doing things until I see them working for people around me.	122	19.7%	40.2%	21.3%	7.4%	4.1%	6.6%	0.8%	2.59	1.41
14	A-1	I find it stimulating to be original in my thinking and behaviour.	122	0.0%	0.0%	0.8%	5.7%	12.3%	50.8%	30.3%	6.04	0.86
15	A-4	*I tend to feel that the old way of living and doing things is the best way.	122	26.2%	33.6%	22.1%	11.5%	3.3%	2.5%	0.8%	2.43	1.29

16	A-5	I am positively challenged by ambiguities (uncertainties) and unsolved problems.	122	0.0%	1.6%	0.0%	7.4%	25.4%	45.9%	19.7%	5.73	0.97
17	A-2	*I must see other people using new innovations before I will consider them.	122	20.5%	40.2%	23.8%	4.9%	4.9%	5.7%	0.0%	2.51	1.33
18	A-5	I am receptive to new ideas.	122	0.0%	0.0%	0.0%	5.7%	13.9%	45.1%	35.2%	6.10	0.85
19	A-5	I am positively challenged by unanswered (awkward) questions.	122	0.0%	2.5%	1.6%	3.3%	24.6%	50.0%	18.0%	5.72	1.01
20	A-2	*I often find myself sceptical of new ideas.	122	15.6%	39.3%	15.6%	13.9%	6.6%	7.4%	1.6%	2.85	1.53

Note: * Indicates questions with reversed scoring, with a low score indicating a more innovative response.

4.3.2 Perceived characteristics for innovating

As noted, based on the work done by Moore and Benbasat (1991:216) in developing a robust survey instrument to measure the perceived characteristics of innovating, the seven-point Likert scale was selected as rating scale in this study.

Table 4-2 presents the total number of responses received for each question expressed as a percentage of 122 responses in total. The instrument is made up of 25 questions with both standard and reversed scoring applied as follows:

(i) Questions 23 to 40, 42, 44 and 45 utilise standard scoring with a higher score representing a higher level of agreement with the statements coupled with a relative importance on the factor or construct being measured.

(ii) Questions 21, 22, 41 and 43 utilise reversed scoring with a lower score representing a higher level of disagreement with the negative statements, thus a low score indicates the respondent placing a higher level of importance on the factor associated with the question.

The questions were reduced into factors (refer to section 4.4) with the primary factor associated with each question also indicated in the table. Note that factors B-1, B-2, B-4, B-5 and B-7 are all made up of questions with standard scoring, while factor B-8 is made up of questions with reversed scoring. Therefore, since the direction of all questions in each of these factors are the same, the results during the factor analysis step can easily be interpreted. However, factors B-3 and B-6 are made up of both standard and reverse scoring questions, and thus the mean obtained and the direction of correlations should be carefully interpreted during further investigation.

The importance assigned to various factors by respondents is further investigated during the factor analysis and comparison steps.

Table 4-2: **Perceived characteristics of innovating: Frequencies and descriptive analyses**

#	F#	Question	N	Likert Scale							Mean	Std. Dev.
				1	2	3	4	5	6	7		
21	B-8	*My boss does NOT require me to use or implement a new technology (or innovation).	122	30.3%	35.2%	13.9%	3.3%	5.7%	9.0%	2.5%	2.56	1.69
22	B-8	*Although it might be helpful, using or implementing a new technology (or innovation) is certainly NOT compulsory in my work.	122	18.9%	24.6%	10.7%	8.2%	16.4%	16.4%	4.9%	3.48	1.95
23	B-1	Using a new technology (or innovation) should enable me (or others) to accomplish tasks more quickly.	122	0.0%	0.8%	1.6%	4.1%	14.8%	38.5%	40.2%	6.09	1.00
24	B-1	Using a new technology (or innovation) should improve the quality of work I do (or the quality of my responsible plant area / office).	122	0.0%	0.0%	0.0%	4.1%	11.5%	42.6%	41.8%	6.22	0.81
25	B-1	Using a new technology (or innovation) should make it easier for me (or others) to do my (their) work.	122	0.0%	0.0%	0.8%	8.2%	9.0%	40.2%	41.8%	6.14	0.95
26	B-1	Using a new technology (or innovation) should enhance my (or others') effectiveness on the job.	122	0.0%	0.0%	0.0%	3.3%	13.1%	34.4%	49.2%	6.30	0.82
27	B-1	Using a new technology (or innovation) should give me greater control over my work (or responsible plant area / office environment).	122	0.0%	0.0%	0.0%	7.4%	18.9%	36.1%	37.7%	6.04	0.93
28	B-4	Using a new technology (or innovation) must be compatible with all aspects of my work (or responsible plant area / office environment).	122	0.0%	0.8%	6.6%	23.8%	17.2%	32.0%	19.7%	5.32	1.26
29	B-4	I think that using a new technology (or innovation) should fit well with the way I (or others) like to work.	122	0.8%	3.3%	8.2%	15.6%	20.5%	32.0%	19.7%	5.26	1.40
30	B-4	Using a new technology (or innovation) should fit into my (or others') work style.	122	2.5%	4.1%	14.8%	13.1%	21.3%	29.5%	14.8%	4.94	1.54
31	B-2	People in my organisation who use a new technology (or innovation) have more prestige (admiration) than those who do not.	122	3.3%	5.7%	8.2%	27.9%	18.9%	25.4%	10.7%	4.72	1.51
32	B-2	People in my organisation who use a new technology (or innovation) have a high profile (high standing in the company).	122	3.3%	2.5%	7.4%	27.0%	27.9%	23.8%	8.2%	4.78	1.36
33	B-2	Having (or implementing) a new technology (or innovation) is a status symbol in my organisation.	122	4.1%	8.2%	12.3%	29.5%	24.6%	13.9%	7.4%	4.34	1.48
34	B-7	My (or others') interaction (knowledge and application) with a new technology (or innovation) should be clear and understandable.	122	0.8%	0.8%	0.0%	4.9%	23.0%	43.4%	27.0%	5.87	1.01
35	B-7	I believe that it should be easy to get a new technology (or innovation) to do what I (or others) want it to do.	122	0.8%	4.1%	9.0%	7.4%	27.9%	36.1%	14.8%	5.25	1.36

36	B-7	Overall, I believe that a new technology (or innovation) should be easy to use.	122	0.0%	0.8%	5.7%	4.1%	19.7%	36.9%	32.8%	5.84	1.15
37	B-7	Learning to operate a new technology (or innovation) should be easy for me (or others).	122	0.0%	1.6%	6.6%	8.2%	23.0%	36.1%	24.6%	5.59	1.22
38	B-6	I would have no difficulty in telling others about the results of using a new technology (or innovation).	122	0.8%	0.0%	0.8%	2.5%	12.3%	40.2%	43.4%	6.20	0.95
39	B-6	I believe I could communicate to others the consequences of using a new technology (or innovation).	122	0.0%	0.0%	1.6%	2.5%	13.9%	42.6%	39.3%	6.16	0.87
40	B-6	The results of using a new technology (or innovation) should be apparent to me (or others).	122	0.0%	0.0%	0.8%	2.5%	21.3%	37.7%	37.7%	6.09	0.87
41	B-6	*I would have difficulty explaining (articulating) why using a new technology (or innovation) may or may not be beneficial.	122	18.0%	44.3%	21.3%	10.7%	1.6%	2.5%	1.6%	2.48	1.25
42	B-3	In my organisation, one sees new technology (or innovations) in many areas of the plant or office buildings.	122	1.6%	3.3%	20.5%	8.2%	30.3%	23.8%	12.3%	4.83	1.48
43	B-3	*New technology (or innovation) is NOT very visible in my organization.	122	17.2%	30.3%	19.7%	9.8%	12.3%	9.8%	0.8%	3.02	1.62
44	B-5	Before deciding whether to use a new technology (or innovation), I (or others) should be able to properly try (or test) it out.	122	0.8%	2.5%	1.6%	10.7%	22.1%	34.4%	27.9%	5.66	1.25
45	B-5	I (or others) should be permitted to use a new technology (or innovation) on a trial basis long enough to see what it will do.	122	0.0%	2.5%	0.8%	11.5%	17.2%	40.2%	27.9%	5.75	1.15

Note: *Indicates questions with reversed scoring, with a low score indicating a higher level of agreement with the underlying factor or construct.

4.4 EXPLORATORY FACTOR ANALYSIS AND FACTOR LOADING

To better interpret the data obtained, exploratory factor analysis (EFA) was done on the data obtained for both sub-sections of the questionnaires to uncover the underlying structure of what is a relatively large set of variables. The intent was to identify a set of latent factors or constructs that better define the data set.

This data reduction step was successful and underlying factors were successfully identified and analysed further on in the research. An overview of justification of data reduction and the factor loading matrices is presented below.

4.4.1 Justification for data reduction

Several statistical tests were performed to test the sample adequacy, data structure, correlations and explain the variance observed. The data associated with each sub-section of the questionnaires was evaluated against the testing criteria as presented in Table 4-3.

Table 4-3: Testing criteria for data reduction and factor loading

	Questionnaires		Statistical tests	
	Personal innovativeness	**Perceived characteristics of innovating**	**Test criteria**	**Test result**
Factor	A-1 to A-5	B-1 to B-8	-	-
N	122	122	-	-
Questions	Q1 - Q20	Q21 - Q45	-	-
Determinant	0.0000626	0.0000004	>0.00001	Pass
Kaiser-Meyer-Olkin (KMO)	0.86	0.83	0.8 - 0.9: very good	Pass
Bartlett	0.0001	0.0001	p<0.05	Pass
Cumulative Variance	54.0	63.2	>50% of variance due to extracted factors	Pass
Communalities	0.3 - 0.8	0.3 - 0.9	>0.3	Pass

The following statistical tests were performed to determine whether proceeding with an exploratory factor analysis was appropriate for the data:

(i) The determinant was calculated to test if correlations are too high. If the determinant is > 0.00001, there is no strong multicollinearity.

(ii) The Kaiser-Meier-Olkin (KMO) test is a measure of sampling adequacy, with KMO>0.5 indicating an acceptable, ‘medium’ level of adequacy. For both sets of data a result between 0.8 – 0.9 was calculated, which indicated ‘very good’ sampling adequacy.

(iii) Bartlett's test of sphericity indicates whether correlations between items are high enough. If $p<0.05$, then correlations are sufficiently high, which was the case for both data sets.

(iv) At least 50% of the total variance should be explained by the extracted factors. The cumulative variance of the identified factors >50% in both cases.

(v) Communalities refer to the proportion of the variance of each question explained by the extracted factors. Communalities for all questions should be >0.3, which was the case for all questions.

Each subset of data passed all required tests and therefore the data was found to be sufficient for further exploratory factor analyses.

4.4.2 Pattern matrices and factor loading for personal innovativeness data

The personal innovativeness sub-section of the questionnaire had 20 questions, which were reduced to 5 factors as presented in Table 4-4. Factor loadings with values <0.3 were typically excluded from the table to make it more legible.

Moore and Benbasat (1991:61) initially developed the scales for the identification of adopter types with the intent to predict the willingness of a population group to adopt innovations across a wide population differing in terms of age and socioeconomic status. Furthermore, they view personal innovativeness as primarily being a willingness to change and therefore argue that the instrument measures a unidimensional construct. Pallister and Foxall (1998:669) did further work on the instrument achieving favourable results in terms of reliability and validity. However, they rejected the claim that the scale is unidimensional and found that in the vast majority of data they analysed five distinct factors were identified in each case.

In support of the work done by Pallister and Foxall (1998:669), five latent factors were clearly identified from the data in this study. Therefore, the argument for a unidimensional scale is not supported by this research and therefore rejected. Also, the names of two of the factors previously suggested by Pallister and Foxall (1998:669) were retained in this study as these names describe the underlying questions well. New names have been proposed by the author for the remaining three factors based on the associated questions and the results obtained from these underlying constructs.

The following factor names are proposed, based on the grouping of the underlying data and factor loading as presented in Table 4-4:

(i) A-1: Eager innovativeness (Pallister & Foxall, 1998:675);

(ii) A-2: Conformists (Pallister & Foxall, 1998:675);

(iii) A-3: Innovative leaders;
(iv) A-4: Laggards; and
(v) A-5: Trailblazers

Questions 1 to 8, 10 to 13, 15 to 17, 19 and 20 loaded to a single factor. All other questions loaded to two or three different factors, although the differences in loading numbers were not noticeable. Questions 9 was assigned to factor A-1 despite loading to two factors as it fits much better with eager innovativeness. Question 14 was also assigned to factor A-1 despite loading to two factors, since it refers to originality and does refer to ambiguities which are in line with the rest of the questions in the constructs. Finally, question 18 loaded to three factors, with the decision being made to assign it to factor A-5, since the question does not relate to leadership and is certainly not in line with the conformist factor.

Factors A-1, A-3 and A-5 are all made up of questions with standard scoring, while factors A-2 and A-4 are all made up of questions with reversed scoring. Therefore, since the direction of all questions in each factor are the same, the results obtained during the factor analysis step can easily be interpreted.

Table 4-4: Factor loading: Personal innovativeness

#	F#	Factor	Question	Factors				
				A-1	A-2	A-3	A-4	A-5
1	A-3	Innovative leaders	My friends or colleagues (peers) often ask me for advice or information.			**0.639**		
2	A-1	Eager innovators	I enjoy trying out new ideas.	**0.548**				
3	A-1	Eager innovators	I seek out new ways to do things.	**0.534**				
4	A-2	Conformists	I am generally cautious about accepting new ideas.		**0.516**			
5	A-1	Eager innovators	I frequently improvise (invent) methods for solving a problem when an answer is not apparent.	**0.833**				
6	A-2	Conformists	I am suspicious of new inventions and new ways of thinking.		**0.782**			
7	A-2	Conformists	I rarely trust new ideas until I can see whether the vast majority of people around me accept them.		**0.921**			
8	A-3	Innovative leaders	I feel that I am an influential member of the group of friends and colleagues (the peer group) I associate with.			**0.485**		
9	A-1	Eager innovators	I consider myself to be creative and original in my thinking and behaviour.	**0.454**			~~0.454~~	
10	A-4	Laggards	I am aware that I am usually one of the last people in my group to accept something new.				**0.504**	
11	A-1	Eager innovators	I am an inventive kind of person.	**0.772**				
12	A-3	Innovative leaders	I enjoy taking part in the leadership responsibilities of the groups I belong to.			**0.523**		
13	A-2	Conformists	I am reluctant about adopting new ways of doing things until I see them working for people around me.		**0.683**			
14	A-1	Eager innovators	I find it stimulating to be original in my thinking and behaviour.	**0.206**				~~0.208~~
15	A-4	Laggards	I tend to feel that the old way of living and doing things is the best way.				**0.329**	

16	A-5	Trailblazers	I am positively challenged by ambiguities (uncertainties) and unsolved problems.					**0.484**
17	A-2	Conformists	I must see other people using new innovations before I will consider them.		**0.461**			
18	A-5	Trailblazers	I am receptive to new ideas.		~~-0.376~~	~~0.399~~		**0.367**
19	A-5	Trailblazers	I am positively challenged by unanswered (awkward) questions.					**0.870**
20	A-2	Conformists	I often find myself sceptical of new ideas.		**0.675**			

4.4.3 Pattern matrices and factor loading for perceived characteristics of innovating data

The perceived characteristics of innovating sub-section of the questionnaire had 25 questions, which were reduced to 8 factors as presented in Table 4-5. Factor loadings with values <0.3 were excluded from the table to make it more legible.

Moore and Benbasat (1991:194) initially developed their scales with the intent to create a robust instrument that is generally applicable to a wide variety of innovations, thereby testing the response of adopters during the initial adoption decision. Their final instrument was set up to measure eight underlying factors and they assigned names to each of these factors based on the work done by them and others.

In support of the work done by Moore and Benbasat (1991:194), eight latent factors were clearly identified from the data in this study with the factor names as proposed by Moore and Benbasat (1991:194) being retained. The factor names were retained, based on the grouping of the underlying data and factor loading as presented in Table 4-5:

(i) B-1: Relative advantage (Rogers, 2003);

Questions 23 to 27 all loaded to factor B-1 as expected. Question 26 also loaded to factor B-6 to a smaller degree and this association was discarded.

(ii) B-2: Image Burt

Questions 31 to 33 all loaded to factor B-2 as expected.

(iii) B-3: Visibility (Moore & Benbasat, 1991);

Questions 42 and 43 all loaded to factor B-3 as expected.

(iv) B-4: Compatibility (Rogers, 2003);

Questions 28 to 30 all loaded to factor B-4 as expected.

(v) B-5: Trialability (Rogers, 2003);

Questions 44 and 45 all loaded to factor B-5 as expected.

(vi) B-6: Result demonstrability (Moore & Benbasat, 1991);

Questions 38 and 40 all loaded to factor B-6 as expected. Questions 39 and 41 loaded to two factors, however, the loading that was initially expected was retained and the second association discarded.

Note that question 41 loaded more heavily to factor B-7, and there appears to be a logical association with the ‘ease of use’ factor given the nature of the question. However, the question was still loaded to the factor B-6, since it is also a sensible association that is supported by the literature.

(vii) B-7: Ease of use (Davis, 1989:319);

Questions 34 to 37 all loaded to factor B-7 as expected. Questions 35 and 36 loaded to two factors, however, the loading that was initially expected was retained and the second association discarded.

Question 34 loaded more heavily to factor B-5, with a very small association measured for the intended factor. However, this question is clearly not related to the ‘trialability’ factor and therefore the logical association with the ‘ease of use’ factor was retained going forward as supported by the literature.

(viii) B-8: Voluntariness of use (Moore & Benbasat, 1991).

Questions 21 to 22 all loaded to factor B-8 as expected.

Factors B-1, B-2, B-4, B-5 and B-7 are all made up of questions with standard scoring, while factor B-8 is made up entirely of questions with reversed scoring. Finally, factors B-3 and B-6 are made up of standard questions with each factor utilising a single question with reversed scoring. Therefore, the relative mean values should be interpreted with caution. Thus, the direction of the underlying questions in each factor needs to be considered during the factor analysis step and can easily be interpreted.

Table 4-5: Factor loading: Perceived characteristics of innovating

#	F #	Factor	Question	Factors							
				B-1	**B-2**	**B-3**	**B-4**	**B-5**	**B-6**	**B-7**	**B-8**
21	B-8	Voluntariness	My boss does NOT require me to use or implement a new technology (or innovation).								**0.657**
22	B-8	Voluntariness	Although it might be helpful, using or implementing a new technology (or innovation) is certainly NOT compulsory in my work.								**0.660**
23	B-1	Relative advantage	Using a new technology (or innovation) should enable me (or others) to accomplish tasks more quickly.	**0.773**							
24	B-1	Relative advantage	Using a new technology (or innovation) should improve the quality of work I do (or the quality of my responsible plant area / office).	**0.840**							
25	B-1	Relative advantage	Using a new technology (or innovation) should make it easier for me (or others) to do my (their) work.	**0.965**							
26	B-1	Relative advantage	Using a new technology (or innovation) should enhance my (or others') effectiveness on the job.	**0.700**					~~-0.312~~		
27	B-1	Relative advantage	Using a new technology (or innovation) should give me greater control over my work (or responsible plant area / office environment).	**0.720**							
28	B-4	Compatibility	Using a new technology (or innovation) must be compatible with all aspects of my work (or responsible plant area / office environment).				**0.491**				
29	B-4	Compatibility	I think that using a new technology (or innovation) should fit well with the way I (or others) like to work.				**0.871**				
30	B-4	Compatibility	Using a new technology (or innovation) should fit into my (or others') work style.				**0.812**				
31	B-2	Image	People in my organisation who use a new technology (or innovation) have more prestige (admiration) than those who do not.		**0.849**						
32	B-2	Image	People in my organisation who use a new technology (or innovation) have a high profile (high standing in the company).		**0.845**						
33	B-2	Image	Having (or implementing) a new technology (or innovation) is a status symbol in my organisation.		**0.653**						
34	B-7	Ease of Use	My (or others') interaction (knowledge and application) with a new technology (or innovation) should be clear and understandable.					~~0.306~~		**-0.088**	
35	B-7	Ease of Use	I believe that it should be easy to get a new technology (or innovation) to do what I (or others) want it to do.						~~-0.367~~	**0.356**	

36	B-7	Ease of Use	Overall, I believe that a new technology (or innovation) should be easy to use.						~~-0.305~~	**0.496**	
37	B-7	Ease of Use	Learning to operate a new technology (or innovation) should be easy for me (or others).							**0.628**	
38	B-6	Result Demonstrability	I would have no difficulty in telling others about the results of using a new technology (or innovation).						**-0.707**		
39	B-6	Result Demonstrability	I believe I could communicate to others the consequences of using a new technology (or innovation).	~~0.326~~					**-0.396**		
40	B-6	Result Demonstrability	The results of using a new technology (or innovation) should be apparent to me (or others).						**-0.599**		
41	B-6	Result Demonstrability	I would have difficulty explaining (articulating) why using a new technology (or innovation) may or may not be beneficial.						**0.186**	~~0.349~~	
42	B-3	Visibility	In my organisation, one sees new technology (or innovations) in many areas of the plant or office buildings.			**-0.850**					
43	B-3	Visibility	New technology (or innovation) is NOT very visible in my organisation.			**0.815**					
44	B-5	Trialability	Before deciding whether to use a new technology (or innovation), I (or others) should be able to properly try (or test) it out.					**0.762**			
45	B-5	Trialability	I (or others) should be permitted to use a new technology (or innovation) on a trial basis long enough to see what it will do.					**0.603**			

4.5 CONSTRUCT VALIDITY

Validity refers to whether a given measure actually correctly measures what it is intended to measure. Therefore, the validity of a study considers the integrity of the conclusions that are generated from the research (Bryman & Bell, 2015:25-26).

Moreover, measurement validity (often called construct validity) specifically addresses the question as to whether or not a given measure accurately reflects the concept that it is supposed to capture. A measure can be reliable but not valid, however, a valid measure must also be reliable since any measure must produce consistent results if one is to draw sensible conclusions. Therefore, an assessment of measurement validity fundamentally assumes that a given measure is also reliable (Bryman & Bell, 2015:25-26).

Extensive work was done on both survey instrument that were adapted for this research to ensure a high degree of validity for a broad set of socio-economic conditions. Validity was not tested for explicitly during this research, however, the underlying survey instruments are considered to be robust and have demonstrated high degrees of validity in past studies (Hurt *et al.*, 1977; Moore & Benbasat, 1991).

4.6 RELIABILITY AND INTERNAL CONSISTENCY

Reliability refers to whether a measure produces consistent results when applied to the same data. Therefore, the reliability of a study indicates whether the results obtained in a study are repeatable and indicates that the measurements devised and used in a study are consistent and able to produce outcomes that are repeatable at a later stage. These factors are important for quantitative research considering business and management concepts (Bryman & Bell, 2015:24).

Cronbach's alpha (α) is a measure of reliability and internal consistency, and indicates whether items and subsets of items in the measuring instrument are highly correlated. It is expressed as a coefficient of reliability(α) and is used to assess the quality of the measurement for the items in a survey instrument with the results obtained expressed on a scale from 0 to 1. A higher value indicates improved reliability (Bryman & Bell, 2015:38).

Due to measurement error, perfect reliability of 1.0 is not expected on a standardised test and practically $\alpha > 0.7$ is considered to be an acceptable guideline value, with $\alpha > 0.5$ also being appropriate, but then interpretation should be done with caution. Moreover, a value of $\alpha > 0.8$ is considered to be good and is often used as evidence to prove that an underlying construct exists.

Conversely, a value of α < 0.5 is considered not to be reliable and this value will be rejected (Bryman & Bell, 2015:38).

Table 4-6 describes each factor or construct in greater detail. All factors are listed, including the questions and number of questions associated with each factor. Also, Cronbach's alpha, the mean score and standard deviation of each factor are also displayed.

Table 4-6: Cronbach's alpha values for all constructs

F#	Factor	Questions	No. of items	Cronbach's alpha	Mean	Std. Dev.
A-1	Eager innovators	Q2, Q3, Q5; Q9, Q11, Q14	6	0.84	5.95	0.66
A-2	Conformists	Q4, Q6, Q7; Q13, Q17, Q20	6	0.88	2.91	1.19
A-3	Innovative leaders	Q1, Q8, Q12	3	0.63	5.97	0.63
A-4	Laggards	Q10, Q15	2	0.58	2.36	1.12
A-5	Trailblazers	Q16, Q18, Q19	3	0.70	5.85	0.75
B-8	Voluntariness	Q21 - Q22	2	0.59	3.02	1.54
B-1	Relative advantage	Q23 - Q27	5	0.92	6.16	0.79
B-4	Compatibility	Q28 - Q30	3	0.80	5.17	1.19
B-2	Image	Q31 - Q33	3	0.82	4.61	1.24
B-7	Ease of use	Q34 - Q37	4	0.79	5.64	0.93
B-6	Result demonstrability	Q38 - Q41	4	0.68	5.99	0.71
B-3	Visibility	Q42 - Q43	2	0.83	4.90	1.43
B-5	Trialability	Q44 - Q45	2	0.64	5.70	1.03

Nine factors all achieve a α ≥ 0.7, which by definition indicates acceptable reliability. Furthermore, the remaining four factors achieved an α ≥ 0.6, which may be considered adequate given the correct circumstances an interpretation. In light of the large amount of work that has already been done on both survey instruments to prove reliability and validity for a wide range of application and the favourable data collected during this study, the reliability of all factors has successfully been demonstrated. Therefore, all factors are considered to be acceptable and were retained for the study (Moore & Benbasat, 1991; Pallister & Foxall, 1998).

4.6.1 Personal innovativeness

As discussed in section 4.4, factors A-1, A3 and A-5 are comprised of questions with standard scoring, therefore a higher level of agreement and a higher mean score indicate a more innovative respondent. A mean score rounded off to 6 was achieved for all three factors with a relatively small standard deviation, indicating a high level of agreement and a high degree of personal innovativeness.

Conversely, factors A-2 and A-4 are comprised of questions with reversed scoring, and therefore a higher level of disagreement and lower mean score indicate a more innovative respondent. A mean score of 2.4 and 2.9 was achieved for both factors. Therefore, on average, respondents indicated at least moderate disagreement or higher when responding to the questions, which again indicate a relatively innovative group of respondents.

From these results, the typical respondent can be classified as falling into the early majority, with many individuals being part of the early adopter category in terms of personal innovativeness. Therefore, the typical respondent has a higher degree of personal innovativeness than expected from the literature study.

4.6.2 Perceived characteristics of innovating

As discussed in section 4.4, factors B-1 to B-8 are comprised of questions with standard, reversed and mixed scoring, and therefore the direction of the questions should be considered when drawing any conclusions. For the factors with mixed scoring, the direction of the questions was considered during the analyses.

All perceived characteristics of innovating were important to respondents when considering an adoption decision, with the lowest mean score achieved by the 'voluntariness of use' (B-8) factor, which indicated only 'moderate agreement' with the questions. Therefore, all factors were important, with a mean score of 'moderate agreement or better for all factors.' Subsequently, this research supports the notion that all the perceived characteristics of innovating should be considered when developing a marketing strategy for the industry. Although all factors were found to be important, a logical sequential grouping in order of importance is as follows:

(i) B-1: Relative advantage (mean = 6.16 with N=122);
(ii) B-6: Result demonstrability (mean = 5.99 with N=122);
(iii) B-5: Trialability (mean = 5.70 with N=122);
(iv) B-7: Ease of use (mean = 5.64 with N=122).

Respondents indicated that their highest level of agreement was with factors B-1 and B-6, followed by factors B-5 and B-7. Therefore, respondents consider “relative advantage” (B-1) and “result demonstrability” (B-6) as the most important innovation characteristics when considering an adoption decision. This is closely followed by “trialability” (B-5) and “ease of use” (B-7), which are also quite important.

“Relative advantage” is typically considered as the most important factor in an adoption decision in diffusion studies. Therefore, this finding is supported by the literature. Moreover, this is a sensible outcome since there should be an advantage associated with an innovation change, otherwise there is no point in adopting in the first place (Ashrafzadeh & Sayadian, 2015:67).

The high mean score for “result demonstrability” is somewhat surprising. Respondents rely heavily on the tangibility of the results that are obtained from an innovation. Also, these results should be clearly demonstrated through observation and communication as these have a significant influence on adoption decisions. Furthermore, “result demonstrability” and “relative advantage” can be quite closely linked in a marketing campaign, with the strategy built around clearly communicating and demonstrating the relative advantage of a certain innovation to potential adopters (Moore & Benbasat, 1991:203).

The high mean scores for “trialability” and “ease of use” which are the inverse of complexity as defined by Rogers (2003) also demonstrate that respondents want the surety to test a new innovation prior to adoption. Moreover, they prefer that innovation must come across as simple and easy to use.

4.7 INDEPENDENT T-TESTS

Further investigation was required to compare groups within the respondent pool to better understand and define their behavioural differences. Respondents were separated into two distinct and independent groups, based on there working environment, in order to determine whether a statistically significant difference exists between the two groups.

Differences were evaluated between primary producers (N=77), who are directly employed in operational roles, and service providers (N=45), who deliver technology, services and consulting work to the industry.

An independent t-test, or two sample t-test, was conducted on the data as described below. The test determines whether a practically significant difference exists between the mean values of different groups according to the following scale:

(i) Effect size > 0.2: Small with no practically significant difference;

(ii) Effect size > 0.5: Medium with a practically visible difference demonstrated; and

(iii) Effect size > 0.8: Large with a practically significant difference demonstrated.

4.7.1 Personal innovativeness

The differences in terms of personal innovativeness between the two groups were investigated. Table 4-7 presents the results from this comparison for the factors related to personal innovativeness.

No practically significant differences were observed between the two groups in terms of any of the factors related to personal innovativeness, with the largest effect size being 0.28 amongst the five factors. If anything, the mean values obtained for producers indicated a slightly higher level of agreement for every factor when compared to service providers indicating a more innovative group. However, due to the very small practical differences achieved with the t-test, these two groups are considered to have similar degrees of personal innovativeness.

Table 4-7: Independent t-test: Perceived characteristics of innovating

F#	Factor	Groups	N	Mean	Std. Dev.	p-values	Effect size
A-1	Eager innovators	Producers	77	5.99	0.71	0.350	0.15
		Technology & service providers; Consultants	45	5.89	0.55		
A-2	Conformists	Producers	77	2.86	1.21	0.530	0.12
		Technology & service providers; Consultants	45	3.00	1.16		
A-3	Innovative Leaders	Producers	77	6.04	0.63	0.134	0.28
		Technology & service providers; Consultants	45	5.86	0.64		
A-4	Laggards	Producers	77	2.25	1.05	0.146	0.26
		Technology & service providers; Consultants	45	2.57	1.22		
A-5	Trailblazers	Producers	77	5.90	0.75	0.330	0.18
		Technology & service providers; Consultants	45	5.76	0.75		

***Note: p-values are reported for completeness sake, but will not be interpreted since a convenience sample instead of a random sample was used.**

From the literature, the argument was repeatedly made that many executives and employees working for primary producers are insular in their thinking with a negative approach towards innovation. Furthermore, they are considered to be conservative in their approach and trained to avoid risk, that is a typical characteristic of the late majority. Subsequently, producers were not expected to have a high degree of personal innovativeness on average. Service providers are typically regarded as more innovative since they are continuously engaging with primary producers to make changes and adopt innovation at their operational plants. However, the results from this study refute that claim and both groups were found to have an equal degree of innovativeness.

4.7.2 Perceived characteristics of innovating

The differences in the perceived characteristics of innovating between the two groups was investigated. Table 4-8 presents the results from this comparison. Also, the view of primary producers must be carefully considered since these individuals form the customer base for innovation and new technologies. Subsequently, primary producers are the key group that will be targeted with a specific marketing campaign.

Following on from section 4.6.2, the same four factors that elicited the highest levels of agreement from all respondents were also found to be the most important factors when only considering producers. Producers attributed a higher weight to each of these factors as compared to service providers, and thus the mean value has increased for this smaller population of N=77.

The most logical sequential grouping in order of importance is as follows for producers is as follows:

- (i) B-1: Relative advantage (mean = 6.34 with N=77);
- (ii) B-6: Result demonstrability (mean = 6.06 with N=77);
- (iii) B-7: Ease of use (mean = 5.86 with N=77); and
- (iv) B-5: Trialability (mean = 5.80 with N=77).

Therefore, the same four factors should be addressed in a marketing campaign aimed at producers when promoting innovations. Producers and service providers appear to be aligned on their understanding of the importance of “trialability” (B-5) and “result demonstrability” (B-6).

However, a practically visible difference was identified with an effect size > 0.5 calculated for the factors “relative advantage” (B-1) and “ease of use” (B-7). In both cases, producers place more emphasis on these factors than service providers do. It is fair to conclude that service providers, technology providers and consultants may underestimate the importance of these factors for producers.

Table 4-8: Independent t-test: Perceived characteristics of innovating

F#	Factor	Groups	N	Mean	Std. Dev.	p-values	Effect Size
B-8	Voluntariness	Producers	77	2.88	1.35	0.250	0.20
		Technology & service providers; Consultants	45	3.24	1.82		
B-1	Relative advantage	Producers	77	6.34	0.75	0.001	**0.65**
		Technology & service providers; Consultants	45	5.84	0.77		
B-4	Compatibility	Producers	77	5.35	1.24	0.026	0.39
		Technology & service providers; Consultants	45	4.87	1.05		
B-2	Image	Producers	77	4.57	1.31	0.623	0.08
		Technology & service providers; Consultants	45	4.68	1.11		
B-7	Ease of use	Producers	77	5.86	0.87	0.000	**0.67**
		Technology & service providers; Consultants	45	5.25	0.91		
B-6	Result demonstrability	Producers	77	6.06	0.74	0.147	0.26
		Technology & service providers; Consultants	45	5.87	0.66		
B-3	Visibility	Producers	77	4.84	1.54	0.540	0.10
		Technology & service providers; Consultants	45	5.00	1.22		
B-5	Trialability	Producers	77	5.80	1.06	0.181	0.24
		Technology & service providers; Consultants	45	5.54	0.97		

***Note: p-values are reported for completeness sake but will not be interpreted since a convenience sample instead of a random sample was used.**

4.8 ANALYSIS OF VARIANCE

Further investigation was required to compare the preferences of various demographic groups within the respondent pool to better understand and define their behavioural differences. In this case, respondents were separated into three distinct and independent groups to determine the differences between them and to confirm traits identified from the literature.

Many comparisons were conducted using different groupings with the intent to identify practically visible and significant differences. Selected, relevant results are reported in this section.

Analysis of variance (Anova) is a statistical technique that determines and quantifies the differences between groups within the data. Since the intent was to compare at least three different groups in each case for this section, a simple t-test was no longer required. Anova is used to determine whether a practically significant difference exists between the mean values of different groups according to the following scale

(i) Effect size > 0.2: Small with no practically significant difference;
(ii) Effect size > 0.5: Medium with a practically visible difference demonstrated; and
(iii) Effect size > 0.8: Large with a practically significant difference demonstrated.

All factors were evaluated against certain criteria and are displayed in the same tables.

4.8.1 Comparison by age

A comparison was drawn by age and all differences were evaluated. Three groups were created with the following age groups to ensure an adequate number of respondents for each category:

(i) 18 – 34 years (N=26);
(ii) 35 – 54 years (N=75);
(iii) 55 or older (N=21).

Table 4-9 presents the results comparing the effect of age on the different factors.

Note that factors A-2 and A-4, the two factors that use reversed scoring for all questions, both resulted in higher levels of agreement as the respondents increase in age. A higher level of agreement with these factors represents a decreased degree of personal innovativeness. Specifically, a practically visible difference was observed between the 55 or older category and the rest of the respondents. Therefore, respondents of 55 years or older have a lower degree of personal innovativeness and are more likely to agree with statements that appeal to “conformists” (A-2) and “laggards” (A-4). However, it should be noted that this group of older respondents is still relatively innovative considering the mean score <3.5 for both factors.

This is an interesting finding, since the literature about the issue is inconclusive, with some authors claiming that personal innovativeness is a trait that is normally distributed regardless of age, while others argue that older people tend to be less innovative, which was the finding of this study.

Finally, the importance placed on "image" (B-4) declines as the respondents age. This is another interesting finding that intuitively makes sense and can be explored further in future studies.

Table 4-9: Anova: Comparison by age

F#	Factor	Group	N	Anova p-value	Welch p-value	Mean	Std. dev.	Effect sizes	
								18 - 34	35 - 54
A-2	Conformists	18 - 34	26	0.049	0.118	2.88	1.15		
		35 - 54	75			2.76	1.09	0.10	
		55 or older	21			3.48	1.42	0.42	0.50
		Total	122			2.91	1.19		
A-4	Laggards	18 - 34	26	0.107	0.214	2.23	1.08		
		35 - 54	75			2.28	1.04	0.05	
		55 or older	21			2.83	1.36	0.44	0.41
		Total	122			2.36	1.12		
B-4	Image	18 - 34	26	0.080	0.062	4.88	1.20		
		35 - 54	75			4.66	1.26	0.18	
		55 or older	21			4.10	1.11	0.66	0.45
		Total	122			4.61	1.24		

***Note: p-values are reported for completeness sake, but will not be interpreted since a convenience sample instead of a random sample was used.**

4.8.2 Comparison by education

A comparison was made in terms of level of education and all differences were evaluated. Three groups were created with adjacent levels of education combined to ensure an adequate number of respondents for each category as follows:

(i) Technicon diploma or degree and less education, which included only having a grade 12 education or being a qualified artisan (N=34);

(ii) University undergraduate degree which included studies at bachelors or honours levels (N=38); and

(iii) University postgraduate degree which included studies at master's level and higher, including a doctoral degree (N=36).

No practically visible effect was observed regarding personal innovativeness as the level of educations varies. This was unexpected, as the literature suggests that personal innovativeness is directly correlated with a person's level of education, with innovativeness increasing as education increases. However, when considering the makeup of this specific sample population, 96% of respondents have some form of tertiary education (refer to section 4.2.2). Moreover, although some respondents are much more highly educated than an artisan, having earned a doctoral degree, for example, and the overall study population is still quite well educated when compared to the average population of South Africa. The relatively high level of education also explains why respondents indicated such a high level of innovativeness on average.

Table 4-10 presents the results comparing the effect of age on the different factors of perceived characteristics of innovating. As education decreases, agreement with the factors increases. Therefore, respondents place increased emphasis on the following factors when only educated at grade 12, artisan or technicon level:

(i) B-1: Relative advantage (mean = 6.43 with N=34);

(ii) B-4: Compatibility (mean = 5.75 with N=34); and

(iii) B-7: Ease of use (mean = 6.02 with N=34).

Table 4-10: Anova: Comparison by level of education

F#	Factor	Group	N	Anova p-value	Welch p-value	Mean	Std. dev.	Effect sizes	
								Tech.	Undergrad.
B-1	Relative advantage	Technicon	34	0.044	0.036	6.43	0.72		
		Undergrad.	38			6.07	0.81	0.45	
		Postgrad.	36			5.98	0.82	0.55	0.11
		Total	108			6.15	0.80		
B-4	Compatibility	Technicon	34	0.001	0.001	5.75	1.03		
		Undergrad.	38			4.73	1.24	0.82	
		Postgrad.	36			4.94	1.13	0.71	0.17
		Total	108			5.12	1.21		
B-7	Ease of use	Technicon	34	0.002	0.001	6.02	0.78		
		Undergrad.	38			5.43	0.92	0.64	
		Postgrad.	36			5.28	0.96	0.78	0.16
		Total	108			5.57	0.94		

***Note: p-values are reported for completeness sake, but will not be interpreted since a convenience sample instead of a random sample was used.**

These findings make intuitive sense, since respondents with a lower level of education are likely to be more hands-on in their approach to work and may primarily consider the practicalities of adopting any technology before making an adoption decision. Therefore, ensuring that new innovations are compatible with existing operations while also being easy to use with low complexity are key considerations for this demographic. Furthermore, these individuals should be truly convinced of the relative advantage of an innovation before adopting it.

Following on from section 4.7.2, where "relative advantage" (B-1) and "ease of use" (B-7) were proven to be particularly important for producers, these factors are also particularly important for respondents with a technicon education or lower. This is a key finding of the research, since the majority of engineers who are employed by producers and work at operational plants do not have a university education and having a technicon diploma or technicon degree are quite commonly found in these roles. Moreover, many senior engineers at production plants are qualified artisans that have come up through the ranks.

4.8.3 Comparison by experience

A comparison was made regarding level of experience and all differences were evaluated. Three groups were created with adjacent levels of experience combined to ensure an adequate number of respondents for each category as follows:

(i) Fewer than 5 years in the industry (N=22);
(ii) More than 5 years and fewer than 15 years in the industry (N=54); and
(iii) More than 15 years in the industry (N=46).

Table 4-11 presents the results comparing the effect of experience age on the different factors of perceived characteristics of innovating. Respondents with less than 5 years of working experience placed less importance on 'compatibility' (B-7) than respondents with more than 5 years of experience. Therefore, more experienced individuals consider the compatibility of an innovation with their existing operation, and are likely to have a deeper and better understanding of their working environment. Conversely, the argument can be made that employees with fewer than 5 years of experience are still getting to know their working environment and are more open to change.

Table 4-11: Anova: Comparison by experience

F#	Factor	Group	N	Anova p-value	Welch p-value	Mean	Std. dev.	Effect sizes	
								Fewer than 5	Fewer than 15
B-7	Compatibility	Fewer than 5 years	22	0.114	0.116	4.70	1.16		
		Fewer than 15 years	54			5.28	1.24	0.47	
		More than 15 years	46			5.28	1.10	0.50	0.00
		Total	122			5.17	1.19		

***Note: p-values are reported for completeness sake, but will not be interpreted since a convenience sample instead of a random sample was used.**

The factors "relative advantage" (B-1) and "ease of use" (B-7) were also affected by the experience level of respondents, however, effect sizes ranged from 0.33 to 0.39, and although these would have a relatively small impact it is an interesting result to take note of. In this case, as experience increases, agreement with the factors increases. Therefore, respondents also place marginally increased emphasis on “relative advantage” (B-1) and “ease of use” (B-7) as they become more experienced. Although it was not displayed in the table due to its relatively low value, this is an interesting finding that yet again demonstrates the importance of demonstrating these factors to the most influential decision makers.

4.9 CORRELATIONS

The correlation coefficient calculates the strength of the relationship between two variables and also indicates the relative movement between the two variables, with values ranging from -1.0 to 1.0. It measures the linear correlation between two variables with a negative correlation between two factors indicating that as the one factor increases, the other one decreases.

The correlation coefficient is used to determine whether a practically significant correlation exists between two factors or constructs according to the following scale

(i) Correlation coefficient > 0.1: Small with no practically significant relationship;
(ii) Correlation coefficient > 0.3: Medium with a practically visible relationship; and
(iii) Correlation coefficient > 0.5: Large with a practically significant relationship.

4.9.1 Personal innovativeness

Table 4-12 presents the correlations of the factors associated with personal innovativeness.

A practically significant relationship exists between “eager innovators” (A-1), “innovative leaders” (A-3) and “trailblazers” (A-5) with a positive correlation > 0.5 between all the factors. Therefore, respondents who agreed with questions in one of these factors also agreed with questions in the other factors. Achieving a high score on the questions associated with these factors demonstrates a higher degree of personal innovativeness. Therefore, individuals who agreed with these three factors are located to the left of the innovativeness continuum and will typically be influential in making adoption decision when a new innovation is poised to cross the innovation chasm.

Conversely, a practically significant relationship exists between “conformists” (A-2) and “laggards” (A-4) with a positive correlation of 0.56. Moreover, these factors also maintain a practically visible negative correlation with factors A-1, A-3 and A-5 as described above. Therefore, individuals who agreed with these two factors are not considered to be very innovative and will likely only adopt innovations as part of the natural diffusion process due to social pressure from their networks. These individuals are not the focus of this study, since they will typically only adopt new technologies once the innovation chasm has successfully been crossed by others.

Table 4-12: Correlations: Personal innovativeness

Factors		Eager innovators	Conformists	Innovative leaders	Laggards	Trailblazers	
		A-1	A-2	A-3	A-4	A-5	
Eager innovators	A-1	1.0	-0.34	0.55	-0.36	0.55	Correlation coefficient
			0.000	0.000	0.000	0.000	p-value
Conformists	A-2	-0.34	1.00	-0.14	0.56	-0.38	Correlation coefficient
		0.000		0.126	0.000	0.000	p-value
Innovative leaders	A-3	0.55	-0.14	1.00	-0.26	0.53	Correlation coefficient
		0.000	0.126		0.004	0.000	p-value
Laggards	A-4	-0.36	0.56	-0.26	1.00	-0.41	Correlation coefficient
		0.000	0.000	0.004		0.000	p-value
Trailblazers	A-5	0.55	-0.38	0.53	-0.41	1.00	Correlation coefficient
		0.000	0.000	0.000	0.000		p-value

***p-values are reported for completeness sake but will not be interpreted, since a convenience sample instead of a random sample was used.**

4.9.2 Personal innovativeness and perceived characteristics of innovating

Table 4-13 presents the correlations of the factors associated with personal innovativeness and the factors associated with the perceived characteristics of innovating. The intent of correlating these factors was to better understand which perceived characteristics of innovating are important for individuals who have a higher degree of personal innovativeness and are more likely to make adoption decisions which may enable certain technologies to cross the innovation chasm into the mainstream market.

"Eager innovators" (A-1) and "innovative leaders" (A-3) presented very similar correlation profiles. Firstly, these factors are highly correlated towards each other as presented in Table 4-12. Secondly, they present almost exactly the same correlations towards the factors linked to the perceived characteristics of innovating, with the following relationships being observed:

(i) Practically significant relationship regarding "relative advantage" (B-1) with correlation coefficients of 0.48 and 0.49 respectively;
(ii) Practically visible relationship regarding "result demonstrability" (B-6) with correlation coefficients of 0.43 and 0.47 respectively; and
(iii) Practically visible relationship regarding "ease of use" (B-7) with correlation coefficients of 0.37 and 0.40 respectively.

Furthermore, the mean values and standard deviation of "eager innovators" (A-1) and "innovative leaders" (A-3) were also found to be very similar (refer to Table 4-6). The question is then raised whether these two factors should indeed be combined into a single factor or construct given their obvious similarities. However, the underlying questions that make up each factor are clearly different with all questions loaded to factor A-3 directly related to leadership in addition to innovation. Therefore, despite the obvious similarities, both factors were retained.

However, when considering practical the actions required for a targeted marketing campaign aimed at increasing the rate of adoption, "eager innovators" (A-1) and "innovative leaders" (A-3) can be considered as a single entity, since the same marketing strategy should be followed when dealing with these individuals.

Therefore, a group emerges from the research that can be classified as individuals with a high degree of innovativeness who are also in leadership roles, since they demonstrate high levels of agreement with both factors A-1 and A-3. This group will likely be open to innovation while also being in a position to influence adoption decisions. This is a key finding for the research, since this group is the perfect target for a marketing campaign with the goal to promote an innovation that is relatively new and has not yet crossed the innovation chasm. As discussed above, the main considerations for this group when considering an adoption decision are as follows:

(i) Relative advantage (B-1);
(ii) Results demonstrability (B-6); and
(iii) Ease of use (B-7).

Finally, respondents who agreed with the trailblazers construct have much in common with the previous group, but they do not put much emphasis on “ease of use” (B-7) when considering a new innovation. They are also interested in the “relative advantage” (B-1) and “result demonstrability” (B-6) factors when making adoption decisions.

Table 4-13: Correlations: Personal innovativeness and perceived characteristics of innovating

Factors		Eager innovators	Conformists	Innovative leaders	Laggards	Trailblazers	
		A-1	A-2	A-3	A-4	A-5	
Relative advantage	B-1	0.49	-0.35	0.48	-0.37	0.37	Correlation coefficient
		0.000	0.000	0.000	0.000	0.000	p-value
Image	B-2	0.11	-0.11	0.02	-0.05	0.07	Correlation coefficient
		0.240	0.223	0.869	0.549	0.435	p-value
Visibility	B-3	0.30	-0.28	0.34	-0.38	0.21	Correlation coefficient
		0.001	0.002	0.000	0.000	0.020	p-value
Compatibility	B-4	0.29	-0.04	0.32	-0.11	0.12	Correlation coefficient
		0.001	0.632	0.000	0.239	0.192	p-value
Trialability	B-5	0.12	0.03	0.24	0.02	0.11	Correlation coefficient
		0.197	0.718	0.008	0.789	0.230	p-value
Result demonstrability	B-6	0.43	-0.32	0.47	-0.43	0.40	Correlation coefficient
		0.000	0.000	0.000	0.000	0.000	p-value
Ease of use	B-7	0.37	-0.09	0.40	-0.12	0.24	Correlation coefficient
		0.000	0.331	0.000	0.185	0.008	p-value
Voluntariness	B-8	-0.28	0.30	-0.18	0.27	-0.25	Correlation coefficient
		0.002	0.001	0.045	0.003	0.006	p-value

***p-values are reported for completeness sake, but will not be interpreted since a convenience sample instead of a random sample was used.**

4.10 CONCLUSION

Respondents are all directly involved with the South African ferroalloy industry either working for a producer or are employed in a service provider role to the industry. Most of the respondents are well educated, experienced individuals occupying relatively senior positions within their respective companies.

Following the extended factor analysis, five factors or constructs were extracted for the personal innovativeness questionnaire, although two of the five factors were quite closely related both factors were retained due to the “innovative leaders” factor clearly testing leadership and innovation as opposed to only innovation. However, the conclusion can be made that all the “eager innovators” in this sample also identified as being leaders. Moreover, respondents who concurred with these two factors were identified as the *eager innovative leaders* that are logically the main targets for a marketing campaign designed to cross the innovation chasm. These *eager innovative leaders* have the combination of an innate willingness to change while also maintaining senior leadership positions in their organizations, thus they will be open to innovation while also being in a position to heavily influence adoption decisions.

Three additional factors or constructs for personal innovativeness were defined in this study over and above the two already found in literature. Overall, the population was found to be quite innovative and more importantly the degree of innovativeness was found to be very similar for producers and service providers. Therefore, the hypothesis that producers are not as innovative as technology providers was rejected.

When testing for the perceived characteristics of innovation, the same eight factors that were identified in the literature were found, and these were retained during the analysis phase. All eight characteristics elicited moderate to high levels of agreement from the respondents, indicating that these factors are in fact important to the potential technology adopter groups.

The factors that proved to be the most important to respondents were “relative advantage”, “trialability”, “result demonstrability” and “ease of use”. Therefore, demonstrating how an innovation relates to these factors will positively affect the perception of a potential adopter towards a given innovation.

When comparing different groups of respondents it was found that producers who are more experienced place a higher emphasis on “relative advantage” and “ease of use” than the rest of the respondents. Furthermore, these factors also correlated quite distinctly with the *eager innovative leaders*. Therefore, a strategy to enter and penetrate the market for South African ferroalloy producers can be established based on the results from this study.

4.11 CHAPTER SUMMARY

The findings of the empirical study were presented in this chapter.

A statistical approach was followed to evaluate the data. Firstly, the demographical profile of respondents and an overview of the study data along with a frequency analysis were presented. Thereafter, a thorough statistical analysis was performed on the data, including an exploratory factor analyses to extract pattern matrices and assign factor loading. The integrity of the data along with reliability and internal consistency was demonstrated. Finally, various respondent groups were compared with one another and correlations were drawn between factors to better describe and analyse the data.

All statistical analyses were completed by means of the SPSS software packages.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The primary objective of this study was to identify the cardinal variables that affect the rate of technology adoption within the South African ferroalloy industry thus increasing the likelihood for successful diffusion of applicable technologies into the market. Furthermore, the impact of the innovation chasm between the early market and the mainstream market was investigated along with the factors that will cause influential and innovative producers to react positively to a given innovation.

The secondary objectives that were realized to achieve the primary objective were firstly to complete a literature study on the diffusion of innovations including the mechanisms through which a new technology penetrates the market. Secondly, to better define the context of the South African ferroalloy industry including the operational, environmental and social constraints coupled with the innovativeness of individuals working in the industry. Thirdly, the perceived characteristics of innovating that affect the rate of technology adoption were identified theoretically and the cardinal variables that have the greatest importance for survey respondents were identified by means of empirical research. Finally, this chapter is devoted to drawing appropriate conclusions from the research in order to achieve the final objective, which is to comment on what elements would be required for a successful, targeted marketing campaign designed to persuade potential adopters to make an adoption decision when faced with an appropriate new technology or innovation.

5.2 CONCLUSIONS REGARDING THE FUTURE OF THE SOUTH AFRICAN FERROALLOY INDUSTRY

Due to massive pressure from both internal and external sources, the South African ferroalloy industry will not be able to continue in its current form. The only two options available for the industry now are:

(i) to embrace disruptive change in the hope of regaining a competitive advantage in what is a very competitive international commodity market; or
(ii) to accept a relatively fast decline and downward death spiral wherein input costs will ultimately increase the cost of production beyond an acceptable price point.

Faced with these two options, a clear innovation imperative now exists with the hope that increased technology adoption and the implementation of key disruptive innovations will create a positive change in the industry by adding real and sustainable value to operations. However, decades of conservative, risk averse behaviour coupled with aggressive cost cutting measures have created an industry that will likely find this change difficult.

Therefore, an imperative also exists to create a targeted marketing strategy that will positively influence producers to adopt certain applicable technologies to improve their operations. Ultimately, the rollout of such an effective strategy should then also increase the rate of innovation diffusion within the industry by demonstrating the relevance of certain characteristics of innovating that are important to producers.

5.3 CONCLUSIONS REGARDING THE BEHAVIOUR AND INNOVATIVENESS OF POTENTIAL ADOPTERS

The overall degree of innovativeness of the respondents was found to be relatively high, without any significant statistical differences observed between adopter groups. More specifically no visible difference was observed between producers and service providers. Furthermore, three new underlying factors or constructs were identified, and appropriate names suggested in relation to the personal innovativeness questionnaire. These new factors were assigned the names “innovative leaders,” “trailblazers” and “laggards.”

The results for “innovative leaders” and “eager innovators” were highly correlated, although these factors clearly applied different questions. Therefore, it appears that the same individuals that display a high degree of personal innovativeness and therefore a willingness to change, also occupy senior leadership positions with the ability to influence adoption decisions.

The conclusion can be drawn that respondents that tended to agree with both the “innovative leaders” and “eager innovators” factors are the perfect target for a marketing campaign that is focused on a specific segment of the market. These individuals, the *eager innovative leaders*, will be receptive towards new innovations while also having the ability to influence technology adoption decisions within their work place.

Conversely, individuals that tended to agree with the “laggards” and “conformists” factors should not be targeted in a marketing campaign intended to cross the innovation chasm, since they have an innately lower degree of innovativeness and a higher resistance to change. These individuals will typically adopt an innovation due to the social pressure exerted on them by their peers and at that point in the diffusion process the innovation has already crossed over the innovation chasm.

5.4 CONCLUSIONS REGARDING THE VARIABLES THAT EFFECT THE RATE OF TECHNOLOGY ADOPTION

The perceived characteristics of innovating were found to be relevant in influencing adoption decisions among respondents, with moderate to high levels of agreement observed for all eight factors. The conclusion can be made that these factors have a large influence on potential adoption decisions, which is also widely supported in literature.

When considering all the respondents, the cardinal variables that were identified as being the most important when considering whether to adopt an innovation or new technology were the following:

(i) Relative advantage (B-1);
(ii) Result demonstrability (B-6); and
(iii) Ease of use (B-7)

Table 5-1: Cardinal variables that effect the rate of innovation diffusion

	Modifier / Description	Factors				
		Relative advantage	Compatibility	Trialability	Result demon-strability	Ease of use
		B-1	B-4	B-5	B-6	B-7
All respondents (N=122)	None	6.16	5.17	5.70	5.99	5.64
Producers (N=77)	Operational role	6.34	5.35	5.80	6.06	5.86
Less education (N=34)	Technion or lower	6.43	5.75	5.54	6.06	6.02
More experience (N=100)	>5 years	5.91	5.28	5.71	6.02	5.70
Avg. correlation coefficient	Eager innovators; Innovative leaders	0.49	0.31	0.18	0.45	0.38
Factor ranking	#	**1**	5	4	**2**	**3**

***Note: The difference in the correlation coefficients for "eager innovators" and "innovative leaders" when compared with the top three factors in this table were negligible (<0.04), thus the average value was reported.**

Refer to Table 5-1 for a summary of the mean scores and the correlations coefficients that were reported in chapter 4. The top row presents all values for the full respondent group (N=122). The succeeding rows present the same data but for a specific demographic group. All fields highlighted in blue refer to variables wherein a statistically significant change exists between the groups being compared.

When focusing on specific combinations of groups that are representative of typical South African ferroalloy producers, the identified cardinal variables become even more important tending towards higher mean scores and higher agreement with that specific market segment. These conditions can be any combination of:

(i) Respondents are producers (N=77);

(ii) Respondents have a technicon degree or less, since producers are less educated on average than technology suppliers and consultants (N=34); and

(iii) Respondents have more than five years' experience (N=100).

Therefore, the findings from the full group of respondents all still valid and essentially get amplified with further sorting and segmentation of the market. Based on all the statistical data, the cardinal variables that are the most important in influencing the rate of technology adoption are also ranked in order of importance in Table 5-1.

Moreover, the respondents that associated with "eager innovators" and "innovative leaders" were identified as the ideal target for a marketing campaign, since they agreed with the importance of the cardinal variables and also demonstrated a high correlation with these variables.

5.5 RECOMMENDATIONS FOR THE INDUSTRY: CROSSING THE INNOVATION CHASM IN THE SOUTH AFRICAN FERROALLOY INDUSTRY

The innovation imperative within the industry has already been discussed and substantiated. However, the mechanisms through which increased adoption can be facilitated still need to be considered. A targeted marketing campaign aimed at producers in the South African ferroalloy industry can be initiated by service providers, technology providers and consultants. The intent of this campaign will be to positively influence individuals in the market to adopt applicable innovations and technology products to add sustainable value to their operations.

When considering personal innovativeness, producers aligning with the "eager innovators" and "innovative leaders" factors are the only logical target for such a marketing strategy since these individuals display a high degree of personal innovativeness and they are also employed in relatively senior positions of leadership. Therefore, these individuals possess both the willingness to change and the ability to influence potential adoption decisions. Refer to Figure 5-1 wherein the relative positions of the adopter types identified in this research are qualitatively overlaid on top of the revised technology adoption lifecycle. The “eager innovators” and “innovative leaders” straddle the innovation chasm since individuals that associate with these factors could present on either side of the innovation chasm, hence their influence in crossing it.

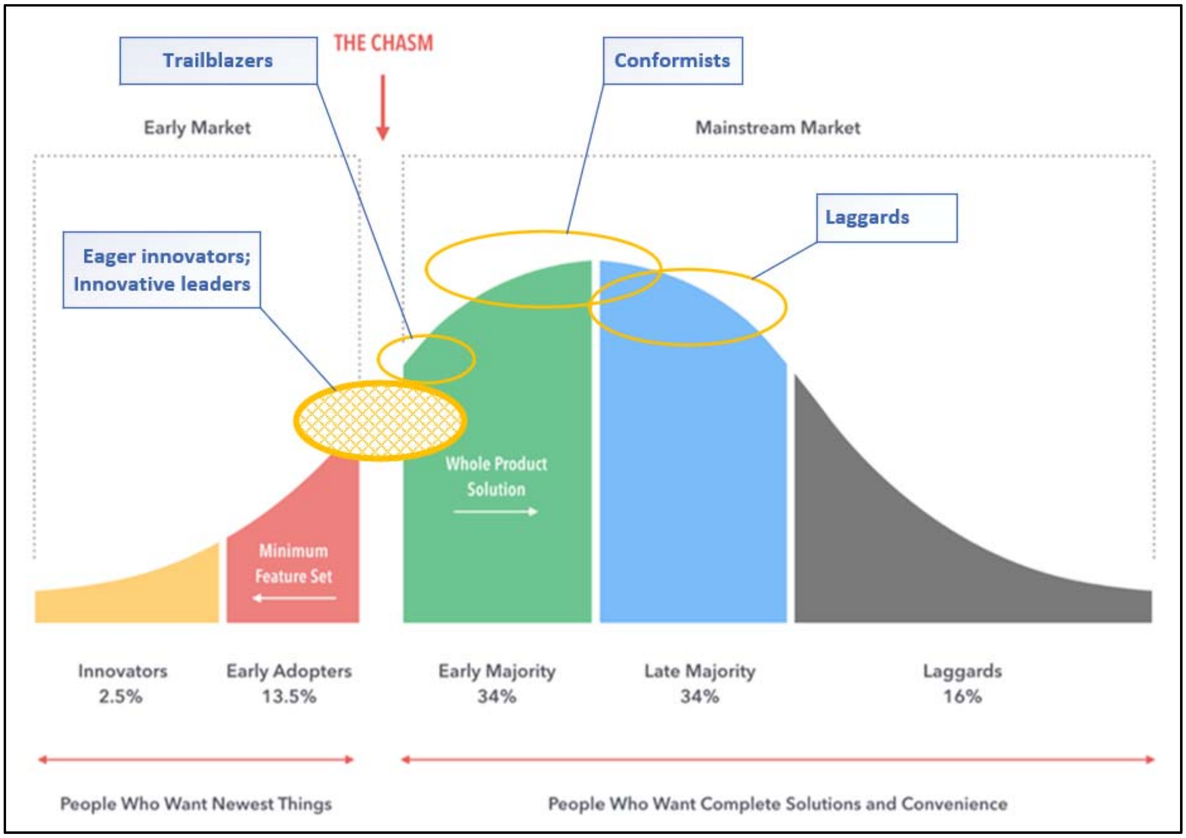


Figure 5-1: Overlay of the position of personal innovativeness factors on the revised technology adoption life cycle

Source: Adapted from Moore (2014:21)

Once these individuals have been identified, the cardinal variables that influence the rate of technology adoption should be clearly demonstrated to them for any new product or innovation that is being considered for adoption. Refer to section 5.4 for the rationale behind selecting the cardinal variables that have the most influence on adoptions decisions, which are as follows in order of importance:

(i) Relative advantage (B-1);
(ii) Result demonstrability (B-6); and
(iii) Ease of use (B-7).

5.6 LIMITATIONS AND IMPLICATIONS FOR FURTHER RESEARCH

Although an argument can be made that the study respondents fit the criteria required for the study very well, the study population cannot be considered as representative of all senior employees that can influence adoption decision within the industry. Therefore, findings from this document cannot be generalized for the entire South African ferroalloy industry since a non-probability convenience sample was collected.

Moreover, this study is only relevant to the ferroalloy industry within South Africa and not for the wider mining and metals industry although much overlap is expected. Therefore, similar innovation diffusion studies can be conducted on the broader mining and metals industry within South Africa and internationally.

The high degree of personal innovativeness of all the respondents was a curious finding, since the respondents were more innovative than expected in what is a traditionally a conservative and insular industry. However, since the group of respondents cannot be considered as representative of the entire population this finding cannot be generalized for the whole population. Due to convenience sampling being done by the researcher, an element of researcher bias may have contributed to the high degree of personal innovativeness observed, since it is possible that the researcher mostly had relationships with individuals that are more innovative on average.

Despite these limitations, this study added to the empirical body of research into innovation in the South African ferroalloy industry. Moreover, the findings and recommendations of this study present options for multiple future research topics that can continue to build upon the body of research.

5.7 RECOMMENDATIONS FOR FURTHER STUDIES

Since limited research has been done in innovation diffusion in the South African ferroalloy industry multiple opportunities exist for further research. Some key options are as follows:

(i) Only two out of five underlying factors or constructs have been defined and described in previous research utilizing the questionnaire related to personal innovativeness. This study again identified five factors related to the personal innovativeness questionnaire, but also suggested names for the balance of factors. Further investigation can be done to better define the new factors and the associated characteristics of individuals that tend towards these factors.

(ii) The cardinal variables, within the perceived characteristics of innovating, that are the most important for various respondent groups were identified. The same process can be completed with a pure probability sample with the intent to describe the entire market clearly and through a representative process.

(iii) A targeted marketing campaign can be developed that leverages the cardinal variables identified in this research in order to appeal to potential adopters of innovations. Moreover, the effectiveness of such a targeted campaign can be measured to gauge its success with further research.

5.8 CONCLUSION

The objective of this study was to identify the cardinal variables that affect the rate of technology adoption and therefore the likelihood of successful innovation diffusion in the South African ferroalloy industry, while considering the existing operational, environmental and social constraints. This objective was framed within the context of crossing the innovation chasm into the mainstream market.

Exploratory research and quantitative empirical research were successfully conducted to achieve this objective. From the research the factors “relative advantage,” “result demonstrability” and “ease of use” were found to be the most important and strategic perceived characteristics of innovating to communicate to potential adopters with the aim of increasing the rate of innovation diffusion and technology adoption.

Three new adopter types emerged from the research during the exploratory factor analysis pertaining to the degree of personal innovativeness of adopters. “Eager innovators” and “innovative leaders” were found to be the ideal target for segmented and targeted marketing campaigns due to their inherent willingness to change and ability to influence adoption decisions within the industry.

5.9 CHAPTER SUMMARY

The findings of the literature review and the empirical research were summarised and presented in this section. Moreover, conclusions and recommendation were made about adopter types and the perceived characteristics of innovating that could be leveraged to positively influence adoption decisions, thereby enabling a given technology to cross the innovation chasm into the mainstream market.

The limitations and implications for further research were discussed and suggestions were made for potential future studies.

REFERENCES

Ashrafzadeh, A. & Sayadian, S. 2015. University instructors' concerns and perceptions of technology integration. *Computing Human Behaviour,* (9)49-61.

Ausubel, J.H. 2015. Nature rebounds. *Long Now Found. Semin. San Fr.* (January). online. [Date accessed: 20 September 2019]

Bartos, P.J. 2007. Is mining a high-tech industry?. Investigations into innovation and productivity advance. *Resoure Policy*, 32(4).

Bass, F.M. 1969. A new product growth for model consumer durables. (August). online. [Date accessed: 13 September 2019]

Basson, J., Curr, T.R., & Gericke, W.A. 2007. South Africa' s ferro alloys industry - present status and future outlook. *Infacon XI Innov. Ferroalloy Ind.* (April). online. [Date accessed: 9 September 2019]

Baxter, R. 2016. The South African presentation outline. (June). [Date accessed: 10 September 2019]

Bhattacharya, J. 2019. Chasm theory, extending the study by Everett to a new level [WWW Document]. *Graphility*. online. [Date accessed: 8 September 2019]

Biermann, W., Cromarty, R.D., & Dawson, N.F. 2012. Economic modelling of a ferrochrome furnace. *J. South African Institution of Mining and Metal,* 112(4):301–308.

Blosch, M. & Fenn, J. 2019. Understanding Gartner's Hype Cycles [WWW Document]. *Gartner*. URL https://www.gartner.com/en/documents/3887767.[Date accessed: 11 September 2019]

BMI. 2016. South Africa mining report: Q4 2016. BMI Research. [Date accessed: 13 September 2019]

BMI. 2017. South Africa mining report: Q4 2017. BMI Research. [Date accessed: 12 September 2019]

Bohlmann, J.D., Calantone, R.J., & Zhao, M. 2010. The effects of market network heterogeneity on innovation diffusion: An agent-based modeling approach. *Journal of Product Innovation Managing,* 27(5):741–760.

Bresciani, S. & Eppler, M. 2015. Gartner's magic quadrant and hype cycle. (February

2015).online. [Date accessed: 23 September 2019]

Bryant, P. 2016. The case for innovation in the mining industry. *Clareo partners*. (1). online. [Date accessed: 24 September 2019]

Bryman, A. & Bell, E. 2015. Research methodology: business and management contexts. Cape Town: Oxford University Press Southern Africa (Pty) Ltd.

Christensen, C.M. 2016. The innovator's dilemma: When new technologies cause great firms to fail. Massachusetts: Harvard Business Review Press..

Creamer. 2017. The Fourth Industrial Revolution is upon us and South African industry must adapt [WWW Document]. *Eng. News*. URL http://www.engineeringnews.co.za/article/the-fourth-industrial-revolution-is-upon-us-and-south-african-industry-must-adapt-2017-10-27. [Date accessed: 14 September 2019]

Creamer, T. 2019. Hydrogen offers pathway for lowering hard-to-abate carbon emissions – IEA Page 1 of 13 [WWW Document]. *Creamer Media*.[Date accessed: 17 September 2019]

Cundy, T.P., Marcus, H.J., Hughes-Hallett, A., Najmaldin, A.S., Yang, G.Z., & Darzi, A. 2014. International attitudes of early adopters to current and future robotic technologies in pediatric surgery. *Journal of Pediatratric Surgery ,* 49(10):1522–1526.

Davis, F.D. 1989. Perceived usefulness, perceived ease of use, and user acceptance of information. *MIS Q.* 13(3). online. [Date accessed: 23 September 2019]

Deloitte. 2017. Innovation in mining in Latin America 2017.[Date accessed: 20 September 2019]

Deloitte. 2018. Tracking the trends 2018: The top 10 issues shaping mining in the year ahead.[Date accessed: 21 September 2019]

Deloitte. 2019. Tracking the trends 2019: the top 10 issues transforming the future of mining. :67. [Date accessed: 20 September 2019]

Deloitte Touche Tohmatsu. 2016. Innovation in mining Australia 2016. [Date accessed: 19 September 2019]

Delre, S.A., Jager, W., Bijmolt, T.H.A., & Janssen, M.A. 2010. Will it spread or not? The effects of social influences and network topology on innovation diffusion. *Journal of Product Innovation Management,* 27(2).

Dibrov, A. 2015. Innovation resistance: The main factors and ways to overcome them. *Procedia*

- *Soc. Behav. Sci. Elsevier B.V.* 166.[Date accessed: 18 September 2019]

Dwyer, A., Gardner, G., & Williams, T. 2011. Global commodity markets - price volatility and financialisation. *RBA Bull.* (June):49–58.

Enderle, G. 2009. A rich concept of wealth creation beyond profit maximization and adding value. *Journal of Business Ethics*, 6(3):34-45.

Eric, R.H. 2014. Production of ferroalloys. 1st ed. Treatise on process metallurgy. New York: Elsevier Ltd.

Eric, R.H. 2018. Sustainability and circular economy – why and how for ferro-alloy manufacturing. (February):25–28. [Date accessed: 19 September 2019]

Eskom. 2019. Eskom annual price increase 2019/20 [WWW Document].[Date accessed: 17 September 2019]

Foss, K. 2013. Adopting new mining technology : Finding a balance between leading and bleeding [WWW Document].[Date accessed: 17 September 2019]

Gholamnejad, J. & Osanloo, M. 2007. Incorporation of ore grade uncertainty into the push back design process. *Journal of South. African Institute of Minerals and Metal,* 107(3).

Goldsmith, B.M. & Balash, J. 2014. Hero or victim: Facing the challenges of change. *Leadewrsh. Excell,* 10(2014).[Date accessed: 23 September 2019]

Hendricks, L. 2016. Disruptive innovation. *Insid. Min.* online. [Date accessed: 10 September 2019]

Hermanus, M. 2017. Mining redesigned - innovation and technology needs for the future - a South African perspective. *South African Institute of Mining Metal,* 117(8).

Hogue, T. 2019. China-U.S. trade war disrupting metal markets, sparking volatility: industry [WWW Document]. *Reuters*. URL https://www.reuters.com/article/us-lmeweek-asia-trade/china-u-s-trade-war-disrupting-metal-markets-sparking-volatility-industry-idUSKCN1SD0X6?il=0. [Date accessed: 15 September 2019]

Hurt, H.T., Joseph, K., & Cook, C. 1977. Scales for the measurement of innovativeness. *Humanities Communocation,* 4(1).

Jacobs, J. & Webber-Youngman, R.C.W. 2017. A technology map to facilitate the process of mine modernization throughout the mining cycle. *Journal of South African Institute of Mineral*

Metal, 117(7):637–648.

Jamasmie, C. 2013. Innovate or perish — Deloitte to the mining industry [WWW Document]. *Mining.com*. URL http://www.mining.com/author/cecilia/.[Date accessed: 16 September 2019]

James, N. 2018. Number of female mineworkers gradually increasing as technology an dconducive policies are introduced [WWW Document]. *Min. Wkly.* URL http://www.miningweekly.com/article/number-of-female-mineworkers-gradually-increasing-as-technology-and-conducive-policies-are-introduced-2018-08-03. [Date accessed: 14 September 2019]

Johnson, A.T. 2015. The technology hype cycle. *IEEE Pulse*, 6(2).

Johnson, K. 2016. The critical role of the mining technology professional. *AusIMM Bull.*[Date accessed: 22 September 2019]

Koukoulas, S. 2015. What wil happen to Australia when the mining boom ends? [WWW Document]. *InTheBlack*. URL https://www.intheblack.com/articles/2015/04/01/what-will-happen-to-australia-when-the-mining-boom-ends. [Date accessed: 18 September 2019]

Lamb, C., Hair, J., McDaniel, C., Boshoff, N., Terblance, R., Elliot, R., & Klopper. 2015. Marketing. 5th ed. Cape Town: Oxford University Press Southern Africa (Pty) Ltd.

Lane, A. & Beier, J. 2015. The future of mining in South Africa. Innovation imperative. *Journal of South African Mining online* [Date accessed: 21 September 2019]

Leach, A. 2014. Is increasing mining R&D the only hope for saving a stalling industry [WWW Document]. *Minerals Technololgies online* [Date accessed: 22 September 2019]

LPI. 2019. 2019-2025 Global top countries ferroalloys market report. [Date accessed: 18 September 2019]

Mahajan, V. & Muller, E. 1998. When is it worthwhile targeting the majority instead of the innovators in a new product launch? *Journal of Market Research,* 35(4):63-76.

Mahajan, V., Muller, E., & Bass, F.M. 1990. New product diffusion models in marketing: A review and directions for research. *Journal of Market Research,* 54(1):1–26.

Mahony, C.S. & Baartman, J.M. 2018. Tariff developments for electricity-intensive industry in South Africa. *J. South. African Instititute of Mineral Metals,* 118(6):43-59.

Marketline. 2018a. Metals & mining in South Africa. (January). online [Date accessed: 11

September 2019]

Marketline. 2018. Global metals & mining. (August):1–37. [Date accessed: 12 September 2-019]

Marketline. 2018b. Metals & mining in South Africa. (October).[Date accessed: 13 September 2019]

McCann, A.L. 2007. The identification of factors influencing the diffusion of an assessment innovation on a university campus. (November). online. [Date accessed: 15 September 2019]

McKay, D. 2019. SA's ferroalloys sector at risk if Nersa approves Eskom request for 15% rate hike [WWW Document]. *Miningmx*.[Date accessed: 20 September 2019]

Mineral council of South Africa. 2018a. Integrated annual review 2017. *Chamber of mines South Africa*.[Date accessed: 24 September 2019]

Mineral council of South Africa. 2018b. Consolidated financial statements for the year ended 31 December 2017. *Chamber of mines South Africa*. (December). [Date accessed: 23 September 2019]

Minerals Council. 2017. Women in mining in South Africa. [Date accessed: 23 September 2019]

Monitor Deloitte. 2016. Innovation in mining: Africa 2016. *Monit. Delloite*.[Date accessed: 13 September 2019]

Moore, G. & Benbasat, I. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Inf. Syst. Res.* [Date accessed: 23 September 2019]

Moore, G.A. 2014. Crossing the chasm. 3rd ed. New York: HarperCollins..

Moore, G.C. & Benbasat, I. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systemns,* 2(3).

Morley, C., Snowden, V., & Day, D. 1999. Financial impact of resource / reserve uncertainty. *J. South. African Inst. Min. Metall.* (December). [Date accessed: 11 September 2019]

Murphy, B.J. & Walker, D. 2018. Breaking new ground : Why mining is good for innovation. online. [Date accessed: 15 September 2019]

Nagji, B. & Tuff, G. 2012. Managing your innovation portfolio. *Harvard Business Review,* 90(5):96-105.

Narayanan, P. 2019. Never-ending trade war sinks commodities into a world of trouble [WWW Document]. *Bloomberg*. URL https://www.bloomberg.com/news/articles/2019-08-02/neverending-trade-war-sinks-commodities-into-a-world-of-trouble. [Date accessed: 10 September 3019]

Ndlovu, S. 2018. Diversity and inclusion in the minerals industry [WWW Document]. *SAIMM*. URL https://www.saimm.co.za/journal-presidents-corner/682-diversity-and-inclusion-in-the-minerals-industry?tmpl=component&print=1&layout=default. [Date accessed: 23 September 2019]

Nelson, L.R. 2014. Evolution of the mega-scale in ferro-alloy electric furnace smelting. *TMS Annual Meeting* online. [Date accessed: 14 September 2019]

Odendaal, N. 2018. Miners halt dividend payouts stay-in-business capex as price languishes in the doldrums. *Mining Weekly.* online. [Date accessed: 17 September 2019]

Oliveira, D. 2017. SA platinum miners enter recycling market despite "mixed" expectations [WWW Document]. *Creamer Media*. URL https://www.engineeringnews.co.za/article/sa-platinum-miners-enter-recycling-market-despite-mixed-expectations-2017-09-22. [Date accessed: 26 September 2019]

Pallister, J.G. & Foxall, G.R. 1998. Psychometric properties of the Hurt-Joseph-Cook scales for the measurement of innovativeness. *Technovation*, 18(11):88-102.

Papp, B.J.F., Bray, E.L., Edelstein, D.L., Fenton, M.D., Guberman, D.E., Hedrick, J.B., Jorgenson, J.D., Kuck, P.H., Shedd, K.B., Tolcin, A.C., & Survey, U.S.G. 2008. Factors that influence the price of Al , Cd , Co , Cu , Fe , Ni , Pb , Rare Earth Elements , and Zn U.S. Geological Survey. online. [Date accessed: 18 September 2019]

Pescher, C. & Spann, M. 2014. Relevance of actors in bridging positions for product-related information diffusion. *Journal of Business Research,* 67(8):1630–1637.

PWC. 2017. SA Mine: 9th ed. (September).

PWC. 2019. Mine 2019: Resourcing the future. online. [Date accessed: 23 September 2019]

Rogers, E.M. 2003. Diffusion of inovations. 5th ed. New York: Free Press.

Rollins, A. 2016. Living in a dematerialised world: The slowing growth of resources. online. [Date accessed: 24 September 2019]

Sawng, Y.W., Om, K., Shin, B., & Lee, J. 2010. Discontinuous innovation and market chasm:

The case of digital convergence services. *Journal of Research in Practical Information Technololgy* 42(3):23-43.

Schreinemakers, P. & Peterson, T.A. 2016. Systems engineering transformation :1–11. online. [Date accessed: 22 September 2019]

Shook, A. 2015. Innovation in mining: Are we different? *AusIMM Bull.* online. [Date accessed: 21 September 2019]

Slabbert, A. 2019. Ferroalloy producers call on Ramaphosa for help as high electricity prices take toll [WWW Document]. *City Press*.

Staffell, I., Scamman, D., Abad, V., Balcombe, P., Dodds, P.E., Ekins, P., & Ward, K.R. 2019. Environmental science The role of hydrogen and fuel cells in the global energy system. *Royal Society of Chemistry*. online. [Date accessed: 19 September 2019]

Steenkamp, J.D. & Basson, J. 2013. The manganese ferroalloys industry in southern Africa. *Journal of South African Institutue of Mining Metal,* 113(8):667–676.

Steyn, L. 2019. Smelters will not survive 15% Eskom tariff hike, industry warns [WWW Document]. *Bus. Live*. online. [Date accessed: 13 September 2019]

Swanepoel, E. 2009. Greater R&D investment imperative to meet mining industry challenges. *Minerals Weekly.* online. [Date accessed: 18 September 2019]

Tanye, H.A. 2016. Perceived attributes of innovation: perceived security as an additional attribute to Roger's Diffusion of Innovation Theory. *International Journal of Multicultural and Multireligious Understanding,* 3(6).

Theron, E. & Volk, P.J. 2015. Research and devlopment: Driving innovation in a declining mininig industry. *9th WCEAM Res. Pap.* online [Date accessed: 16 September 2019]

Tupy, M.L. 2012. The miracle that Is the iPhone (or How Capitalism Can Be Good for the Environment). *Cato Institute.* online. [Date accessdL 17 September 2019]

Visser, W. 2017a. The lack of innovation in mining: Why the mining industry is slow to innovate [WWW Document]. *Int. Resour. J.* URL http://www.internationalresourcejournal.com/the_lack_of_innovation_in_mining/.[Date accessed: 13 September 2019]

Visser, W. 2017b. The lack of innovation in mining [WWW Document]. *Int. Resour. J.* URL http://www.internationalresourcejournal.com/the_lack_of_innovation_in_mining/. [Date accessed: 11 September 2019]

Wells, P. & Nieuwenhuis, P. 2018. Over the hill ? Exploring the other side of the Rogers ' innovation diffusion model from a consumer and business model perspective. *Journal of Clean. Production,*(3):194-205.

Whitchurch, C. 2016. Global Influences [WWW Document]. *High. Educ. Q.* URL http://global-influences.com/global-citizens-digital-creativity/. [Date accessed: 12 September 2019]

Whyle, S. 2016. Adoption of mining technology stressed. *Mining Weekly.* online. [Date accessed: 22 September 2019]

Yameogo, T. 2015. How mining can win back its innovation groove. *Can. Min. J.* :54. online. [Date accessed: 21 September 2019]

APPENDIX A: COVER LETTER TO REQUEST COMPLETION OF QUESTIONNAIRE

Dear Colleague

Request to complete a questionnaire for a research study

Dissertation Title: Crossing the innovation chasm in the South African ferroalloy industry

I am currently concluding my studies in business administration at the Northwest University. The completion of a research project in the form of a dissertation is one of the requirements for the degree. You are kindly requested to complete a short questionnaire as input into this research.

Your time and feedback are highly appreciated.

The questionnaire will take about 10 minutes to complete. The form is electronic and can be accessed via the following link:

https://docs.google.com/forms/d/e/1FAIpQLSdyuzhtQZ_Ozvl59QcS04isEg8QXUmwfh96YXc4eqda39Fncw/viewform?usp=sf_link

Will you please be so kind to complete the web form on / before the 20th of November 2019?

The aim of the study is to identify the attributes of new technologies (or innovations) that would appeal to people associated with the South African ferroalloy industry to better understand what factors affect the rate of technology adoption within the industry. The study will contribute towards research in the field of innovation diffusion in the ferroalloy industry in South Africa.

All responses will be treated as strictly confidential and participation in this study is voluntary. The results of this study will be made available to you on request. Ethical clearance has been obtained.

Regards

Researcher:	**Supervisor:**
Mr. Frans Hannemann	Mr. Johan Coetzee
email: fhannemann@gmail.com	Email: Johannes.Coetzee@nwu.ac.za
Phone: 076-652-7624	Phone: 018-299-4012

APPENDIX B: SURVEY QUESTIONNAIRE

Innovation and technology adoption in the South African ferroalloy industry

Thank you for your willingness to participate in this survey.
Your participation is voluntary, and your time is profoundly appreciated.

The entire questionnaire should take about 10 minutes to complete.
All individual responses are confidential and findings will only be published in group context.

The purpose of this research is to identify the attributes of new technologies (or innovations) that would appeal to people associated with the South African ferroalloy industry to better understand what factors affect the rate of technology adoption (innovation diffusion) within the industry.

* Required

1. **Email address** *

North-West University Business School

NWU ® | BUSINESS SCHOOL BESIGHEIDSKOOL SEKOLO SA KGWEBO

Demographic profile and working environment

Please select one option per question that most closely reflects your demographics, current station, employment status and level of engagement in the industry

2. **Age** *
   Mark only one oval.
   - 18-24 years old
   - 25-34 years old
   - 35-44 years old
   - 45-54 years old
   - 55-64 years old
   - 65 years or older

3. **Gender** *
   Mark only one oval.
   - Male
   - Female

4. **Highest level of education** *
   Mark only one oval.
   - High school (grade 12) or equivalent
   - Qualified artisan (passed trade test)
   - Technicon diploma or degree (diploma or B-Tech)
   - University undergraduate (bachelor's or honours) degree
   - University postgraduate master's degree
   - University postgraduate doctor's (PHD) degree or higher

5. **How long have you been actively involved with the ferroalloy industry in South Africa?**
Mark only one oval.

- No experience in the industry
- Less than 1 year
- 1 year to less than 3 years
- 3 years to less than 5 years
- 5 years to less than 10 years
- 10 years to less than 15 years
- More than 15 years

6. **Position (Job description)** *
Please select the position that most closely matches your level of employment
Mark only one oval.

- Works Manager / General Manager / Principal Engineer or higher level
- Manager / Senior Engineer / Senior Consultant
- Superintendent / Engineer / Consultant
- Specialist / Junior Engineer / Junior Consultant
- Supervisor / Technologist / Designer
- Artisan / Draughtsperson / Clerk / Administrator
- Operator or lower level
- Other: ______________________

7. **Relation of employment to the South African ferroalloy industry** *
The ferroalloy industry includes all operators that produce various alloys of iron combined with one or more elements. This includes producers of Ferrochrome, Ferromanganese, Siliconmanganese, Silicon, Ferronickel, Ferrosilicon, Ferrovanadium and so forth.
Mark only one oval.

- Employed directly by a producer in the South African ferroalloy industry
- Consultant, service provider or technology provider doing work for the South African ferroalloy industry on a full time or part time basis
- Work has been done or services rendered for the South African ferroalloy industry in the past
- No work has been done or services rendered for the South African ferroalloy industry

Preferences of the Individual

Please rate each question in terms of your personal agreement with the statement (how relevant each statement is for you personally).

Please answer all questions in this section according to the following scale:
1: Strongly disagree
2: Disagree
3: Moderately disagree
4: Undecided
5: Moderately agree
6: Agree
7: Strongly agree

8. **1. My friends or colleagues (peers) often ask me for advice or information.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

9. **2. I enjoy trying out new ideas.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

10. **3. I seek out new ways to do things.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

11. **4. I am generally cautious about accepting new ideas.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

12. **5. I frequently improvise (invent) methods for solving a problem when an answer is not apparent.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

13. **6. I am suspicious of new inventions and new ways of thinking.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

14. **7. I rarely trust new ideas until I can see whether the vast majority of people around me accept them.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

15. **8. I feel that I am an influential member of the group of friends and colleagues (the peer group) I associate with.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

16. **9. I consider myself to be creative and original in my thinking and behaviour.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

17. **10. I am aware that I am usually one of the last people in my group to accept something new.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

18. **11. I am an inventive kind of person.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

19. **12. I enjoy taking part in the leadership responsibilities of the groups I belong to.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

20. **13. I am reluctant about adopting new ways of doing things until I see them working for people around me.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

21. **14. I find it stimulating to be original in my thinking and behavior.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

22. **15. I tend to feel that the old way of living and doing things is the best way.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

23. **16. I am positively challenged by ambiguities (uncertainties) and unsolved problems.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

24. **17. I must see other people using new innovations before I will consider them.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

25. **18. I am receptive to new ideas.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

26. **19. I am positively challenged by unanswered (awkward) questions.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

27. **20. I often find myself skeptical of new ideas.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

Perceptions on new technologies (or innovations)

Please rate each question in terms of your personal agreement with the statement (how relevant each statement is for you personally).

Please answer all questions in this section according to the following scale:
1: Strongly disagree
2: Disagree
3: Moderately disagree
4: Undecided
5: Moderately agree
6: Agree
7: Strongly agree

Approach towards answering questions in this section

Think of a specific new technology (or innovation) that you have recently encountered when answering the questions below. Consider what factors were important to you when deciding whether to adopt (implement) it in your working environment.

The term "new technology (or innovation)" refers to a new method, process, idea or physical piece of equipment available in the market that can be implemented at a production plant or as part of your normal duties in the office.

28. **1. My boss does NOT require me to use or implement a new technology (or innovation).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

29. **2. Although it might be helpful, using or implementing a new technology (or innovation) is certainly NOT compulsory in my work.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

30. **3. Using a new technology (or innovation) should enable me (or others) to accomplish tasks more quickly.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

31. **4. Using a new technology (or innovation) should improve the quality of work I do (or the quality of my responsible plant area / office).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

32. **5. Using a new technology (or innovation) should make it easier for me (or others) to do my (their) work.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

33. **6. Using a new technology (or innovation) should enhance my (or others') effectiveness on the job.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

34. **7. Using a new technology (or innovation) should give me greater control over my work (or responsible plant area / office environment).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

35. **8. Using a new technology (or innovation) must be compatible with all aspects of my work (or responsible plant area / office environment).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

36. **9. I think that using a new technology (or innovation) should fit well with the way I (or others) like to work.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

37. **10. Using a new technology (or innovation) should fit into my (or others') work style.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

38. **11. People in my organization who use a new technology (or innovation) have more prestige (admiration) than those who do not.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

39. **12. People in my organization who use a new technology (or innovation) have a high profile (high standing in the company).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

40. **13. Having (or implementing) a new technology (or innovation) is a status symbol in my organization.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

41. **14. My (or others') interaction (knowledge and application) with a new technology (or innovation) should be clear and understandable.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

42. **15. I believe that it should be easy to get a new technology (or innovation) to do what I (or others) want it to do.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

43. **16. Overall, I believe that a new technology (or innovation) should be easy to use.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

44. **17. Learning to operate a new technology (or innovation) should be easy for me (or others).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

45. **18. I would have no difficulty in telling others about the results of using a new technology (or innovation).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

46. **19. I believe I could communicate to others the consequences of using a new technology (or innovation).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

47. **20. The results of using a new technology (or innovation) should be apparent to me (or others).** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

48. **21. I would have difficulty explaining (articulating) why using a new technology (or innovation) may or may not be beneficial.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

49. **22. In my organization, one sees new technology (or innovations) in many areas of the plant or office buildings.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

50. **23. New technology (or innovation) is NOT very visible in my organization.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

51. **24. Before deciding whether to use a new technology (or innovation), I (or others) should be able to properly try (or test) it out.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

52. **25. I (or others) should be permitted to use a new technology (or innovation) on a trial basis long enough to see what it will do.** *
Mark only one oval.

	1	2	3	4	5	6	7	
strongly disagree	◯	◯	◯	◯	◯	◯	◯	strongly agree

Acknowledgements

Thank you for taking the time to complete this questionnaire. It is highly appreciated.

This questionnaire was adopted from previous work done in the field of innovation diffusion, with a focus on personal innovativeness and the perceived attributes of an innovation.

Sources:

Hurt, H.T., Joseph, K., & Cook, C. 1977. Scales for the measurement of innovativeness. Hum. Commun. Res. 4(1).

Pallister, J.G. & Foxall, G.R. 1998. Psychometric properties of the Hurt-Joseph-Cook scales for the measurement of innovativeness. Technovation. 18(11):663–675.

Moore, G.C. & Benbasat, I. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. Inf. Syst. Res. 2(3):192–222.

APPENDIX C: PERMISSION TO ADOPT EXISTING SURVEY QUESTIONNAIRE

From:	Benbasat, Izak
To:	Hannemann, Frans
Subject:	Re: Request to adopt your questionnaire for my research
Date:	Thursday, November 28, 2019 8:54:35 PM

Dear Frans:

You have my permission to use the questionnaire for your research study.

Best wishes.

Izak Benbasat
Fellow of the Royal Society of Canada
Sauder Distinguished Professor of Information Systems Emeritus
Former Canada Research Chair in Information Technology Management
Sauder School of Business
University of British Columbia
Vancouver, Canada
http://www.sauder.ubc.ca/Faculty/People/Faculty_Members/Benbasat_Izak/Publications_Record

On Nov 28, 2019, at 10:10, Hannemann, Frans <frans.hannemann@hatch.com> wrote:

Dear Mr. Benbasat

I hope you are well.

I am currently completing my studies at the North-West University in South Africa, with the goal to achieve a masters degree in business administration.
The title of my dissertation is as follows: "Crossing the innovation chasm in the South African ferroalloy industry."

I came across the work Mr. Moore and yourself did to develop a robust instrument to measure the perceived characteristics of innovating.
Your paper entitled "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation" has been a very useful resource to me.
I would like to adapt your questionnaire as part of my research, and would like to ask your permission to do this.
I have of course already cited yourself and Mr. Moore in my literature study for the work I am doing.
Kindly let me know if this will be in order.