Effect of dynamic workforce capabilities on firm level innovation in the South African metals industry

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A thesis submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Doctor of Philosophy

Johannesburg, 2024

ABSTRACT

Increasing employee diversity in gender, age, ethnicity generally has a positive impact on the firm level innovation due to diversification of views and experiences. Employee education is an important factor for innovation since education stimulates the capacity of employees to comprehend, create and process information due to better understating of the theoretical concepts of their trade. On the other hand, employee tenure is associated with experience and employees with a long organisational tenure are more familiar with the processes of the organisation and its strategy. Accumulated work experience, inside and outside the organisation, is also important as experienced employees have developed skills that are relevant and specific to their domain, thereby, tackling problems in a more focused and relevant way. The research outlined in this document proposes to combine attributes such as gender, age and ethnicity into a demographic background factor. The current research investigates the effect of this demographic background factor, together with education qualification and tenure, on firm-level innovation in the South African metals industry. The hypothesis is that these three factors (education qualification, tenure, and demographic background) are dynamic workforce capabilities that influence firm-level innovation in the South African metals industry and warrant consideration in the dynamic capabilities' literature.

The South African metals and engineering sector consists of approximately 10,000 companies that employ over 220,000 blue-collar workers and contributes around 3% of the country's GDP or R900 billion. It has been facing challenges including production fluctuations and external economic pressures since 2008 but remains a key player in South Africa's industrial landscape. The dynamic capabilities framework is typically applied in environment of rapid change and the organisations in the metal South African metals industry are characterised by legacy machinery and equipment that make up a substantial part of their infrastructure. While the technological changes in other industries are fast-paced, the metals industry is moving at a slower pace. Due to the high numbers of blue-collar workers in this sector, understating the impact of factors such as the three under investigation in this paper could be significant for the industry.

A positive correlation was found across all three tested factors (education qualification, tenure and demographic attributes) and firm-level innovation. The positive value of the correlation coefficient also showed that a positive change in these three factors results in a positive change in the firm level innovation in the South African metals industry.

The conclusions were that dynamic workforce capabilities, which is a combination of education qualification, tenure, and demographic background factors, warrant further consideration to the literature on dynamic capabilities in the context of firm level innovation.

KEY WORDS

Innovation; firm level innovation; dynamic capabilities; dynamic managerial capabilities; dynamic workforce capabilities; employee experience; South African metals industry.

DECLARATION

I, Luyolo Andrew Baxolise Mabhali, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Doctor Philosophy in Management at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Luyolo Andrew Baxolise Mabhali Signature:

Signed at ……………………………………………………

On the …………………………….. day of ………………………… 20…..

DEDICATION

This work is dedicated to my wife, Nonhlanhla Jaqcoline Mabhali, and my children, Nobuhle Angel Mabhali, Khanyisa Angela Mabhali and Luyanda Andy Khanyiso Mabhali. Thank you very much for allowing me to conduct this study and for all the love and support. To my parents, Xoliswa Margaret Plaatjie and Linda Oscar Mabhali, thank you very much for all your support.

ACKNOWLEDGEMENTS

I would like to acknowledge the support and guidance I received from my supervisors, Prof Mjumo Mzyece and Dr Pelayo Omotoso, without whom this work would never have been successful. Dr Dominikus Heil is appreciated for assistance in kicking off this work. The South African Mint Company is acknowledged for allowing me time to conduct this research despite all the production pressures and for financial support. Human Sciences Research Council is acknowledged for supplying data. Mr Oscar J.H. Sono is much appreciated for his friendship and advice which kept me focused during this work. Nobuhle Mabhali is also appreciated for the post-review of this work.

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LIST OF ABBREVIATIONS AND ACRONYMS

Item	Definition
4IR	Fourth Industrial Revolution
ANOVA	Analysis of variance
CIS	Community Innovation Survey
CSIR	Council for Scientific and Industrial Research (CSIR).
CoP	Communities of practice
COVID-19	Coronavirus disease 2019
EU	European Union
FMCG	Fast-Moving Consumer Goods
GDP	Gross Domestic Product
HEIs	Higher Education Institutions
HiPPO	Highest Paid Person’s Perspective
HSRC	Human Sciences Research Council
ICT	Information and Communications Technology

IP	Intellectual Property
KPIs	Key Performance Indicators
MNCs	Multinational Corporations
NGOs	non-government organisations
NSI	National System of Innovation
OECD	Organisation for Economic Cooperation and Development
RSA	Republic of South Africa
R&D	Research and Development
SEIFSA	Steel and Engineering Industries Federation of Southern Africa
SMEs	Small and Medium Enterprises
SMMEs	Small, Medium and Micro Enterprises
STI	Science, Technology, and Innovation
The dtic	the Department of Trade, Industry and Competition
Wits	University of the Witwatersrand

CHAPTER 1. INTRODUCTION

1.1 Purpose of the study

South Africa's metals and engineering sector is a strategic and important sector of the country's economy. According to the Steel and Engineering Industries Federation of Southern Africa (SEIFSA), this sector consists of approximately 10,000 companies that employ over 220,000 blue-collar workers and contributes around 3% of the country's GDP or R900 billion (BusinessTech, 2024; SEIFSA, 2024). This sector is crucial not only due to its size but also because it contributes significantly to the country's manufacturing output and has deep linkages with various industries, including construction, automotive, and mining. It has been facing challenges like production fluctuations and external economic pressures since 2008 but remains a key player in South Africa's industrial landscape (SEIFSA, 2024). Therefore, innovation is required at all levels in this sector in order to address the socio-economic challenges faced by South Africa such as high unemployment rates, poverty, social inequality, and inadequate public service access (Cook, 2019; Msiza, 2021; Qithi & Mkhize, 2023). It is through innovation that the GDP contribution of the manufacturing sector in South Africa can grow from current levels of 12% to higher level, like the 23% currently achieved by Malaysia (Chandran Govindaraju et al., 2013; Loewald, 2020; Trading Economics, 2019). Due to the high numbers of blue-collar workers in this sector, understating their impact on innovation is important for firm-level sustainability, national economic growth and academic knowledge advancement. Organisations within the metal industry are characterised by legacy machinery and equipment that make up a substantial part of their infrastructure (Rasool & Rasool, 2020). While the technological changes in other industries are fast-paced, the metals industry is moving at a much slower pace which allows for the involvement of other employee with less academic qualification (Rasool & Rasool, 2020). This work investigates the impact of employee qualification, tenure and demographic background attributes on firm-level innovation in the South African metals industry. The study is warranted as it seeks to understanding the dynamic capabilities in an environment where there is less rapid technological change, using dynamic workforce capabilities, has both scholarly and application merits.

The fourth edition of the Oslo Manual defines innovation as “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (Oslo Manual, 2018, p. 20). This is the definition of innovation that is used in this work. The focus is only on a new (or improved) product or process that has either been brought to market or used within the firm’s operations (Gault, 2018). However, Almeida and Fernandes (2008) suggested that innovation only needs to be new to the firm but not necessarily to the industry, the country, or the world. This extension fits the South African context since it is a developing country that still needs to catch up to the world’s technological frontier (Almeida & Fernandes, 2008).

The purpose of this work is to expand the literature on the dynamic capabilities framework, which was introduced by Teece and Pisano (1994), by including workforce capabilities which are influenced by employee experience such as qualification, tenure and demographic background attributes. The current dynamic capabilities model focuses on innovation at firm level (Teece, 2018) and management level (Adner & Helfat, 2003). Teece (2007) defined the higher order capabilities which are necessary for firm level dynamic capabilities as sensing and shaping capabilities, seizing capabilities, and managing threats and reconfigurations. Sensing involves identifying and assessing emerging opportunities; seizing involves directing (and redirecting) resources to address, grasp, and capitalise on opportunities; managing threats and reconfigurations involves transforming the organisation’s tangible and intangible assets, renewing core competencies, and developing new customer value propositions (Čirjevskis, 2019). This work intends to extend the dynamic capabilities framework, specifically the sensing capability, by incorporate employee capabilities and to test their influence on firm level innovation. However, the seizing capabilities are also applicable as only innovations that have been implemented in the firm and brought to market are considered in line with the definition of innovation used in this study. The implemented innovation could lead to reconfiguration of internal resources, but this is typically done at an organisation level than individual employee level. To change habitual routines, organisations need to look at their culture, policies and procedures as well as implement effective change management (Fusch et al., 2020; Mendy, 2020; Naranjo-Valencia et al., 2019).

Various authors have contributed to the topic of dynamic managerial capabilities (Adner & Helfat, 2003; Ambrosini & Altintas, 2019; Andersson & Evers, 2015; Fainshmidt et al., 2017; Helfat & Peteraf, 2015), but none on the dynamic employee capability especially with regards to the non-management employee capabilities which is investigated in this work. The juxtaposition between non-management employee, simply referred to as the workforce or employees or line employee, and managers was also done by various authors (Hasson et al., 2013; Patti et al., 2004; Sánchez-Vidal et al., 2012). Carnevale et al. (2017) discussed that the adaptive challenges facing organisations today call for greater effort not only from management but also from employees who observe and engage in the daily operations of the business. Employees are increasingly expected to actively contribute to their organisations success, such as through developing novel ideas, communicating these ideas to management and implementing creative ideas and solutions (Carnevale et al., 2017). This work from Carnevale et al. (2017) also differentiates the innovation idea creation between managers and employees. The work by Hasson et al. (2013) investigated the motivators for increasing productivity and creating harmony between the goals of the organisation and staff by providing a dichotomy between these two groups (employees and managers). This work proposes that the workforce dynamic capabilities also influence innovation at firm level. Therefore, dynamic workforce capabilities should also be added in literature studies on firm level innovation. A recent study by Wang et al. (2024) also looked to explore this gap in literature by looking at impact of the employee dynamic capabilities on employee digital performance in China. However, their focus is more employee digital performance, which is the utilisation of digital technologies by the employees, in Chinese small and medium enterprises engaged in digital operations (Wang et al., 2024). Therefore, the profile and technologies used by these organisations would differ to those use by organisations in the metals industry in South Africa. The South African basic conditions of employment act, no. 75 of 1997 also makes a distinction between employees and managers (South African Government Gazette, 2020). In this act, managers are referred to as employers, while nonmanagement employees are referred to as employees. These two types of employees have different responsibilities within the organisations. The managers are responsible and accountable for innovation in their firms, while the employees (nonmanagers) volunteer their innovative ideas to the organisations. This is also elaborated by Carnevale et al. (2017), who concluded that employees are more likely to contribute their ideas to the organisation and devote their synergy to identifying and resolving problems if there is a good relationship between them and their managers. De Jong and Den Hartog (2007) also showed that the behaviour of managers towards their employees influences the employees' innovative behaviour, including idea generation and application behaviour. This was explored during the interviews with employees and managers in this study. Saunila (2017) used the perspectives of managers and employees to determine a has a positive effect between innovation capability and firm performance. The results from that study reveal that managers and employees have different perceptions on what aspects of innovation capability affect firm-level performance (Saunila, 2017).

The hypothesis is that the dynamic workforce capabilities are influenced by employee experience. The proposed employee experiences factors that are considered in this work are education qualification, tenure, and demographic background attributes. Education was selected since the research by Medase (2020) showed that it stimulates the capacity of employees to comprehend, create and process information swiftly compared to those without education. Further training of employees is also crucial for innovation as it adds to the knowledge and capabilities of the workforce (Brandenburg et al., 2007). Employee tenure is associated with experience and employees with a long organisational tenure have more work experience and become more familiar with the processes of the organisation and its strategy (Liu et al., 2016). Accumulated work experience, inside and outside the organisation, is also important as experienced employees have developed skills that are relevant and specific to their domain, thereby, tackling problems in a more focused and relevant way (Carmeli et al., 2006). The employee demographic background of interest in this study were age, gender, and ethnic background. These attributes were selected based on the work by Østergaard et al. (2011) which showed that increasing employee diversity in gender, age, ethnicity, and education resulted in increased firm level innovation.

The five phases of innovation that were presented by Mariello (2007) are idea generation and mobilisation; advocacy and screening; experimentation; commercialisation; and diffusion and implementation. Later on, Odetunde (2019) reduced these to a three phase model which involves creativity (idea generation), innovation (idea implementation) and innovation adoption. This work focuses on the idea generation phase as it looks at innovative ideas generated by the workforce. However, only ideas that have been implemented (i.e., new products brought to market or processes implemented within the firm's operation) are tested. Therefore, the first two phases in Odetunde (2019)'s model (creativity and innovation) are considered and not innovation adoption. This means implementation in this work does not test for success of the innovation in the market, but rather only the introduction to market (or implementation in firm's production processes) is tested.

Innovation is not a linear process as shown in the five generations of innovation models by Hobday (2005) and the Klein Rosenberg value chain model presented by Tohidi and Jabbari (2012). Therefore, the idea that is implemented might differ from the original idea that was created due to various factors such as technology capability, company strategy, resource availability, etc. However, for the purpose of this work, the implemented innovation is the one that is considered and traced back to who generated the idea, and the innovation is then attributed to the individual(s) who generated the idea. Performance (success or failure) of the innovation in the market (or process success/ failure) is not part of the scope of this work. However, it is acknowledged that some innovations fail in the market due to several factors, such as being introduced too early before the market is ready. The focus of this work is on product innovation and process innovation that has been implemented within the organisation's operation or in the market (Gault, 2018). However, it must be acknowledged that innovation need not only be implemented but can just be made available to potential users, which is another way of bringing it to market (Gault, 2020).

Multivariate statistical methodology is used to determine the influence of these employees on innovation at firm level for organisations in the South African metals industry. The novel output of this work is the expansion of the dynamic capabilities model to include workforce capabilities, and the quantitative work that shows the relationship between employee experience factors and innovation. This quantitative work has been further reinforced with qualitative interviews conducted with two employees from three different organisations in order to gain more insight into their innovation processes.

1.2 Research problem

South Africa has the most advanced and diverse metal industry in Africa that creates major spill-over effects into other parts of the economy (South African Government, 2003). This industry is crucial to the country's economy as it consists of approximately 10,000 companies that employ over 220,000 blue-collar workers and contributes around 3% of the country's GDP or R900 billion (BusinessTech, 2024; SEIFSA, 2024). The steel-depended industries such as mining, construction, and automotive contribute to over 8 million jobs in South Africa. Therefore, the sustainability of the metals industry is crucial for South Africa. The industry has survived many economic crises and is currently on a downturn due to challenges within the steel and foundry industry, amongst others. There is also a high ratio of non-managerial workers to manager, and a low ratio of traditional research and development worker to the total workforce. Therefore, expanding innovation activities to the larger workforce is key for survival of organisations in this industry. This work seeks to understand the effect on the workforce capabilities, such as qualification, tenure and demographic background attributes, on firm-level innovation in the South African metals industry.

The innovation framework that deals with dynamic capabilities, at a firm-level, was introduced by Teece and Pisano (1994). The focus was more on firm-level capabilities, which were sensing, seizing and reconfiguration. Adner and Helfat (2003) expanded this framework to include the concept of dynamic managerial capabilities, which focussed on managers at an individual level. The work on dynamic managerial capabilities has been further developed in the past decade (Ambrosini & Altintas, 2019; Heubeck & Meckl, 2021; Huy & Zott, 2019; Schwarz et al., 2020; Teece, 2018) and a review and synthesis of its literature was conducted by Helfat and Peteraf (2015). However, due to the challenges highlighted within the South African metals industry, an academic focus on the workforce capabilities is warranted. Furthermore, Ambrosini and Altintas (2019) identified the three main antecedents to dynamic managerial capabilities as the managerial human capital, managerial social capital, and managerial cognition. However, since their focus was on managerial capabilities, they ignored the capabilities of the workforce in the organisation, especially those employees who are not managers. Teece (2018) also acknowledges that there is a human element which has a desire to exercise its own will and design capabilities. However, the author was referring only to managers and did not consider the dynamic capability of the non-management workforce in a firm.

The importance of employees to firm level innovation was highlighted by Odetunde (2019) who acknowledged that the employees are the ones who invent, implement and adopt new technologies and business ideas in their individual work roles which lead to innovation in the organisation. Even though the work by Odetunde (2019) focused on middle management in the mobile telecommunication companies in Nigeria, it is relevant for this study as it looks at employee level innovation. Odetunde (2019) found that employee creativity has a direct causal effect on employee innovation and employee innovation adoption, while employee innovation has a direct causal effect on employee innovation adoption. This work seeks to demonstrate the significant role that employees that are not managers play in innovation development within the South African metals industry. It seeks to also show that there is a positive relationship between employee factors and firm level innovation in the aforementioned industry. The influence of the workforce on innovation was also studied by Rothaermel and Hess (2007) but the focus was on highly skilled employees such as scientists with advanced post graduate (masters and doctorate) degrees in the pharmaceutical industry. However, the majority of employees in the manufacturing sector in the Republic of South Africa do not fall under this category (Makgetla, 2014). The current study aims to address this gap by proposing an expanded dynamic capabilities model that includes employee workforce capabilities.

According to a review by Fallon-Byrne and Harney (2017), there is little understanding of the mechanisms determining the origin and evolution of dynamic capabilities, while the role of employees has been neglected. This work proposes that employee experiences such as education, tenure and demographic background are dynamic workforce capabilities that have a positive influence on firm level innovation. Nonaka and Takeuchi (1995) also acknowledged that innovation can come from a shop floor worker who draws on years of experience to come up with a new process of innovation. This innovation is similar to the Kaizen concept which is a Japanese term that means change for the better or continuous improvement that involves managers and workers alike (Carnerud et al., 2018; Iwao, 2017; Nonaka & Takeuchi, 1995; Singh & Singh, 2009). It is associated with incremental innovation and the overall goal is to make small changes over a period of time in order to create improvements within the company (Iwao, 2017).

In this work, it is proposed that workforce capabilities are influenced by employee experiences which include qualification, tenure and demographic background attributes. This is similar to the incremental innovation defined by Iwao (2017), but the difference is that the scope of innovation in this work is not limited to incremental innovation but includes radical innovation as well as employee experience factors such as education, tenure and demographics that influence the generation of innovative ideas. The impact of employee experience on innovation is studied in this work using a multivariate statistical methodology. Backes-Gellner et al. (2011) also used multivariate statistical methodology to successfully study the effect of employee age on company performance. The intended contribution of this work is the expanded dynamic capabilities model that includes workforce capabilities and also the quantitation work that shows the relationship between employee experiences and innovation.

1.3 Research questions

The main research question in this study is the following:

What is the relationship between the three employee experience factors (education qualification, tenure and demographic background factors) that make-up the dynamic workforce capabilities and innovation at firm level?

The hypothesis is that there is a positive relationship between the above employee factors and firm level innovation in the South African metals industry.

Preliminary work was conducted to test if the South African metals industry is innovative and to determine the level of participation of non-managerial employees in the innovation process within this industry. The sub-question was who generates more innovation ideas between employees and managers in the South African metals industry? The purpose of this preliminary work was to support the main research question above since the focus was on non-managerial employees. Non-managerial employees work closer to the technologies used in production processes and have a deeper understanding of internal products and processes, based on amount of time spent exposed to these. Therefore, understanding impact of these three factors, education qualification, tenure and demographic background attributes, on firm level innovation in the South African metals industry is warranted.

1.4 Significance of the study

The theoretical significance of this work is to expand the literature on dynamic capabilities to include workforce capabilities which have an impact on firm level innovation. The dynamic capabilities framework was expanded by Adner and Helfat (2003) to include dynamic managerial capabilities. Further work on dynamic managerial capabilities has been conducted by various authors (Adner & Helfat, 2003; Ambrosini & Altintas, 2019; Andersson & Evers, 2015; Fainshmidt et al., 2017; Helfat & Peteraf, 2015). This work aims to expand this framework further to include dynamic workforce capabilities since it is the employees who build, promote and breathe life into the innovative culture of organisations

(Odetunde, 2019). However, culture begins with leaders who impose their own values and assumptions on a group (Schein, 2010; Schein & Schein, 2016). Therefore, the role of leaders in applying their own beliefs, values, assumptions, and behavioural rules on their subordinates is crucial in developing organisational culture (Schein & Schein, 2016). Nevertheless, for culture to survive, it is crucial that these values are adopted and owned by the workforce, therefore, this emphasises the importance of the workforce in keeping and maintaining organisational culture (Odetunde, 2019; Schein, 2010).

The majority of employees in the metals industry in South Africa are unskilled and semiskilled workers (Makgetla, 2014). Therefore, the work on employee innovation by Rothaermel and Hess (2007) is not the same as the current work since those authors focused on highly skilled employees such as scientists with advanced (post graduate) degrees. Rothaermel and Hess (2007) conducted their studies on pharmaceutical companies that focus on human therapeutics which has a different workforce compared to the metals industry in South Africa in terms of education levels. The pharmaceutical companies have a large focus on the production of patents and journal publications which is not the focus for small, medium and micro enterprises (SMMEs) that process metals in South Africa (Almeida & Fernandes, 2008). Also, the companies sampled in the study by Rothaermel and Hess (2007) were large organisations from America, Europe and Japan which are financially, geographically and culturally different to the South African SMMEs landscape. The study by Rothaermel and Hess (2007) also used the number of biotechnology patents applications granted per year as the dependent variable or innovation output, while this study uses firm level innovation which is determined using product and process innovation ideas generated by employees (see Section 4.4.1). The study by Rothaermel and Hess (2007) uses intellectual human capital and star scientist (based on number of publications), research and development (R&D) capacity (based on R&D expenditure), biotech alliances and biotech acquisitions as the independent variables, while the independent variables in the current study were derived from qualification, tenure, and demographic background attributes variables. Coetzer (2007) also showed employees that work for smaller (10-49 full time equivalent employees) manufacturing companies in New Zealand preferred informal learning processes as opposed to formal academic training.

This study aims to further quantify the relationship between employee experience (qualification, tenure, and demographic background attributes) and innovation. The business significance is that managers in the South African metals industry will be in a better position to understand the impact of employee experience factors on innovation in their organisations. This work provides inputs for policymakers and business managers to improve the innovative performance of their companies. The population consists of organisations that are producing or processing metals in the Republic of South Africa. The intended contribution of this work to literature is the expanded dynamic capabilities model that includes workforce capabilities and also the quantitation work that shows the relationship between employee experiences and innovation.

1.5 Delimitations of the study

This work only focuses on the dynamic capabilities framework for innovation even though it is acknowledged that there are other frameworks that workforce capabilities may impact or influence. There are many theories and frameworks that have been used to study innovation such as the systems of innovation (national, regional, sectoral, firm level/corporate, openness), actor network theory, knowledge-based view of innovation, dynamic capabilities, resource advantage view and the Schumpeterian theory of innovation (Freeman, 1995; George et al., 2012; Grawe, 2009; Ramadani & Gerguri, 2011; Roberts, 2001; Vertova, 2014b). The focus of this work is on dynamic capabilities since it aims to expand this framework. The dynamic capabilities framework empowers organisations to adapt and evolve their resources and capabilities to align with the changing environment, in order to survive. This is also true for organisations within the South African metals industry who have to compete in a global stage. The focus is only on product and process innovation at organisational level. Other types of innovation such as marketing and business model innovation (Camisón & Monfort-Mir, 2012) are not part of this study.

This work only considered product or process related ideas that have been generated and implemented in the market or within the production processes of the organisation. Marketing and business development innovation were excluded in this work since the primary engineering output for organisations in the South African metals industry is to produce products and to optimise processes. These delimitations are not prejudicial to the conclusions of this thesis since the focus is on products or processes implemented within the organisation or brought to market as per the definition of innovation used in Oslo Manual, which was used in this study (Oslo Manual, 2018). The study by Kamutando and Tregenna (2023) showed that there are complementary between product and process innovation for South African SMME's. This study also excluded marketing and business development innovation. Similarly Chandran Govindaraju et al. (2013), also studied product and process innovation for Malaysian firms, which excluded other types of innovation such as marketing and business development innovation, and this did not prejudice the outcomes of that study.

Ideas that were generated and parked, as well as mothballed products were not considered as these did not contribute to the revenues of the business. This delimitation is in line with the definition of innovation adopted in this study which requires that innovation be made available to potential users or brought into use within the organisation' production processes. The population was only limited to the South African metals industry and not the entire South African manufacturing sector. The reason for this is to use companies that produce similar products rather than to consider companies that also produce gases, medical supplies, cables, etc.

The theoretical delimitations of this study are that it only focuses on dynamic capabilities framework and does not cover innovation frameworks such as Schumpeterian framework, national system of innovation, knowledge-based view, resource-based view and other frameworks. This study only focuses on commercial, for-profit entities, and does not explore dynamic capabilities for non-commercial entities such as non-government organisations (NGOs), non-profits, social enterprises and government departments and agencies.

1.6 Context of the study

Manufacturing is an engine of economic growth, a source of resilience to economic shocks, and an important contributor to GDP. It has high economic multipliers due to its forward and backward linkages to both downstream and upstream production sectors of the economy (South African Reserve Bank, 2020). Additionally, it contributes to exports and employment, and the jobs tend to be better paying, stable, and less vulnerable to shocks compared to other sectors (Cantore et al., 2017). The manufacturing sector makes up a large portion of South Africa's economy and it contributes over 12% to the GDP, 12% to formal sector employment, and 42% to the rand value of exports in 2019 (South African Reserve Bank, 2020). This sector in South Africa has been traditionally resource-based and heavily dependent on minerals. Most of these minerals are exported in primary metal (or ore) form and this limits the country from beneficiating its vast mineral resources (Oerlemans & Pretorius, 2006). This has resulted in the decline in manufacturing sector share as a percentage of GDP from around 22% during the commodity boom period, to about 12% by 2019. According to Statistics South Africa (2021) the South African manufacturing industry has lost almost 309 000 jobs in the 16 year period between 2005 and 2021. Therefore, innovation is required to grow the sector and reduce unemployment in South Africa. The manufacturing industry also has strong linkages with a variety of suppliers and supporting industries, particularly mining and agriculture, as well as service providers. Manufacturing is expected to beneficiate mined ores by converting them to primary metals and value-added products. The success of the manufacturing sector will supplement and revive the service sector since high-value manufacturing generates a demand for technology-intensive services.

This work explores innovation in the metals industry, which incorporates basic iron and steel, non-ferrous metals products, metals products and machinery according to Statistics South Africa (2019). For many decades, the metals, machinery, and mining equipment industries have been at the core of the South African industrial ecosystem. This is largely due to the importance of mining and the close demand and supply side linkages with metals and machinery production. These industries include basic iron and steel, non-ferrous metals, fabricated metals, and machinery. In 2019, they accounted for 19% of manufacturing value add and contributed 23% of employment, i.e., 284 000 direct jobs, mainly in downstream fabricated metal products and machinery and equipment (Statistics South Africa, 2019). Steel is by far the most important basic metal, followed by aluminium and other non-ferrous metals that are cast into basic fabricated products as input into downstream production of machinery and equipment. Cast metal products are produced in foundries through melting steel and other metals to produce components that are used by a range of downstream finished manufacturers.

This study proposes an expansion of the dynamic capabilities framework to include the workforce capabilities which are influenced by experience (qualification, tenure and demographic background attributes). It aims to contribute to the literature on the dynamic capabilities theory. Teece et al. (1997) defined the dynamic capabilities framework as “the framework that analyses the sources and methods of wealth creation used by private firms operating in environments of rapid technological change” (Teece et al., 1997, p. 509). Organisations within the metal industry are characterised by legacy machinery and equipment that make up a substantial part of their infrastructure (Rasool & Rasool, 2020). While the technological changes in other industries are fast-paced, the metals industry is moving at a slower, but sure pace (Rasool & Rasool, 2020). Therefore, understanding the dynamic capabilities in an environment where there is less rapid technological change is warranted. This framework focuses on exploiting existing internal and external firm-specific competences to address changing environments (Teece, 2007; Teece & Pisano, 1994; Teece et al., 1997). Teece (2009) refined the definition of dynamic capabilities to “high-level activities that link to management’s ability to sense and then seize opportunities, navigate threats, and combine and reconfigure specialized and co-specialized assets to meet changing customer needs, and to sustain and amplify evolutionary fitness, thereby building long-run value for investors” (Teece, 2009, p. 54). Activities that bring about a general dynamic capability include searching for new ideas and methods, comparing company practices to the best in the industry, evaluating practices in other industries and experimenting (Le Bas & Scellato, 2014b). The limitation of the dynamic capabilities framework is that it does not consider innovation at individual level since the focus was on innovation at an organisational level.

Adner and Helfat (2003) expanded on this framework by introducing the concept of dynamic managerial capabilities which are “capabilities with which managers build, integrate, and reconfigure organisational resources and competences” (Adner & Helfat, 2003, p. 1012). Most strategic and operational decisions that are made in companies are done by managers and hence they have an influence on innovation at a firm level (Macpherson et al., 2015). Teece (2007) further expanded this framework to include the development of management capabilities and a combination of organisational, functional and technological skills that are difficult to imitate. However, industry innovation is also driven by the workforce which are non-managers (do not have direct subordinates) and hence their capabilities should also be taken into consideration even though, employee level innovation still requires executive or management sponsorship in order to be commercialised.

Rothaermel and Hess (2007) investigated the effect of the firm’s antecedents to innovation at individual, firm, and network level on innovation outputs using a quantitative research approach. The individual level in the study by Rothaermel and Hess (2007) represented intellectual human capital and the focus was on highly skilled and talented employees such as scientists who hold advanced university degrees and doctorates. For this highly educated group of employees, Rothaermel and Hess (2007) concluded that the firm’s innovative output is a positive function of its intellectual human capital. However, the majority of employees in the metals industry in the Republic of South Africa are not highly educated, therefore they do not fall into this category (Makgetla, 2014). The novel component of this study is the investigation of the key components of innovation within the South African metals industry and understanding of the impact employees play in innovation within this industry. This will assist in understanding reasons organisations in this industry are innovative and what the key employee capabilities required for firm-level innovation in the South African industry are.

1.7 Conceptual Framework

A conceptual framework is "a structure which the researcher believes can best explain the natural progression of the phenomenon to be studied" (Adom et al., 2018, p. 439). It is the researcher's explanation of how the research problem will be explored. The aim of this work is to expand the dynamic capability theory by showing a relationship between employee experience factors which make-up the dynamic workforce capabilities and firm level innovation in the South African metals industry. These employee experience factors are employee qualification, tenure and demographic background attributes. This work follows the structure in Figure 1 below. It starts by exploring if product and or process innovation exists in the South African metals industry, then tests who developed these innovative ideas (manager with direct reports or employees with no direct reports), then tests if the ideas generated by employee with no direct reports were implements, for implemented ideas it tests for employee factors that were critical for the idea generation and concludes by testing if these factors have an impact on firm level innovation..

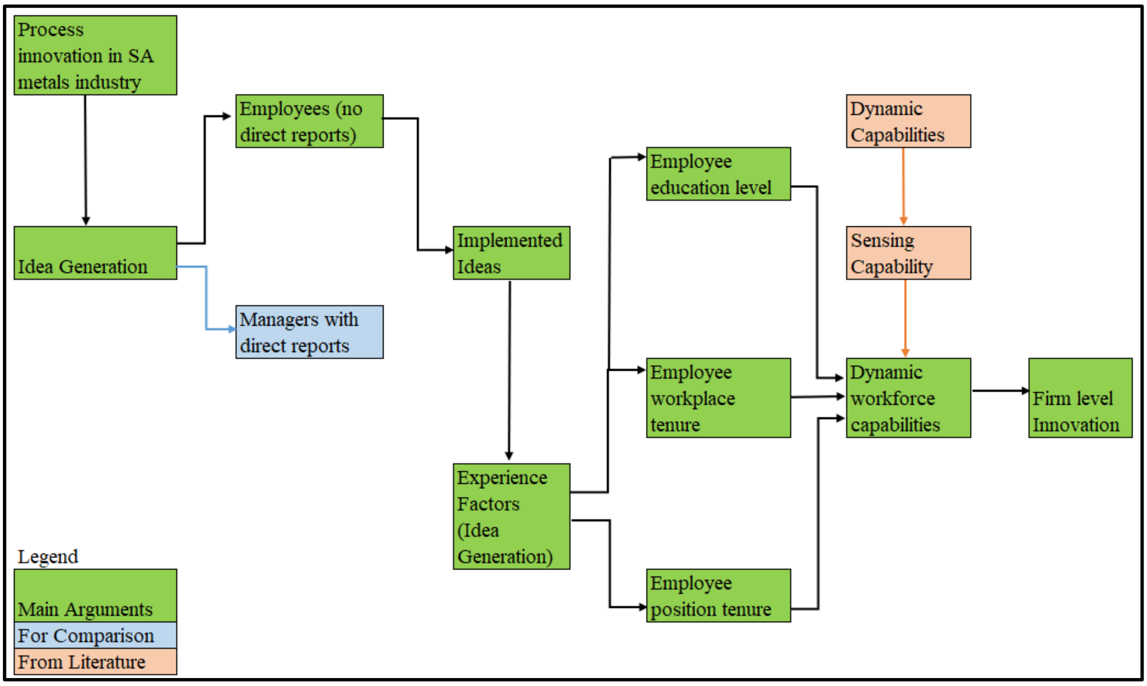

Figure 1: Graphic representation on the flow of this study

This study uses a mixed methods research strategy to determine the occurrence of innovation (product and process) within the South African metals industry using a questionnaire and interviews. Innovative ideas that originate from combined management and workforce efforts are attributed to employees since the prevailing paradigm is top-down, so any instance of employee-level innovation, irrespective of whether it's wholly attributable to the employee(s), is a valid counterexample and such an example highlights the presence of the employee level factors. Therefore, innovative ideas developed by employees, or jointly by them and managers, are considered as innovation by the workforce in this study. The next step would be to prove that this innovation is due to workforce capabilities not management, by controlling for innovation ideas generated by managers. Lastly, this work tests for the relationship between employee experience factors and firm level innovation using regression statistics. Interviews were conducted with two employees from three different organisations in order to validate the results obtained. The sample size for the interviews was sufficient for this work as it is used to support the findings of the quantitative work which had a larger sample size of 36 organisations. The research approach, design and data collection method are outlined in CHAPTER 3 of this document.

1.8 Definition of terms

Dynamic capabilities framework – "the framework that analyses the sources and methods of wealth creation used by private firms operating in environments of rapid technological change" (Teece et al., 1997, p. 509).

Dynamic managerial capabilities – "capabilities with which managers build, integrate, and reconfigure organisational resources and competences" (Adner & Helfat, 2003, p. 1012).

Dynamic workforce capabilities – difficult to imitate employee capabilities that are influenced by employee experiences and positively contribute to innovation at firm level.

Innovation – "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (Oslo Manual, 2018, p. 20).

National System of Innovation – "is that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies which provide the framework within which governments form and implement policies to influence the innovation process" (Metcalfe, 1995, p. 38).

Policy – "a statement or set of statements in which goals are set, and programmes are developed by decision-makers, in response to conditions in a particular society" (De Beer, 2005, p. 53).

South Africa – Republic of South Africa.

1.9 Assumptions

The following assumptions will have an influence on the outcome of this work:

- There is a causal link between idea generation and innovation. This is a reasonable assumption as ideas need to be generated before they get to implementation (Odetunde, 2019). Only ideas that went into implementation are assessed as part of this work. However, adoption that was presented by Odetunde (2019) is not tested in this work.
- The respondents gave true responses about their organisations, and they were not influenced by any external factors such as passage of time and potential confirmation bias (Duncan, 2019). This assumption is also reasonable since the responses were given anonymously in order to protect the names of the organisations and the identities of the respondents. However, the limitation is that the accuracy of the recollection of past events and ability to convey them during the interview process by the respondents could not be reconfirmed with other sources (Duncan, 2019).
- The sample that was taken from the South African metals industry was a representative of the population. The data from the South African Business Innovation Survey 2014-2016 were received from the Human Sciences

Research Council (HSRC). The data were pre-filtered by the HSRC and only 33 organisations from the data received represented the metals industry in South Africa.

- In the qualitative work (interviews), it was assumed that participants recognised that the success of their organisations was not guaranteed and was dependent on their ability to develop a lasting competitive advantage in their industry. This entailed that participants were aware that their firms' ability to stay in business was based on their capacity to continuously compete in a turbulent and evolving operating environment (Duncan, 2019).

1.10 Conclusion of introduction

The research objective, significance, and research issues that will be addressed by this study were introduced in this chapter. The main purpose of this work is to expand the literature on the dynamic capabilities framework, which was introduced by Teece and Pisano (1994), by including workforce capabilities which are influenced by employee experience such as qualification, tenure and demographic background attributes. The high-order capability of interest is the sensing capability which involves identifying and assessing emerging opportunities as it relates to employee experiences (qualification, tenure and demographic background attributes). However, seizing which involves directing (and redirecting) resources to address, grasp, and capitalise on opportunities is considered since only ideas that have been implemented or taken to market are considered in line with the definition of innovation used in this study (Čirjevskis, 2019; Teece, 2007). But, managing threats and reconfigurations, which involves transforming the organisation's tangible and intangible assets, renewing core competencies, and developing new customer value propositions are also not explored since these are done at an organisation level and involve changing organisational structures, operations and cultures to respond to external environments which are not typically done at employee level (Fallon-Byrne & Harney, 2017).

The scope of this work, which examines innovative ideas produced by the workforce, is restricted to the idea generating stage. However, only ideas that have been implemented (i.e., new products brought to market or processes implemented within the firm's operation) are tested. The novel output is the expansion of the dynamic capabilities model to include workforce capabilities, and the quantitative work that shows the relationship between employee experience factors and innovation. To acquire a deeper understanding of the innovation processes of the three separate organisations, qualitative interviews with two employees from each organisation will be conducted to support this quantitative work. The main research question in this study is the following:

> *What is the relationship between employee experience factors (qualification, tenure and demographic background attributes) that make-up the dynamic workforce capabilities and innovation at firm level?*

The following chapter is a critical review of the scholarly articles relevant to this research. It explores and discusses key concepts and definitions that are relevant to this research study.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The focus of this work is on the effect of workforce capabilities on innovation in the South African metals industry. This chapter is structured in order to review the literature on the key points of this objective. It presents literature on innovation in general, the dynamic capabilities model and the South African metals industry.

2.2 Innovation

Organisations are operating within a business environment which can be defined in terms of the Schumpeterian concept of creative destruction, where new products tend to meet customer needs better, making previous versions inadequate or obsolete (Spencer & Kirchhoff, 2006; Tülüce & Yurtkur, 2015). Organisation globally, and within South Africa, operate in dynamic internal and external environments, which require innovativeness to remain sustainable. There are various definitions of innovation and a few of these will be elaborated on in this section. Various authors have acknowledged and recognised Joseph Schumpeter as the pioneer in the study of innovation; hence, its definition derived from this framework is listed first (Ramadani & Gerguri, 2011; Roberts, 2001; Schumpeter, 1935, 1947; Vertova, 2014b). Schumpeter (1935) defined innovation as “changes in production functions which cannot be decomposed into infinitesimal steps” (Schumpeter, 1935, p. 4). Schumpeter distinguished between the invention, which is the discovery of new scientific and technical knowledge, and innovation which is the application on the invention in a practical sense that helps companies to improve their productivity (Schumpeter, 1947). According to Schumpeter (1947), innovations refer to technical progress or to the widening of markets and/or sources of supply for companies. It is the “the fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers’ goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates” (Schumpeter, 1947, p. 83). This definition which included the includes the introduction of new goods, services or production methods to the market, opening new markets, developing a new source for the supply of raw materials and the implementation of a new type of organisation, was also referenced by other authors in later years (Ramadani & Gerguri, 2011; Schumpeter, 1934/1997; Vertova, 2014b). The novelty was also expressed earlier by Ramadani and Gerguri (2011) who defined innovation as "a process of transforming the new ideas, new knowledge into new products, processes and services" (Ramadani & Gerguri, 2011, p. 269). However, Nelson and Rosenberg (1993) had earlier recognised that the operationalising of new manufacturing processes or new product designs within a firm could also be called innovation. Therefore, the product or process only needs to be new at the firm, even if it is not new to other organisations. This is critical for the work in this study as the innovations considered would not necessarily be new to the industry as long as they are new to the organisation. Product innovation usually faces greater imitation risks than process innovation, because products can be more easily acquired, analysed, and reverse engineered (Schoemaker et al., 2018). Therefore, if products are only new to the firm and not the industry, then these imitations would be considered. This inclusion was also done in the work by Sithole et al. (2021), while testing for innovation in various organisations within the South African business sector, including the manufacturing sector. This data was collected using the South African Business Innovation Survey (Human Sciences Research Council, 2008) and a similar inclusion was also done in the European Community Innovation Survey (CIS) survey (Eurostat, 2020). This work focuses on innovation, which is different from invention (Edler & Fagerberg, 2017; Tirmizi et al., 2020). Invention is the discovery of a new product, process or idea, while innovation is an extraction of commercial value from this invention (Edler & Fagerberg, 2017; Roberts, 1988, 2007). Therefore, for innovation to occur, the new product or process should be brought to the market or used internally within the organisation to extract commercial benefits (Roberts, 2007; Tirmizi et al., 2020). This means innovation is not just doing (R&D) but extracting value from this R&D for commercial benefits or to be used by society. This was also acknowledged by Edler and Fagerberg (2017), who stated that exploitation of the ideas for economic and societal benefits is more important than the idea itself. For this reason, this work not only tests if ideas are generated, but if there are benefits for the South African metals industry derived from these ideas. The benefits considered in this study are either new/improved products taken to market or new/improved processes developed and implemented. The exploitation of the idea was also included in the definition by Karahan and Karhan (2013) who defined innovation as taking advantage of an idea rather than creating a new one (Karahan & Karhan, 2013, p. 130).

The definition of innovation that is used during this work comes from the Oslo Manual (2018). The fourth edition of the Oslo Manual defines innovation as “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (Oslo Manual, 2018, p. 20). This definition is also used by Keresztes and Endresz (2020). The focus is only on a new (or improved) product or process that has either been brought to market or used within the firm’s operations (Gault, 2018; Keresztes & Endresz, 2020). This perspective points to two aspects of innovation, namely novelty and implementation. However, it must be acknowledged that innovation need not only be implemented but can just be made available to potential users, of which making it available to the market is one way of bringing the innovation to potential users (Gault, 2020). Another example of making innovation available is licensing it to other organisations or potential users. Also, novelty may not necessarily mean new to the world as it can also refer to something that is new to those that produce or use the innovation (Edler & Fagerberg, 2017). According to Lendel and Varmus (2011), innovation strategy is defined as the “innovative direction of company approach to the choice of objectives, methods and ways to fully utilize and develop the innovative potential of the enterprise. This is the direction given of its boundary, which determines the potential of innovative strategies” (Lendel & Varmus, 2011, p. 819). It is the strategy for determining long-term fundamental business objectives and determines the activities and resources for achieving these goals (Lendel & Varmus, 2011).

In this study, innovation needs to only be new to the firm but not necessarily to the industry, the country, or the world because South Africa as a developing country still needs to catch up to the worlds technological frontier (Almeida & Fernandes, 2008; Edler & Fagerberg, 2017). South African firms can acquire new technology by purchasing new or used equipment (foreign or domestic), by engaging in technology licensing agreements (from foreign or domestic sources), or by hiring consultants (Almeida & Fernandes, 2008). However, only acquiring new technology, parking it and not utilising it in the firm's operations does not constitute innovativeness unless new products, processes or services are developed using these acquired technologies. This is important as the adoption and subsequent exploitation of the innovation in the market or within the firm's processes is crucial in the definition of innovation used in this study. If organisations only buy new equipment to increase capacity (i.e. extending its production line by buying more of the same equipment) but do not produce new products or change their processes due to this acquisition, then those organisations are not considered in this work.

2.2.1 *Open and closed innovation types*

Innovation can be grouped into two types, open and closed innovation (Ahmed et al., 2018; Dost et al., 2020). In closed innovation, only internal resources to the organisation are responsible for generating, developing and implementing innovations (Almirall & Casadesus-Masanell, 2010; Dost et al., 2020). According to Chesbrough (2004), this type of innovation is typically conducted by large companies with significant resources and long-term research program. The concept of open innovation was introduced by Chesbrough in 2003 and outlined a new model for industrial innovation which integrates ideas that are generated by external sources such as suppliers, collaborators and customers with internal R&D (Almirall & Casadesus-Masanell, 2010; Chesbrough, 2012; Holgersson et al., 2022; Lazzarotti & Manzini, 2009; Von Hippel, 2010). As a results of interactions with clients or suppliers or through the interaction with business associations or universities, companies gain more insights about state-of-the-art technology available and how these could be used to give the organisation a competitive edge (Almeida & Fernandes, 2008). Therefore, external interactions are crucial for the organisations to stay abreast with new technologies.

Almirall and Casadesus-Masanell (2010) stated that closed innovation protects the intellectual property (IP) of the organisation, while open innovation combines efforts of a large pool of contributors, resulting in better alignment of products to customer expectations. Open innovation can be outside-in, inside-out or coupled (Chesbrough, 2012; Holgersson et al., 2022). In the outside-in open innovation, the organisation searches, sources and integrates external inputs and contributions to incorporate them into their innovation processes (Chesbrough, 2012; Holgersson et al., 2022). This is the most common type of open innovation for commercial businesses and according to Almeida (2021) this type of innovation is mostly used by smaller companies who prefer to adopt external knowledge from suppliers and clients. The inside-out open innovation requires organisations to allow unused and underutilised ideas to go outside the organisation for others to use in their businesses and business models (Chesbrough, 2012; Holgersson et al., 2022). The organisation can commercialise the technology through licensing intellectual-property rights, creating spinoffs based on previously developed technologies or products, or outsourcing innovation (Almeida, 2021; Chesbrough, 2012; Holgersson et al., 2022). In the coupled model, the organisation combine the outside-in and inside-out models to develop innovations and bring them to market (Holgersson et al., 2022).

Organisations which practice open innovation can also participate in creating IP but the difference is that these organisations are active buyers and sellers of IP as opposed to protecting their own IP (Grimaldi et al., 2021). In most instances, organisations do not adopt a completely closed or open innovation approach but fall in a continuum between the two innovation concepts (Lazzarotti & Manzini, 2009; Manzini et al., 2017). Manzini et al. (2017) states that factors that drive the companies toward closed innovation are high levels of R&D investment, high emphasis on radical innovation, high technology intensity and globalisation. Organisations within the South African metals industry are expected to fall within this continuum with some leaning towards open innovation and others towards closed innovation. However, these organisations will lean more towards the open innovation spectrum due to low technology intensity and lower R&D investments compared to other sectors such as aerospace and medical sectors (Andreoni &

Tregenna, 2020; Ghebrihiwet, 2019; Mustapha & Kondlo, 2019). The degree of openness for each organisation is determined by the following factors which were defined by Lazzarotti and Manzini (2009):

1. The degree of protection of innovation (formal and informal);
2. The number of sources of external innovation (suppliers, collaborators, customers);
3. The degree to which the organisation relies on relationships with other stakeholders (informal and formal).

2.2.2 *Models of innovation*

The earlier innovation understanding was grounded in the neo-classical economic theory, which defined innovation as a linear model (De Beer, 2005; Stefanovska Ceravolo & Polenakovik, 2016). The linear model treats innovation as a sequential process as shown in Figure 2 below (Hobday, 2005). The model assumes rational behaviour on the part of economic actors and that each actor has a definite role which does not overlap with the role of the other actors in the innovation cycle (De Beer, 2005). Teece's sensing, seizing, and reconfiguring model of dynamic capabilities, which is the focus of this work, also follows the linear model approach (Steen et al., 2021).

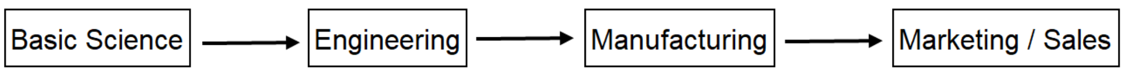

Figure 2: Linear model of innovation (Hobday, 2005).

There are five generations of innovation models defined by Hobday (2005) and these are shown in Table 1 (Hobday, 2005). The first three generations are all linear models, while the latter are flexible, integrated models. These latter models are grounded in evolutionary economic theory, in which innovation occurs with the characteristics of a closed innovation system (De Beer, 2005). In these models, there are complex interactions between the actors in the innovation system while there is also continuous learning by all the actors in the system.

Table 1: Five generations of firm level innovation models (Hobday, 2005)

1st Generation Technology push 1950s to mid-60s	Simple linear sequential process. Emphasis on R&D push. The market 'receives' the results of the R&D
2nd Generation Market pull Mid-1960s–1970s	Market (or need) pull; again a simple, linear sequential process. Emphasis is on marketing. The market is the source of ideas and provides direction to R&D. R&D has a reactive role
3rd Generation Coupling models Mid 1970s–1980s	Sequential model, but with feedback loops from later to earlier stages. Involves push or pull-push combinations. R&D and marketing more in balance. Emphasis is on integration at the R&D–marketing interface
4th Generation Integrated model Early 1980s–1990	Parallel development with integrated development teams. Strong upstream supplier linkages and partnerships. Close coupling with leading edge customers. Emphasis on integration between R&D and manufacturing (e.g. design for manufacturability). Horizontal collaboration including joint ventures and strategic partnerships
5th Generation Systems integration and networking model Post-1990	Fully integrated parallel development supported by advanced information technology. Use of expert systems and simulation modelling in R&D. Strong linkages with leading edge customers (customer focus at the forefront of strategy). Strategic integration with primary suppliers including co-development of new products and linked CAD systems. Horizontal linkages including: joint ventures, collaborative research groupings, collaborative marketing arrangements etc. Emphasis on corporate flexibility and speed of development (time-based strategy). Increased focus on quality and other non price factors

2.2.3 *Phases of innovation*

Mariello (2007) presented the five phases of innovation as follows:

1. **Idea generation and mobilisation** – this is the first phase and involves generation of new ideas. Successful idea generation should be fuelled both by the pressure to compete and by the freedom to explore. Once the idea is generated, it passes on to the mobilisation stage, wherein the idea travels to a different physical or logical location. This is the phase that the current work focuses on.
2. **Advocacy and screening** – the pros and cons of the idea are weighed in this phase. Ideas are generally filtered in this phase and those with potential commercial success progress to the following phases. The evaluation process needs to be transparent, so employees are more comfortable in contributing more ideas.
3. **Experimentation** – This phase tests the sustainability of ideas for the organisation. The organisation needs to assess the timing of the idea as well as potential customers and markets to explore.
4. **Commercialisation** – In this phase, the organisation looks for customers to verify that the innovation actually solves their problems and then analyses the costs and benefits of rolling out the innovation.
5. **Diffusion and Implementation** – this is the final phase and involves ensuring that the organisation is geared up to deliver on the customer expectations. Diffusion is the process of gaining final, companywide

acceptance of an innovation, and implementation is the process of setting up the structures, maintenance and resources needed to produce it.

In contrast, Odetunde (2019) showed innovation as a three-phase model which involves creativity (idea generation), innovation (idea implementation) and innovation adoption. Frankenberger et al. (2013) did a synthesis of innovation process phases from literature and found that most authors used a four-phase model with initiation, ideation, integration and implementation as the phases. The initiation and ideation were combined into the idea generation phase by Hansen and Birkinshaw (2007) and later by Odetunde (2019). Adoption of innovation occurs when employees accept and use innovations generated from outside their organisation (Hansen & Birkinshaw, 2007; Odetunde, 2019; Wisdom et al., 2014). Therefore, the ability of employees to recognise potential value in outside innovations and new knowledge as well as their degree of receptiveness and willingness to convert and apply these innovations within their organisations is crucial for adoption. The work by Odetunde (2019) highlighted the importance of employees in adopting, adapting and exploiting existing innovations in order for their organisations to succeed. The current work focuses on product and process innovation in the metals industry in South Africa. It follows the Odetunde (2019) approach to innovation but only considers idea generation and implementation of these innovations in the organisation's production processes or in the market. Adoption of the innovation is investigated by the percentage increase in turnover due to new/improved product/process that has been implemented.

2.3 Theory, concepts and frameworks

In order to understand theoretical frameworks, one needs to define essential terms such as theory, concept, conceptual frameworks and theoretical frameworks. A theory is defined as "a set of interrelated concepts which structure a systematic view of phenomena for the purpose of explaining or depicting it" (Imenda, 2014, p. 186). It applies value to some of the variables and usually specifies how relationships may vary depending upon the values of critical variables (Sabatier & Weible, 2014). According to Varpio et al. (2020), a theory describes the relationship between concepts that help us understand the world.

This means that there should be specific relationships between concepts and it is usually more mathematical in nature (Imenda, 2014; Kivunja, 2018; Sabatier & Weible, 2014; Varpio et al., 2020). This work aims to extend the dynamic capability theory by showing a relationship between employee experience factors which make-up the dynamic workforce capabilities and innovation in the South African metals industry. As stated by Imenda (2014), a theory must accurately describe a large class of observations on the basis of predictions about the results of future observations. Therefore, a theory can be disproved when a single observation disagrees with the predictions of that theory (Imenda, 2014). A narrow view of a theory is that it consists of universal statements capable of falsification while a more universal view is that it develops a general explanation for a discipline or a body of knowledge (Lambert & Montemari, 2017).

Imenda (2014) defined a concept as an image or symbolic representation of an abstract idea and such ideas as the fundamental building blocks of thoughts and beliefs. A research framework is a structure that provides guidance for the researcher as study questions are fine-tuned, methods for measuring variables are selected and an analysis is planned (Imenda, 2014, p. 188). A theoretical framework is the application of a theory, or set of concepts drawn from one or more theories, to offer an explanation of an event, or shed some light on a particular phenomenon or research problem (Imenda, 2014, p. 189). To create a theoretical framework the researcher must define any concepts and theories that will provide the grounding of the research, unite them through logical connections, and relate these concepts to the study that is being carried out (Kivunja, 2018; Varpio et al., 2020).

A conceptual framework is the end result of bringing together a number of related concepts to explain or predict a given event, or give a broader understanding of the phenomenon of interest or research problems (Imenda, 2014, p. 189). Sabatier and Weible (2014) pronounces that a conceptual framework identifies a set of variables and the relationships among them that presumably account for a set of phenomena. It need not identify directions among relationships but can specify some hypotheses (Sabatier & Weible, 2014). It is a justification for why a given study should be conducted and describes the state of known knowledge, usually through a literature review, identifies gaps in our understanding of a phenomenon or problem and outlines the methodological underpinnings of the research project (Varsani, 2018). Therefore, a conceptual framework is derived from concepts, while on the other hand a theoretical framework is derived from theories. Both theoretical and conceptual frameworks refer to the epistemological paradigm that a researcher adopts in looking at a given research question (Hall, 1990). Epistemology is the study of limitations in knowledge in a particular field of study especially with regard to its methods, validity, and scope, and the distinction between justified belief and perspective (Dana & Dumez, 2015). A model is a representation of a specific situation and is usually much narrower in scope, and more precise in its assumptions, than the underlying theory (Sabatier & Weible, 2014).

2.4 Theoretical framework for innovation

There are many theories and framework that have been used to study innovation and a few of these will be discussed in this work (Freeman, 1995; George et al., 2012; Grawe, 2009; Ramadani & Gerguri, 2011; Roberts, 2001; Vertova, 2014a). These are the systems of innovation (national, regional, sectoral, firm level/corporate, openness), actor network theory, knowledge-based view of innovation, dynamic capabilities, resource advantage view and the Schumpeterian theory of innovation.

According to various authors, Joseph Schumpeter was the pioneer of innovation (Ramadani & Gerguri, 2011; Roberts, 2001; Vertova, 2014a). According to the Schumpeterian framework, innovation consists of introduction of a new good to the market, introduction of a new method of production, opening a new market, conquest of a new source of supply of raw materials or half-manufactured goods, and implementation of a new form of organization (Ramadani & Gerguri, 2011; Vertova, 2014a). The key point of this framework is that innovation leads to novelty (Vertova, 2014a). The Schumpeterian logic states that at firm level, the factors that slow the rate of competitor imitation are crucial for the company to maintain firm level profit persistence(Roberts, 2001). According to Ramadani and Gerguri (2011), innovation is a process by which a novel idea is brought to the stage where it eventually produces money. It is a dynamic technical, economic and social process involving the interaction of people coming from different horizons, with different perspectives and different motivations (Ramadani & Gerguri, 2011). The Schumpeterian framework implies a positive relation between R&D intensity, the rate of patenting, technological change, and the growth rate of output per worker (Zachariadis, 2003). According to Grawe (2009) Schumpeterian innovation framework considers the impact of firm size and available resources on firm level innovation. Schumpeter's perspective views large firms as having greater capacity to innovate due to greater market power and R&D spending (Grawe, 2009).

Open innovation describes a phenomena where organisations rely increasingly on external sources for innovation (Lazzarotti & Manzini, 2009). These external sources can be suppliers, customers, research institutes and other collaborators. Closed innovation describes a phenomena where organisations rely mainly on internal resources and internal R&D for innovation.

George et al. (2012) investigated innovation in India through the social lens of inclusive growth. The authors' defined inclusive innovation as innovation that benefits the disenfranchised, is a process as well as a performance outcome. Growth was defined as improvements in the social and economic wellbeing of communities that have structurally been denied access to resources, capabilities, and opportunities (George et al., 2012). Inclusive innovation create or enhance opportunities to improve the wellbeing of those at the base of the pyramid (George et al., 2012; Hart & Christensen, 2002). The current studies will not focus on this type of innovation but on innovation at a firm level.

According to Freeman (1995), national and regional systems of innovation are essential for economic growth and are necessary for organisations to innovate. The national government is responsible for developing policies that influence the national education system, industrial relations, technical and scientific institutions, government policies, cultural traditions and many other national institutions. Therefore, they play a crucial role in promoting innovation at a country level. The concept of National Systems of Innovation (NSI) is the main theoretical tool attempting to take into account and integrate the importance of the economic environment for firms' possibility to innovate (Vertova, 2014a). It is used to show international differences or similarities in countries' ability to innovate and to be on the technological edge. On the other side, it becomes a normative tool used to give policy suggestions in order to support firms' innovative activities (Vertova, 2014a). For nations to prosper, they should not only acquire the achievements of other more advanced nations but they should increase them by their own efforts (Freeman, 1995). According to Rooks and Oerlemans (2005), innovation can also be defined as a set of distinct institutions which jointly and individually contributes to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. In this definition, NSI involves those institutions that produce diffuse and adapt new technical knowledge, which may be industrial firms, universities or government agencies (Rooks & Oerlemans, 2005).

Le Bas and Scellato (2014a) investigated innovation persistence at firm level. The authors used three theoretical frameworks in their study and these are the 'knowledge accumulation' approach, the 'success-breeds-success' hypothesis and the concept of sunk costs in R&D activities (Le Bas & Scellato, 2014a). Accumulation of knowledge over time tends to induce persistent innovative behaviour and that the availability of internal funds enhances the ability of the organisation to continuously engage in innovation. However, access to local knowledge stocks generated by spill overs from other firms can also affect the degree of persistence of innovative activities (Le Bas & Scellato, 2014a). The hypothesis of 'knowledge accumulation' implies that experience in innovation is associated with dynamically increasing returns in the form of learning-by-doing and learning-to-learn effects (Le Bas & Scellato, 2014a). The 'success-breeds-success' hypothesis asserts that innovation feeds profitability, which later funds innovation activities (Le Bas & Scellato, 2014a). Therefore, economic and commercial success is crucial in this hypothesis. The concept of sunk costs in R&D suggests that organisations at each time period face the choice between investing and not investing in R&D activities. Those that invest in R&D incur high start-up costs which are usually not recoverable and these sunk costs represent a barrier to both entry to and exit from R&D activity (Le Bas & Scellato, 2014a).

The dynamic capabilities framework analyses the sources and methods of wealth creation and capture by private enterprise firms operating in environments of rapid technological change (Teece et al., 1997). Teece (2009) defined dynamic capabilities as “high-level activities that link to management’s ability to sense and then seize opportunities, navigate threats, and combine and reconfigure specialized and co-specialized assets to meet changing customer needs, and to sustain and amplify evolutionary fitness, thereby building long-run value for investors”. Activities that underlie a general dynamic capability include searching for new ideas and methods, comparing company practices to the best in the industry, evaluating practices in other industries and experimenting (Le Bas & Scellato, 2014a). The competitive advantage of firms is seen as resting on distinctive processes (ways of coordinating and combining), shaped by the firm’s (specific) asset positions (such as the firm’s portfolio of difficult-to-trade knowledge assets and complementary assets), and the evolution path(s) it has adopted or inherited (Teece et al., 1997). The dynamic capabilities framework suggests that private wealth creation in regimes of rapid technological change depends in large measure on honing internal technological, organisational, and managerial processes inside the firm (Teece, 2009; Teece et al., 1997). The dynamic capabilities framework focuses on exploiting existing internal and external firm-specific competences to address changing environment (Teece, 2007). It emphasizes the development of management capabilities and difficult-to-imitate combination of organisational, functional and technological skills. It integrates and draws upon research in areas such as the management of R&D, product and process development, technology transfer, intellectual property, manufacturing, human resource, and organisational learning (Teece, 2007). Organisations within the metal industry are characterised by legacy machinery and equipment that make up a substantial part of their infrastructure (Rasool & Rasool, 2020). While the technological changes in other industries are fast-paced, the metals industry is moving at a slower, but sure pace (Rasool & Rasool, 2020). Therefore, understanding the dynamic capabilities in an environment where there is less rapid technological change is warranted.

The knowledge-based view of innovation centres on knowledge as the most important resource of the firm (Eisenhardt & Santos, 2002; Grawe, 2009;

Quintane et al., 2011). The uniqueness of a firm's knowledge is fundamental in the firm's ability to develop a sustained competitive advantage (Grawe, 2009; Quintane et al., 2011). Quintane et al. (2011) defined innovation as an outcome from knowledge perspective. Eisenhardt and Santos (2002) defined knowledge as an unambiguous, reducible and easily transferable construct, while knowing is associated with processing information. According to Alguezaui and Filieri (2014), knowledge-based view of the firm assumes that the wealth-creating capacity of enterprises is situated on the knowledge and capabilities that they acquire and retain. Knowledge is an intangible asset, and its management is more complex than managing information or any other physical asset such as machineries, raw materials, industrial establishments and the like (Alguezaui & Filieri, 2014). Innovation can be viewed as a process or an outcome of a process. Innovation as a process refers to the activities that companies undertake in order to develop innovations and is described with concepts such as production and emergence; discovery and creation; development, solving and implementation; or introduction and application (Quintane et al., 2011). Innovation as an outcome of this process is considered in terms of new ideas; combinations; solutions; or processes, products and procedures (Quintane et al., 2011). The knowledge-based view concept views innovation acknowledges that existing knowledge is crucial in generate a radical innovation, accelerate the implementation of a new innovation and sustaining organisational innovativeness (Quintane et al., 2011). The dominant perspective in the knowledge literature is to consider that an innovation comes from a process of knowledge exchange and recombination (Quintane et al., 2011). This includes the re-use of existing knowledge and capabilities in a new application setting (Quintane et al., 2011).

The theory of S-curves explains the origins and evolution of radical innovations (Grawe, 2009). The S-curves develop as technologies are introduced. It depicts a process that starts slowly, then gradually gather pace until they move into fast growth which continues until saturation is reached, then growth slows done and eventually plateau (Brown, 1992). This curve is typically used to demonstrate a product life cycle. This is also applicable for technological innovations. Little consumer benefit is realized in the introduction phase, benefits increase as the technology develops, and benefits increase at a slower rate as the technology enters maturity (Grawe, 2009). New innovations are required before current ones reach the phase of slowed growth or plateau.

According to Li et al. (2008), the notion of exploration and exploitation has been widely used in studies on organisational learning, strategic renewal and technological innovation. This framework was introduced by March (1991); (Martini et al., 2013). The exploration-exploitation framework considers two distinctive types of innovation (March, 1991). Exploratory innovations are radical innovations that are designed to meet the needs of new markets and require new knowledge or a departure from existing knowledge within a firm (Grawe, 2009; Martini et al., 2013). According to Li et al. (2008), exploration includes things captured by terms such as search, variation, risk taking, experimentation, flexibility, discovery, and innovation. Exploitative innovations are innovations that are incremental and designed to meet the needs of existing customers or markets (Grawe, 2009). According to Li et al. (2008), exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, and execution. According to Grawe (2009), exploitative innovations are characterized by refinement, implementation, and efficiency. Li et al. (2008) used the exploration and exploitation to study technological innovation. Technological innovation is considered as a critical competitive capability for growth and adaptation and it demonstrates a firm's capability of effective organisational learning (Li et al., 2008; Schumpeter, 2000). Exploration is the search for new knowledge, technology, competences, markets or relations, and that exploitation is the further development of existing ones, their interpretation of these constructs differs substantially (Li et al., 2008; March, 1991). According to Li et al. (2008), exploration can be interpreted as distant knowledge search and exploitation as proximate knowledge search. The degree of exploration/exploitation depends on how local or distant the knowledge search is along the cognitive, temporal or spatial dimension of the knowledge space (Li et al., 2008; Maletič et al., 2014; March, 1991). R&D projects are defined as exploration while development projects are exploitation. A successful innovation also requires searching for product market knowledge gained from customers, suppliers and even competitors as a complementary source to scientific and technological knowledge (Li et al., 2008; Maletič et al., 2014). Product innovation typology defines exploration and exploitation according to the interplay between technology search and product market knowledge search (Li et al., 2008). According to Li et al. (2008), exploration is the technology search that aims at meeting future market demand, and exploitation is the technology search that aims at meeting current market demand.

The resource-advantage theory was introduced by Hunt (1995). According to resource-advantage theory, firms seek to use their resources to gain a competitive advantage in the market, which will ultimately lead to superior financial performance (Grawe, 2009; Hunt, 1995; Hunt & Morgan, 2005). The resources referred to include organisation's assets, processes, information, and knowledge that help a firm improve efficiency and effectiveness (Grawe, 2009). Organizations will innovate to improve their resource position and those occupying positions of competitive advantage can maintain such positions by engaging in proactive innovation to ensure that their resources are comparatively better than the resources of competing firms (Grawe, 2009; Hunt & Morgan, 2005). This resource-advantage theory was also used by Grawe (2009) to develop a model of innovation logistics. Logistics innovation is defined as any logistics related service that is seen as new and helpful to a particular focal audience (Grawe, 2009).

Network theory is concerned with the nature of long-term interorganisational relationships (Grawe, 2009). The network theory framework in concerned with variables such as position, power, embeddedness, and density (Grawe, 2009). It considers the roles associated with each firm in a network and the resulting impact on innovation. According to Harty (2008), an actor-network theory approach emphasizes the roles that both human actors and non-human agents play in the performance and outcomes of these interactions. Tatnall (2005) expanded this definition by adding that actor-network theory was developed to analyze situations where separation of these elements is difficult. The example used was from information technology where it is difficult to differential which part of a piece of software is just an inanimate object and which the result of human interactions (Tatnall, 2005). The actor-network theory works on the premise that both human and non-human actors are treated fairly and in the same way

(Tatnall, 2005). Miettinen (1999) used the actor-network theory and cultural-historical theory to study technical innovation. According to Miettinen (1999), innovation process should be studied as a simultaneous development of an artifact and a network of actors connected to it.

2.5 Dynamic capabilities framework

There are many theories and frameworks that have been used to study innovation and this work focused mainly on dynamic capabilities since it aims to expand this theory to include the dynamic workforce capabilities (Freeman, 1995; George et al., 2012; Grawe, 2009; Ramadani & Gerguri, 2011; Roberts, 2001; Vertova, 2014b). Winter (2003) defined organisational capability as the organisation's ability to effectively manage resources such as employees to gain an advantage over competitors. These capabilities need to be dynamic in order for the organisation to adapt to the internal and external environments (Varsani, 2018). Firms need to renew or update their resources in order to adjust them to the changing environment (Vladova, 2018).

The theory of dynamic capabilities draws upon concepts such as innovation, organisational learning and knowledge management which are key mechanisms for organisational change (Fallon-Byrne & Harney, 2017). It emphasises the management of unique capabilities and inimitable combinations of resources that cut across all functions of the organisation, including R&D, product and process development, manufacturing, human resources and organisational learning (Breznik & Hisrich, 2014; Lawson & Samson, 2001; Okanga & Groenewald, 2017). These unique dynamic capabilities are built and developed within the organisation rather than bought and applied (Fallon-Byrne & Harney, 2017). In this work, the unique capabilities of interest are human resources and their innovative ideas.

The dynamic capabilities framework was defined by Teece et al. (1997) as a "framework that analyses the sources and methods of wealth creation used by private firms operating in environments of rapid technological change" (Teece et al., 1997, p. 509). This definition focuses on organisations which operate in environments of rapid technological change and this excludes in less rapid technological change. Teece (2009) offered another definition, which is slightly modified in comparison to the earliest definition, and defined dynamic capabilities as “high-level activities that link to management’s ability to sense and then seize opportunities, navigate threats, and combine and reconfigure specialized and co-specialized assets to meet changing customer needs, and to sustain and amplify evolutionary fitness, thereby building long-run value for investors” (Teece, 2009, p. 54). This definition places the responsibility to sense and then seize opportunities on the managers, not the non-managerial workforce. It is the most widely used definition in recent research (Gremme & Wohlgemuth, 2017; Leemann & Kanbach, 2021; Vladova, 2018; Wendra et al., 2019). In this work, the ideas generated by employees are the main focus, though it is acknowledged that it is the managers’ responsibility to ensure that these ideas eventually get implemented. Therefore, the definition by Teece (2009) is still valid in the context of this work.

Activities that bring about a general dynamic capability include searching for new ideas and methods, comparing company practices to the best in the industry, evaluating practices in other industries and experimenting (Le Bas & Scellato, 2014b). This work focuses on new or improved ideas and production methods in the South African metals industry. The competitive advantage of firms is seen as resting on distinctive processes (ways of coordinating and combining), shaped by the firm’s (specific) asset positions (such as the firm’s portfolio of difficult-to-trade knowledge assets and complementary assets), and the evolution path(s) it has adopted or inherited (Teece et al., 1997). Performing ad hoc problem solving and implementing best practice are not dynamic capabilities and they do not necessarily result in the company outperforming its competitors (Teece, 2007). According to Helfat et al. (2007), there are two conceptual measures of dynamic capabilities and these are technical fitness and evolutionary fitness. Technical fitness is defined by “how effectively a capability performs its function when normalised (divided) by its costs” (Helfat & Peteraf, 2009, p. 97). This measure considers the financial performance of the capabilities discovered. Evolutionary or external fitness refers to “how well a dynamic capability enables an organisation to make a living by creating, extending, or modifying its resource base" (Helfat & Peteraf, 2009, p. 98). Teece (2007) also argued that entrepreneurial fitness should be added as a conceptual measure of dynamic capabilities since it is an "element of dynamic capabilities that involves shaping (and not just adapting to) the environment" (Teece, 2007, p. 1321).

The dynamic capabilities framework suggests that private wealth creation in regimes of rapid technological change depends in large measure on honing internal technological, organisational, and managerial processes inside the firm (Teece, 2009; Teece et al., 1997). It focuses on exploiting existing internal and external firm-specific competences to address the changing environment (Rasouli et al., 2015; Teece, 2007). The dynamic capabilities perspective is more relevant in highly changing and dynamic environments, contrary to the resource-based view, which has a static outlook on a business environment (Owoseni & Twinomurinzi, 2019; Rasouli et al., 2015). This is in agreement with the work by Rasouli et al. (2015) who indicate that the resource-based view focuses more on the operational capabilities that support current processes to achieve the current target of a system, while the dynamic capabilities perspective aims to align a system with respect to changes in an environment.

The emphasis of the resource-based view is on the development of management capabilities and difficult-to-imitate combinations of organisational, functional and technological skills (Dixon et al., 2014). It integrates and draws upon research in areas such as the management of R&D, product and process development, technology transfer, intellectual property, manufacturing, human resource, and organisational learning (Teece, 2007). However, the resource based view has been criticised as being too inward focused and not accounting for external environmental factors that may influence a firm's performance (Duncan, 2019; Pisano, 2015). Therefore, it is attuned to cultivating resources in static environments and is not well-suited to providing insight into dynamic capability development which is the intent of the dynamic capabilities view (Duncan, 2019).

Teece (2018) stated that dynamic capabilities should not only be viewed at corporate level as they are also important at the business unit and product levels. However, these capabilities need to be aligned and linked to the strategic vision of the organisation in order to yield profit (Teece, 2018). Adner and Helfat (2003) expanded on the dynamic capabilities framework by introducing the concept of dynamic managerial capabilities which are “capabilities with which managers build, integrate, and reconfigure organisational resources and competences” (Adner & Helfat, 2003, p. 1012). Senior managers in organisations influence the nature of a firm’s competitive advantage through its dynamic capabilities, which depend on the human ability to reconfigure, combine and integrate resources to create appropriate strategies (Macpherson et al., 2015). Teece (2018) stated that managers have a desire to exercise their own will and design capabilities within the firm. However, the workforce capabilities are currently not captured in literature. These are not the ordinary capabilities that employees use in order to allow the firm to achieve best practice levels of efficiency but dynamic capabilities that ensure that the firm is able to respond to threats and opportunities (Teece, 2018). The focus of work by Teece on human resource is centred around managers and their capabilities (Teece, 2018). The basis is that it is the responsibility of managers to continuously scan the environment (internal and external) for opportunities even though implementation is done by the collective organisational resources. However, this work intends showing that qualifications, tenure and demographic background attributes are useful for employees to generating idea in the South African metals industry.

Giniuniene and Jurksiene (2015) studied the relationship between dynamic capabilities, organisational learning and innovations. Organisations need to have the ability to learn faster than their competitors in order to have sustainable competitive advantage (Coetzer, 2007). Organisational learning is used to incorporate dynamic capabilities into the internal processes of the firm (Giniuniene & Jurksiene, 2015). Organisational learning is a crucial antecedent for innovation and has a positive relationship with company performance (Giniuniene & Jurksiene, 2015). Giniuniene and Jurksiene (2015) showed that innovation and organisational learning are intermediate concepts in relations between dynamic capabilities and firm performance. Dynamic capabilities are seen as an overarching framework that explains how different routines and processes such as organisational learning and innovation positively influence the firm’s performance and help enterprises to sustain a competitive advantage (Giniuniene & Jurksiene, 2015; Okanga & Groenewald, 2017). These capabilities increase the ability of organisations to innovate and have also proven to positively contribute to organisational performance (Giniuniene & Jurksiene, 2015). This work also endeavours to determine if there is a link between investment in learning and development within the organisation and firm level innovation within the metals industry in South Africa.

Dynamic capabilities have been applied to non-governmental organisations (NGOs) who provide humanitarian support, social enterprises and government and academic institutes (Bhardwaj & Srivastava, 2021; Heaton et al., 2019; Mishra et al., 2022; Tabaklar et al., 2021; Vézina et al., 2019). In this instance, the main concern is wastage of disaster relief materials along the supply chain, such as food that gets rotten because it was stored for too long, which strains already scarce resources (Mishra et al., 2022; Tabaklar et al., 2021). In this environment, the sensing model of dynamic capabilities is the key capability as it incorporates agility, which together with adaptability and alignment can build sustainability (Mishra et al., 2022). Agility and resilience were also identified as required dynamic capabilities for governments, when dealing with social pandemics like the coronavirus disease 2019 (COVID-19) pandemic, by Mazzucato and Kattel (2020). According to Mishra et al. (2022), seizing in this environment can be achieved through effective contingency planning, which is underpinned by information sharing, while transforming would involve realigning the structure and culture of disaster relief stakeholders to both fully utilise existing capabilities while investing in additional capabilities through enhancing collaboration with governments and NGOs. Mishra et al. (2022) also proposed a fourth capability for NGOs and called sustainability which is underpinned by a continuous learning process that allows for the evaluation and identification of constraints.

Social enterprises have a dual role of addressing social goals while maintaining financial sustainability (Bhardwaj & Srivastava, 2021; Vézina et al., 2019). According to Vézina et al. (2019) dynamic capabilities can be applied to social enterprises. In this instance, the sensing capability is the ability of the enterprise to identify a societal demand for social transformation, the seizing capability is about shaping societal demands into a commercial offer and the reconfiguring capability concerns organisational innovation to integrate actual and new knowledge through innovative routines (Vézina et al., 2019). However, later work by Bhardwaj et al. (2021) showed that the critical dynamic capabilities for social enterprises are sustainability of beneficiaries, involving beneficiaries in decision-making, defining unique business models and selective suppliers for critical resources. These dynamic capabilities enable social enterprises to achieve continuous social improvement and socio-economic success (Bhardwaj & Srivastava, 2021; Bhardwaj et al., 2021).

2.6 Micro-foundations of dynamic capabilities

The dynamic capabilities framework is used to explain how firms successfully adapt to changing environments (Arndt, 2011; Nayak et al., 2020; Teece et al., 1997). According to Teece (2007), the dynamic capabilities of organisations are its sensing, seizing, and reconfiguring capabilities which assist the firm to be sustainable in changing environments. These are capabilities that enable the organisation to adapt, integrate and reconfigure skills, resources, and functional competences in changing environments (Dixon et al., 2014). The higher order organisation capabilities identified by Teece (2007) are:

1. Sensing – refers to the ability of a firm to identify threats locally and abroad. It involves scanning, creation, learning, and interpretive activity across technologies and markets. It also involves research activity and the probing of customer needs and technological possibilities.
2. Seizing – refers to the ability of the organisation to mobilise resources to deliver value and shape new markets.
3. Transforming and reconfiguration – refers to the ability of the firm to continually renew itself and engage in periodic major strategic shifts (Teece, 2007)

Fallon-Byrne and Harney (2017) indicated that the higher orders capabilities mentioned by Teece (2007) are not micro-foundations of dynamic capabilities but are detailed descriptions of the dynamic capabilities themselves rather than the processes which underpin them. Therefore, each of the higher order capabilities identified by Teece (2007) has its own micro-foundations. The micro-foundations of dynamic capabilities at firm level are distinct skills, processes, procedures, organisational structures, decision rules, and disciplines that are found in that firm (Duncan, 2019; Meyer-Doyle et al., 2018; Saul & Gebauer, 2018; Teece, 2007). These involve both individual skills and organisational capabilities. This work focuses more on the individual skills and their impact on firm level innovation in South Africa. Saul and Gebauer (2018) reported that individual skills capture the attitudes, expertise, and cognitive skills (e.g., managerial foresight, instrumental cognition, or entrepreneurial alertness); while organisational routines involve rules, tools, and procedures that companies apply. Therefore, individual skills are as crucial on firm level innovation as the organisation routines.

The work by Duncan (2019) identified absorptive, adaptive and innovative capabilities as micro-foundations of dynamic capabilities at firm level for emerging additive manufacturing industry in the United States of America (USA).

- Absorptive capability is “the firm’s ability to leverage external and internal information for its benefit” (Duncan, 2019, p. 18). This is the ability of the firm to value external information, internalise it, and subsequently exploit it for commercial means (Duncan, 2019).
- The adaptive capability is “the firm’s ability to quickly reconfigure its resources and processes in order to benefit from opportunities that it observes are occurring within its business environment” (Duncan, 2019, p. 20). It requires that the organisation take a proactive rather than reactive approach to its environment and is based on the firm’s ability to continuously learn in order to facilitate disruption and complexity within its organisation (Duncan, 2019).
- Innovative capacity is “the firm’s ability to manage innovation through the continuous reconfiguration of its organisational resources, knowledge, and processes” (Duncan, 2019, p. 23). It involves the organisation’s capacity to create new processes, products, services, and markets.

Later work by Bhardwaj et al. (2021) showed that in order to have dynamic capabilities, firms need to have the ability to recognise and exploit opportunities. The micro-foundations of dynamic capabilities were defined by Bhardwaj et al.

(2021) as all the processes, procedures and structures underlying each capability and influencing its sensing, seizing and reconfiguring capacities. This expands from the definition of the high order capabilities by Teece (2007) and adds lower order dependencies (processes, procedures and structures) required for dynamic capabilities. Khan et al. (2020) also stated that high level capabilities of sensing, seizing and reconfiguring capabilities are undergirded by micro-foundations that are composed of distinct skills, processes, and organisational activities (Khan et al., 2020). The micro-foundations of each dynamic capabilities as defined by Bhardwaj et al. (2021) are shown in Table 2 below.

Table 2: Classification of dynamic capabilities with respect to their micro-foundations (Bhardwaj et al., 2021).

Capabilities	Related micro-foundations
Sensing	-Acquiring knowledge to sense opportunities and learn to shape them -Identifying processes related to – directing internal R&D, selecting new technology and probing market -Processes for identification of customer needs, engaging with suppliers and stakeholders and creation of new opportunities
Seizing	-Developing or selecting a business model – defining its design, target segment and mechanism for capturing or creating value -Selecting organizational boundaries to manage resources -Developing architecture for products/services – their design and pattern -Engaging stakeholders and building communications and loyalty
Reconfiguration	-Aligning and realigning resources and competencies in a continuum -Managing strategic fit and cospecialization of resources -Restructuring and decentralization of organization to enhance coordination and efficiency -Knowledge management, continuous learning and integration of know-how

The focus of the current work is not on organisational capabilities but on dynamic resource-based capabilities that make up the dynamic workforce capabilities. These are identified as workforce experiences which include education, tenure and demographic information. Education was selected since the research by Medase (2020) showed that stimulates the capacity of employees to comprehend, create and process information swiftly compared to those without education. Employee tenure is associated with total work experience and employees with a long organisational tenure have more work experience and become more familiar with the processes of the organisation and its strategy (Liu et al., 2016). Accumulated work experience, inside and outside the organisation, is also important as experience employees have developed skills that are relevant and specific to their domain, thereby, tackling problems in a more focused and relevant way (Carmeli et al., 2006). Employee demographic background of interest in this study were age, gender, and ethnic background. These attributes were selected based on the work by Østergaard et al. (2011) which showed that increasing employee diversity in gender, age, ethnicity, and education result in increased firm level innovation. The focus of this work on the sensing capabilities as stated in CHAPTER 1. The subsections below explain the micro-foundations of each higher order capability that were identified by Teece (2007) to make up the dynamic capabilities.

2.6.1 *Micro-foundations of sensing capabilities*

The dynamic sensing capability in an organisation is the ability to direct internal R&D decide on new technologies, bring suppliers and contributors innovation, identify target market segments and recognise customer needs (Bhardwaj et al., 2021). Sensing activities focus on understanding customer needs, latent demands, development of markets and the responses from suppliers and competitors (Khan et al., 2020). The ability of individuals and organisations to create and discover new opportunities relies on access to information and the ability to recognise, sense, and shape developments (Teece, 2007). This would form part of the idea generation phase in the innovation model presented by Mariello (2007). The ability to recognise opportunities depends in part on the individual's capabilities and extant knowledge (or the knowledge and learning capacities of the organisation to which the individual belongs) particularly on user needs in relationships to existing as well as novel solutions (Teece, 2007). While certain individuals in the enterprise may have the necessary cognitive and creative skills, the more desirable approach is to embed scanning, interpretative, and creative processes inside the enterprise itself (Teece, 2007). The enterprise will be vulnerable if the sensing, creative, and learning functions are left to the cognitive traits of a few individuals (Fallon-Byrne & Harney, 2017).

New ideas are not only generated internally but can be discovered externally from collaborators, suppliers and customers (Saul & Gebauer, 2018). There is a high probability that an innovation will be successful commercially when the developer understands the needs of the end users and customers (Teece, 2007). At managerial level, the entrepreneurial aspects of the manager can also be viewed as micro-foundation for dynamic capabilities (Arndt, 2011). At organisational level, it is crucial to align reward and appraisal systems to be beneficial and supportive of innovation efforts (Fallon-Byrne & Harney, 2017).

2.6.2 *Micro-foundations of seizing capabilities*

Seizing capabilities refers to the activities that focus on the implementation of that opportunity, which has been identified as conducive to competitive advantage (Khan et al., 2020). Once a new (technological or market) opportunity is sensed, it must be addressed through new products, processes, or services (Arndt, 2011; Teece, 2007). Therefore, the recognition of a new opportunity must be followed and addressed through manufacturing new products, formulating new processes and or services (Bhardwaj et al., 2021). Organisations must make investment decisions on which innovation to support, and these decisions are typically made in the top management structures of the organisation. Although these investment decisions are made by top management, the work by Kohavi et al. (2007) showed that the Highest Paid Person's Perspective (HiPPO) can sometimes undermine the benefits to the customer when developing solutions. Therefore, a more objective matrix to guide innovation selection would be needed by organisations instead of relying only on sponsors from top management level. Employee motivation and strong relationships with suppliers and customers are also important for seizing capability (Khan et al., 2020). Firms may use interpersonal relations, social networks, communities of practice (CoP) or interest associations to learn about opportunities and threats, and to develop new competencies for dealing with them (Arndt, 2011).

According to Teece (2007), the micro-foundations for seizing are selecting product architectures and business models; selecting enterprise boundaries; managing complements and platforms; and avoiding bias, delusion and deception. The important business model choices include technological choices, market segments, investment and financial strategies, and sales strategies

(Afuah, 2014; Khan et al., 2020). Enterprise boundaries are necessary to ensure that innovation is more likely to benefit the sponsor of the innovation rather than imitators and emulators. The ability of organisations to develop innovations internally or outsource this function depends on critical skills. The critical strategic element associated with capturing value from innovation is the ability of the innovating enterprise to identify and control the ‘bottleneck assets’ or ‘choke points’ in the value chain from invention through to market (Teece, 2007).

2.6.3 *Micro-foundations of reconfiguration capabilities*

Reconfiguring capabilities refer to the ability of a firm to recombine and reconfigure its resource base in order to address an identified opportunity conducive to competitive advantage (Khan et al., 2020). According to Teece (2007), reconfiguration capabilities involve business model redesign as well as asset-realignment activities, and the revamping of routines (Bhardwaj et al., 2021; Teece, 2007). Reconfiguring resources and changing routines towards innovation is not an easy task in part because people tend to abandon creative actions in favour of habitual routines (Fallon-Byrne & Harney, 2017). To change habitual routines, organisations need to look at their culture, policies and procedures as well as implement effective change management (Fusch et al., 2020; Mendy, 2020; Naranjo-Valencia et al., 2019). Therefore, the key to sustained profitable growth is the ability to recombine and to reconfigure assets and organisational structures as the enterprise grows, and as markets and technologies change (Bhardwaj et al., 2021; Helfat et al., 2007; Teece, 2007).

Organisations need to reconfigure and refresh existing resources in order to create new ones as a response to changing environments (Fallon-Byrne & Harney, 2017). The capabilities of the organisation to reconfigure itself is required to maintain evolutionary fitness in changing environments since market success may breed some level of routine and complacency (Jantunen et al., 2012; Khan et al., 2020; Teece, 2007). Successful enterprises will develop hierarchies, rules and procedures which ultimately constrain certain interactions and behaviours unnecessarily and hence reconfiguration is crucial for sustainability. An important managerial function is achieving semi-continuous asset orchestration and corporate renewal, including the redesigning of routines (Teece, 2007).

The micro-foundations of reconfiguration capabilities involve decentralisation of decision making (Teece, 2007). However, this requires maturity of employees and empowerment and autonomy from the organisation. This is also supported by Fallon-Byrne and Harney (2017) who highlighted the importance of flexible structures and empowered employees in supporting innovation in organisations. The basic rationale of this reconfiguration was to achieve greater accountability of managerial decisions so that the recognition of opportunities and threats could proceed more thoroughly and expeditiously (Teece, 2007). However, decentralisation can compromise the organisation's ability to achieve integration.

Another important micro-foundation is managing co-specialisation which means the physical assets, human resources and the intellectual property of a company, having developed together over time, are more valuable in combination than separately, and give a firm a sustainable competitive advantage (Teece, 2007). This concept looks at complementary innovation and complementary assets which are of great significance, particularly in industries in which innovation might be characterised as cumulative, and/or where industry 'platforms' exist or are needed (Teece, 2007). It involves managing strategic fit so that asset combinations are value enhancing (Teece, 2007). The ability of management to identify needs and opportunities to 'invest' in co-specialised assets (through its own development or astute purchase) is fundamental to dynamic capabilities. This requires coordination of R&D investment and activity with alliances (Teece, 2007).

Another crucial micro-foundation is learning, knowledge management and corporate governance (Teece, 2007). These are critical intangible assets to the organisation. The ability to integrate and combine assets including knowledge is a core skill for dynamic capabilities and involves internal and external knowledge know-how (Fallon-Byrne & Harney, 2017). However, it is important for an organisation to develop policies for monitoring and managing the 'leakage,' misappropriation, and misuse of know-how, trade secrets, and other intellectual property (Teece, 2007).

Micro-foundations of dynamic capabilities have also been studied in a social innovation environment. Tabaklar et al. (2021) studied dynamic capabilities for social innovation for a logistic company that transports the supply of humanitarian aid using semi-structure interviews. The finding were the following (Tabaklar et al., 2021):

1. Sensing capability – early anticipation of needs in disaster-affected areas and lessons-learned exercises are the micro-foundations of sensing capabilities.
2. Seizing capability – building capacity, supply network service provision, collaboration with logistics service providers, local partner engagement, building trust, and reconciliation are the micro-foundations of seizing capabilities.
3. Reconfiguring capability – coordination and adaptability are the micro-foundations of reconfiguring capabilities in the humanitarian aid context.

2.7 Measures of innovation at firm level

Banu (2018) conducted a study to determine the key performance indicators (KPIs) for innovation. The author determined the following key KPIs for innovation (Banu, 2018):

1. Performance of the innovation;
2. Relationship between actual financial resources needed, projected budget and expected experimental results;
3. Lastly, increase innovation success rate by identifying as many external channels as possible for accessing expertise in critical areas of the project.

The focus by Banu (2018) is on performance (actual vs. budgeted) of the innovation but does not explicitly explore input factors for the innovation. The work by Hagedoorn and Cloodt (2003) identified R&D inputs, patent counts and patent citations to new product announcements as key indicators for innovation success. However, typically, organisations in the South African metals industry are not driven by the number of patents produced, but the development of processes or products within their organisation. The high costs of maintaining patents could be the deterrent for the metals industry to file for patents. Also, South African organisations in the metals industry are mainly involved in incremental innovation which is working in an imitation mode as stated by Oerlemans and Pretorius (2006), which was also confirmed by Almeida and Fernandes (2008). This was further echoed by Kraemer-Mbula et al. (2019) who also stated that the fact that innovation that take the forms of imitation does not make it any less important economically. It may be the necessary condition for the business to maintain a competitive position in the local market.

Sibanda (2017) stated that tracking R&D spending is not the only important thing, but organisations need to measure the outcomes of innovation which are new goods, processes and knowledge that could form basis for patents and competitiveness. Therefore, the degree to which companies introduce inventions into the market (or within their manufacturing processes) is a key measure. This is defined as innovative performance by Hagedoorn and Cloodt (2003) and indicates the ability of innovation to move from conception of an idea up to the introduction of an invention into the market.

The Oslo Manual (2018) gives guidelines for collecting, reporting and using data on innovation. For manufacturing firms in Europe, the Community Innovation Survey (CIS) has been used successfully to measure and rank countries and organisations in terms of innovativeness (De Jong & Vermeulen, 2006; Frenz & Ietto-Gillies, 2009; Kleinknecht et al., 2002; Oslo Manual, 2018). The CIS (or a modified version) is also used by other countries outside Europe and this work also uses it to measure innovation within the South African metals industry (Blankley, 2007; Cirera & Muzi, 2016, 2020; Mohnen & Therrien, 2002).

2.8 The South African metals industry

The manufacturing industry makes up a large portion of South Africa's economy and it contributes over 18% of the national gross domestic product (GDP) (Chimucheka et al., 2019; Du Toit, 2003; South African Government, 2003). This industry in South Africa has been traditionally resource based and heavily dependent on minerals. Most of these minerals are exported in primary metal (or ore) form and this limits the country from beneficiating its vast mineral resources (Oerlemans & Pretorius, 2006). Therefore, innovation is required to grow the sector and reduce unemployment in South Africa. Manufacturing is expected to beneficiate these ores by converting them to primary metals and value-added products. The success of the manufacturing sector will supplement and revive the service sector since high-value manufacturing generates a demand for technology-intensive services (South African Government, 2003).

Booyens (2011) reported that the current macro-economic strategies of South Africa are focused on transforming the economy from a natural resource dependent to a knowledge-based economy. If South Africa fails to progress from a resource-based industry, it will be vulnerable to current global trends of deteriorating terms of trade for commodity producers (Dube et al., 2014; Edwards, 2004). Thus, manufacturing can be seen as an important catalyst for the upgrading of the entire economy (South African Government, 2003). Du Toit (2003) showed that only 58% of the useful knowledge in an organisation is recorded information (documents and databases) and the remaining 42% resides in employee brains. Therefore, the value of human capital and knowledge retention are crucial for organisations to succeed (Overall, 2015). According to (Calof & Sewdass, 2020), employees are also crucial for competitive intelligence of the organisations as they gather information and develop insights on the external environment (competitors, external environment, customers, suppliers, technology, etc.) in order to make organisational decisions about the external environment. This work aims to understand what the employee experience factors that influence innovation are and how these affect innovation at firm level.

The divisions and subdivisions of manufacturing as reported in the Statistics South Africa (2019) report are listed in Table 3 below. In the first quarter of 2019, most of these divisions and subdivisions did not yield any positive growth. This work only focuses on organisations that manufacture or process metals. This falls within the "basic iron and steel, non-ferrous metals products, metals products and machinery" division in Table 3 (Statistics South Africa, 2019).

Table 3: Divisions of manufacturing sector in South Africa (Statistics South Africa, 2019).

Manufacturing division and major group	Weights	Dec 2018 – Feb 2019	Mar – May 2019	% change between Dec 2018 – Feb 2019 and Mar – May 2019	Contribution (% points) to the total % change
Food and beverages	**26,64**	**108,1**	**108,8**	**0,6**	**0,2**
Meat, fish, fruit, etc.	6,69	104,5	104,7	0,2	0,0
Dairy products	2,15	109,5	119,2	8,9	0,2
Grain mill products	3,37	98,0	96,9	-1,1	0,0
Other food products	8,14	111,7	112,1	0,4	0,0
Beverages	6,29	112,2	111,7	-0,4	0,0
Textiles, clothing, leather and footwear	**3,12**	**89,7**	**88,3**	**-1,6**	**0,0**
Textiles	0,78	97,8	92,3	-5,6	0,0
Other textile products	0,40	95,7	92,9	-2,9	0,0
Knitted, crocheted articles	0,09	90,0	84,7	-5,9	0,0
Wearing apparel	1,04	82,8	82,4	-0,5	0,0
Leather and leather products	0,46	79,3	85,6	7,9	0,0
Footwear	0,35	99,2	96,3	-2,9	0,0
Wood and wood products, paper, publishing and printing	**11,45**	**96,3**	**94,8**	**-1,6**	**-0,2**
Sawmilling and planing of wood	1,73	98,2	100,1	1,9	0,0
Products of wood	2,57	99,9	100,1	0,2	0,0
Paper and paper products	4,14	100,0	96,7	-3,3	-0,1
Publishing	1,43	79,5	77,5	-2,5	0,0
Printing, recorded media	1,58	93,6	90,6	-3,2	0,0
Petroleum, chemical products, rubber and plastic products	**23,07**	**100,2**	**100,3**	**0,1**	**0,0**
Coke, petroleum products and nuclear fuel	8,67	103,2	107,5	4,2	0,4
Basic chemicals	4,29	95,9	90,1	-6,0	-0,2
Other chemical products	6,19	98,5	93,9	-4,7	-0,3
Rubber products	1,24	95,2	98,0	2,9	0,0
Plastic products	2,68	104,2	109,2	4,8	0,1
Glass and non-metallic mineral products	**3,18**	**99,5**	**94,3**	**-5,2**	**-0,2**
Glass and glass products	0,66	113,6	117,7	3,6	0,0
Non-metallic mineral products	2,52	95,8	88,2	-7,9	-0,2
Basic iron and steel, non-ferrous metal products, metal products and machinery	**18,69**	**101,4**	**104,7**	**3,3**	**0,6**
Basic iron and steel products	3,57	111,8	114,2	2,1	0,1
Non-ferrous metal products	2,58	107,4	107,1	-0,3	0,0
Structural metal products	1,99	82,8	89,8	8,5	0,1
Other fabricated metal products	3,79	104,2	108,6	4,2	0,2
General purpose machinery	2,58	90,5	100,4	10,9	0,3
Special purpose machinery	3,41	102,2	103,8	1,6	0,1
Household appliances	0,77	101,1	91,3	-9,7	-0,1
Electrical machinery	**1,64**	**82,8**	**84,7**	**2,3**	**0,0**
Radio, television and communication apparatus and professional equipment	**1,54**	**94,1**	**91,1**	**-3,2**	**0,0**
Radio, television and communication apparatus	0,90	101,8	99,6	-2,2	0,0
Professional equipment	0,64	83,3	79,3	-4,8	0,0
Motor vehicles, parts and accessories and other transport equipment	**7,56**	**104,0**	**104,2**	**0,2**	**0,0**
Motor vehicles	2,82	106,4	104,6	-1,7	0,0
Bodies for motor vehicles, trailers and semi-trailers	0,47	106,0	109,6	3,4	0,0
Parts and accessories	3,04	110,4	112,2	1,6	0,1
Other transport equipment	1,23	82,0	81,2	-1,0	0,0
Furniture and other manufacturing	**3,11**	**101,4**	**98,9**	**-2,5**	**-0,1**
Furniture	1,07	89,3	91,1	2,0	0,0
Other manufacturing groups	2,04	107,8	103,0	-4,5	-0,1
Total	**100**	**101,7**	**102,0**	**0,3**	**0,3**

The 1996 White Paper on Science and Technology introduced the notion of a ‘national system of innovation (NSI)’ into South Africa’s formal public policy discourse (Manzini, 2012). According to Edler and Fagerberg (2017), the national system of innovation approach to innovation policy emerged during the late 1980s and early 1990s in the world and became popular among policymakers after its adoption by the Organisation for Economic Cooperation and Development (OECD). However, Lundvall (2022) puts the date for first use of the national innovation system concept to 1982 by Christopher Freeman in a working paper for OECD linking national economic performance to technological infrastructure. The OECD adopted its own version of the concept and since then national governments have used it to frame science, technology and innovation (STI) policies (Lundvall, 2022). The 1996 White Paper on Science and Technology became the cornerstone of the South African government policy on science and technology (Manzini, 2012). Success of innovation depends on a number of different factors, such as knowledge, skills, financial resources, demand, etc. of which government policies have an influence on (Edler & Fagerberg, 2017). This policy was updated in 2019 and is now called the White Paper on Science, Technology and Innovation (South African Government, 2019). The major change between these white papers is the technology changes brought by the Fourth Industrial Revolution (4IR) and the promotion of an inclusive economy at all levels including society and industry participation rather than focussing too much on just patents and development of high-level science, engineering and technology skills (South African Government, 2019).

The paper further states that South Africa needs to concentrate on increasing the research capacity of domestic firms in order to strengthen their competitiveness in the global value chains (South African Government, 2019). For this to happen, South African organisations need to be innovative, which is the focus of the current study. Various megatrends (such as population growth and urbanisation) and technological advances present opportunities and threats in South Africa. For an example, changing manufacturing environments can lead to economic growth but also to the loss of traditional jobs, especially for unskilled and semiskilled labour where jobs are lost due to automation (South African Government, 2019). Therefore, the work on understating the impact of employee innovation on firm level innovation is crucial so that organisations do not dismiss innovations coming from these unskilled and semiskilled workforces while only adopting technology driven innovations.

De Beer (2005) defined policy as “a statement or set of statements in which goals are set, and programmes are developed by decision-makers, in response to conditions in a particular society” (De Beer, 2005, p. 53). Policy is developed as a strategic response by government to address a particular need by the society (De Beer, 2005; Edler & Fagerberg, 2017; Lundvall, 1992a). Even though government is responsible for building and maintaining some of the boundaries of the innovation system through regulations, other boundaries such as global economy, are outside the control of a single government (Gault, 2010; Lundvall, 1992b). The innovation policy has a primary function of stimulating, guiding, and monitoring knowledge-based activities within a political jurisdiction such as a nation or a region (De Beer, 2005; Edler & Fagerberg, 2017; Lundvall, 1992b). However, the role of innovation policy has been expanded to more explicitly contribute to tackling societal challenges in recent times, which is relevant for South Africa due to high (34.9% in the third quarter of 202) unemployment rates (Boon & Edler, 2018; Trading Economics, 2022). Therefore, the social and economic problems that innovation aims to solve should be clearly defined in the innovation policy (Edler & Fagerberg, 2017). Innovation policy should not only focus on tax incentives for R&D expenditure but stimulate job creation and productivity (Edler & Fagerberg, 2017). However this is difficult to measure due to long lags between innovation and its social and economic impact because other policies and interventions are simultaneously implemented by the government to stimulate the markets (Edler & Fagerberg, 2017; Qi et al., 2020).

According to Wolf (2006), the ability of companies to innovate depends crucially on the knowledge system in which they operate. Innovations in the manufacturing sector in South Africa are governed within the National System of Innovation (NSI). Metcalfe (1995) defined the national system of innovation as “that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process” (Metcalfe, 1995, p. 38). Rooks and Oerlemans (2005) defined the system of innovation as “a set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies, and provides the framework within which governments form and implement policies to influence the innovation process" (Rooks & Oerlemans, 2005, p. 1205). The nation supplies knowledge, skills, financial resource and demand which are crucial for innovations to succeed and also highlight the important role government plays in each nation through fiscal incentives and policies, in promoting innovation (Edler & Fagerberg, 2017; Qi et al., 2020). This work does not focus on innovation at a national level although the influence of the national system of innovation in promoting firm level innovation is acknowledged.

The organisation's performance is measured mainly based on financial sustainability and other measurable key performance indicators, which include safety and productivity. In the South African manufacturing sector, innovation is seldom seen as a key performance indicator as it is an intermediate step, even though it results in long-term financial sustainability. Alegre et al. (2006) developed a methodology to measure performance for product innovation. This method used efficacy and efficiency to measure innovation. Efficacy is defined as the degree of success of an innovation, while efficiency is the effort required to succeed (Alegre et al., 2006, p. 334). This measure looks at both effort, which is determined by both development time and costs of the innovative project, and success which is determined by market performance of the innovative product (Alegre et al., 2006). The performance of innovative ideas that were generated was not measured in this work since the focus was on the workforce capabilities during the innovation generation and not on the success or failure of the innovative ideas.

Oerlemans and Pretorius (2006) investigated the impact of internal knowledge based on the use of internal and external innovation sources on innovative outcomes of South African firms using the resource-based and activity-based views of innovation. Organisations involved in process and product innovation need to constantly scan their internal and external environments, and ensure that they make use of resources that are conducive to innovation (Oerlemans et al., 2022; Oerlemans & Pretorius, 2006). For R&D activities, these internal resources are normally highly educated personnel (Oerlemans & Pretorius, 2006; Suchek et al., 2021; Yun & Liu, 2019). However, contribution to innovation is not only limited to R&D but can come from a variety of internal resources (Oerlemans &

Pretorius, 2006). External sources of innovation come from business networks (including electronic databases and patents) that facilitate the learning and diffusion of new technology know-how (Almeida & Fernandes, 2008; Oerlemans et al., 2022; Oerlemans & Pretorius, 2006). Oerlemans and Pretorius (2006) used quantitative research method and data were obtained using a survey derived from the South African Innovation Survey of 2001. The variables that were used by Oerlemans and Pretorius (2006) in their study are shown in Table 4 below. Some of these variables such as control variables (firm size, foreign ownership, exports and innovation funds) are adopted in the current study.

Table 4: Variable used in the study on firm level innovation in South African by Oerlemans and Pretorius (2006).

Variable	Measurement
Innovation outcomes	Innovative sales in 2000.
Strength of the internal knowledge base	R&D effort = number of persons assigned to R&D divided by the total workforce percentage of higher-educated employees.
Utilization of internal knowledge sources	How important were internal sources for the innovation processes of the firm? (4-point Likert scale: not important to very important.) These six sources were: (1) purchasing; (2) marketing and sales; (3) research; (4) development; (5) engineering; (5) production.
Utilization of external knowledge sources	How important were external sources for the innovation processes of the firm? (4-point Likert scale: not important to very important.) External sources are: (1) own group; (2) new personnel; (3) buyers; (4) suppliers; (5) competitors; (6) consultants; (7) research laboratories; (8) universities; (9) innovation centres; (10) sector institutes; (11) patents; (12) electronic databases; (13) professional literature; (14) professional conferences and exhibitions.
Firm size	The number of the firm's employees in 2000.
Foreign ownership	Was the head office of the firm located in South Africa?
Export	Did the firm export in 1998 and 2000?
Innovation funds	Innovating firms were asked to indicate which of the following external innovation funds were used in 2000: (1) THRIP; (2) Innovation Fund; (3) Support Programme for Industrial Innovation; (4) Sector Partnership Fund; (5) Competitive Fund; (6) venture capital; (7) development capital (banks, IDC); (8) research cooperation (science councils). Each item was dummy coded and a total score was computed by adding all items.
Sector	Manufacturing sectors, e.g. textiles, clothing, and leather products; metal products, electrical and optical equipment; and furniture. Non-manufacturing sectors: wholesale; financial intermediation; transport and communication; business services.
Level of innovation	To what extent did product, service or process innovations cause changes of other products, services or processes within firms? Scale: 1 = no change to 5 = drastic changes. Two items were used to measure the level of innovation (one for product/service innovation, one for process innovations). Cronbach's alpha = 0.781, indicating a reliable scale.

In Table 4, foreign ownership is added since the study by Almeida and Fernandes (2008) showed that the majority foreign-owned firms are less likely to engage in technological innovations than minority foreign-owned firms or domestic firms. The reason for this is that the technology transferred from multinational parents to majority owned subsidiaries is more mature than that transferred to minority-owned subsidiaries (Almeida & Fernandes, 2008). The results from the study by Oerlemans and Pretorius (2006) showed that the greater the percentage of highly educated employees in the firm, the higher its innovative outcomes will be (Oerlemans & Pretorius, 2006). However, R&D efforts did not have an impact on innovation outcomes as the resources devoted to R&D are too low to maintain an

R&D infrastructure in the South African business sector, and to complete innovation development processes (Oerlemans et al., 2022; Oerlemans & Pretorius, 2006). This is in contradiction to the study by Karahan and Karhan (2013) who identified R&D as an engine for driving innovation within the industry. The reason provided for this discrepancy is that in the case of South Africa, only few employees who are relatively highly educated perform this R&D function and it does not involve the critical mass in the manufacturing sector. Organisations in developing countries are more involved in incremental rather than radical innovation (Edler & Fagerberg, 2017; Gault, 2010). Almeida and Fernandes (2008) had also stated that the majority of firms in developing countries adopt new technology without having conducted formal R&D activities and proposed that engagement in technological innovation should be used as a measure, instead of R&D expenditure, to capture technological innovation in developing countries (Almeida & Fernandes, 2008). In this study, this is expanded to include engagement in process innovation as well.

Most organisations in South Africa are involved in incremental innovation which is working in an imitation mode due to resource constraints compared to firms in developed countries (Oerlemans et al., 2022; Oerlemans & Pretorius, 2006). According to Oerlemans et al. (2022), about 22% of European innovators reported lack of internal resources, while South African firms reported a much higher levels of 32.5%. These organisations in South Africa simply imitate or adapt existing production techniques to local conditions (Almeida & Fernandes, 2008). This means that they typically imitate innovations from developed countries rather than getting involved in novel innovations (Oerlemans et al., 2022). Another interesting outcome of the study by Oerlemans and Pretorius (2006) was that smaller firms generate higher levels of innovative outcomes than larger ones (Oerlemans & Pretorius, 2006). The use of internal resources for innovation also had a positive relationship with innovation outcomes, and radical innovators seem to be in a do-it-yourself innovation mode (Ahmed et al., 2018; Grimaldi et al., 2021; Oerlemans & Pretorius, 2006). Organisations that use the internal resources for innovation are mostly working on more secrecy based innovation mode (Oerlemans & Pretorius, 2006). Therefore, most of the innovative work these organisations are involved in is not published in literature.

The metals industry in South Africa consists of SMMEs, large corporations and multinational corporations (MNCs). The ability of MNCs to innovate is closely linked to their ability to generate, source, and integrate knowledge globally (Michailova & Zhan, 2015). Therefore, subsidiaries play an important role in innovation for MNCs as they can source and acquire knowledge both from their home country and from host countries where they are located. For many multinational companies in South Africa, like ArcelorMittal South Africa, the parent company resides in Europe or America. Only innovation that happens within the borders of South Africa is considered in this study. The ability of a subsidiary to proactively pursue opportunities can facilitate new knowledge generation and link this knowledge to the innovation value chain (Michailova & Zhan, 2015). It is this innovation that this work intends to investigate on MNCs and the focus is on how dynamic workforce capabilities influence this innovation.

It is acknowledged that knowledge and innovation gained from parent and sister subsidiaries is likely to enrich the knowledge and innovation pool of the local subsidiary (Michailova & Zhan, 2015). Okanga and Groenewald (2017) studied the effect of innovation culture on dynamic capabilities for SMMEs in the South African manufacturing industry. The research was done using a mixed qualitative research method entailing a meta-synthesis of different theories and triangulation with the interview findings on dynamic capabilities building approach used by the small and medium enterprises (SMEs) in the manufacturing sector (Okanga & Groenewald, 2017). The authors used the three steps for dynamic capability that were developed by Teece (2007) which are sensing and shaping opportunities; seizing opportunities; and managing threats and reconfiguration (Okanga & Groenewald, 2017; Teece, 2007). The conclusion was that lack of innovation culture limits the generation of new ideas for SMMEs in this sector to reconfigure their value creating resources to adapt to market and industry changes (Okanga & Groenewald, 2017). This highlights that innovation culture is a prerequisite for organisations to implement dynamic capabilities. However, the majority of SMMEs in the South African manufacturing sector do not engage in research and development and those that highlighted the importance of research and innovation have often not demonstrated the commitment of ensuring that innovation is effectively undertaken to enhance the development and improvement of their dynamic capabilities (Okanga & Groenewald, 2017; Schoemaker et al., 2018). These SMMEs avoid research and innovation because of lack of financial investment and resources to undertake such initiatives (Okanga & Groenewald, 2017).

According to Booyens (2011), SMMEs are catalysts for innovation, facilitating change and enhancing competition in the industry. In South Africa, SMMEs generate employment, which assists in alleviating poverty. In order to increase the productivity of these SMMEs, innovation and early adoption of new technologies is crucial (Wolf, 2006). In South Africa, SMMEs contribute an estimated 50% to the GDP and employ 60% of the labour force, while in developed countries SMMEs contribute to 90% of the GDP in the OECD group of countries (Booyens, 2011). Therefore, there is still a large potential for SMMEs to contribute more to South Africa, especially if they are innovative. However, a large majority of the SMMEs in South Africa are survivalists in the informal economy. Lack of funding is highlighted as one of the limitations to growth of these SMMEs because banks cannot give them loans and guarantees (Akinyemi & Adejumo, 2017; Booyens, 2011; Muriithi, 2017). SMMEs operate in the same environment as larger organisations but do not have adequate financial capital and extended human resources that these corporations enjoy (Smit & Watkins, 2012). This has also led to the high failure rate of SMMEs in South Africa.

Most multinational companies in South Africa are not involved in technological innovations because foreign-owned subsidiaries rely mostly on the direct transfer of technology from their parents (Almeida & Fernandes, 2008). However, this is tested during this study. According to Urban and Naidoo (2012), the deficiency of operational skills in the manufacturing sector in South Africa has been the main failure of SMMEs. This deficiency of operational skills is also applicable in larger organisations that produce metals in South Africa. Improving operational and industry-specific skills will have a positive effect on the performance of organisations in South Africa since these skills serve as sources of competitive advantage, especially when combined with entrepreneurial skills (Urban & Naidoo, 2012). The production operation is the major value adding process in a manufacturing organisation and the best opportunity to introduce efficiencies to reduce costs (Oerlemans & Pretorius, 2006; Urban & Naidoo, 2012). In manufacturing environments, technical resources are primary strategic resources that need to be acquired and developed (Oerlemans & Pretorius, 2006).

Almeida and Fernandes (2008) also showed that there is a connection and positive relationship between labour productivity and technological innovation. However, in South Africa, the employees directly involved in the production process generally have lower education training and are mostly technologically illiterate (Urban & Naidoo, 2012). Therefore, skills development and education in general are required in order to improve productivity and innovativeness (Felstead et al., 2020; Urban & Naidoo, 2012). This needs to be supported by technological innovations that are user friendly to unskilled/semi-skilled labour so this group of workers do not become obsolete (Edwards, 2004; Gaimon et al., 2011). However, current global technologies which are procured by South African firms are more skilled labour biased technologies (Edwards, 2004). This forces South African firms to adapt their current (existing) technologies to do more than what they were intended for, and this type of innovation (modification) is driven by workforce. However, there had been a rise in percentage of skilled labour in the South African manufacturing sector which is driven by the current legislations which require grade 12 as a minimum qualification for work purposes and the reliance on skill biased technologies procured from developed countries (Edwards, 2004; Leibbrandt et al., 2010). The reliance on computer literacy for production operations has exacerbated this trend (Edwards, 2004). This work aims to show that there is a high level of innovation ideas generated by employees compared to managers and the following hypotheses are tested:

Hypothesis 1A:

Null Hypothesis: There is no process/product innovation of innovation in the South African metals industry.

Alternate Hypothesis: Process/product innovation exists in the South African metals industry.

According to Carnevale et al. (2017), Employees are increasingly expected to actively contribute to their organisations success, such as through developing novel ideas, communicating these ideas to management and implementing creative ideas and solutions. It is the employees who observe and engage in the daily operations of the business and therefore their innovation is also of management and scholarly importance (Carnevale et al., 2017). Carnevale et al. (2017) differentiated between innovation ideas created by managers and employees, similar to the current study. In this study, a survey was sent to various organisations in the South African metals industry to understand the level of idea generation between managers and non-managerial employees, between 2019 and 2021. The responses were tested based on actual data (generated and implemented ideas) and perspectives from various organisations. Interviews were also conducted to unpack the perspectives of the managers and non-managerial employees. A similar approach was conducted by Saunila (2017) who explored the perspectives of managers and employees for SMEs in Finland, using a web-based questionnaire, to determine a positive effect between innovation capability and firm performance. The results from that study reveal that managers and employees have different perceptions on what aspects of innovation capability affect firm-level performance (Saunila, 2017). The perspective of managers for SMEs in Finland was that their role in innovation is more directing innovation activities towards an end goal, rather than participating in the innovation process. The current study aimed at understanding the level of idea generation between managers and non-managerial employees in the South African metals industry, which is a developing country while Finland is a developed country. The hypothesis is shown below.

Hypothesis 1B:

Null Hypothesis: There is no insignificant proportion of innovation ideas that are generated by employees compared to managers in the South African metals industry.

Alternate Hypothesis: There is a significant proportion of innovation ideas that are generated by employees compared to managers in the South African metals industry.

2.9 Dynamic workforce capability factors that impact on innovation in the South Africa metals industry

This work focuses on the dynamic workforce capabilities that have an effect on firm level innovation in the South African metals industry. The hypothesis is that employee education qualifications, tenure at the current job and demographic background attributes are workforce capability factors that have a positive relationship with firm level innovation in the South African metals industry. Høyrup (2010) showed that employee-driven innovation is crucial for the success of organisations and that firms should not rely exclusively on experts and R&D but also realise the importance of employees in driving product and process innovations. This was also corroborated by Felstead et al. (2020) who showed that employees of all kinds come up with ideas about improving the work processes they use, the products they make and services they provide. Felstead et al. (2020) also found that the strength of employee involvement, the nature of workplace support and development and performance management are strongly associated with employees' willingness and ability to come up with innovative ideas. Employees have considerable skills and acquire significant knowledge through their interactions with technology, materials, the market, customers and users (Echebiri et al., 2021; Hammond et al., 2011; Høyrup, 2010; Tirabeni & Soderquist, 2019). Employees can be in the centre of the flow of information in the firm and can exchange practical knowledge and know-how in activities in informal internal networks (Echebiri, 2020; Høyrup, 2010). Hammond et al. (2011) showed that there was a positive relationship between an employee's creative personality and innovation at organisational level. The work focused on highly skilled employees who were publishing researchers. Employees who are more open to new experiences have high intellectual curiosity, imagination, independence, and sensitivity to the arts which makes them more likely to be innovative (Hammond et al., 2011; Jordaan, 2012). Therefore, openness to experience is positively correlated with innovative performance as observed by Hammond et al. (2011), who also found a positive relationship between education and job tenure with innovation, and a positive relationship between job discretion with innovation. As individuals gain knowledge and experience, they build a larger and more integrated repository of response possibilities, which include ideas, facts, and cognitive scripts, from which to draw creative problem solving ideas (Hammond et al., 2011).

2.9.1 *Academic qualifications*

In order for the manufacturing sector in South Africa to move into value added products rather than over relying on raw material intensive manufacturing, the companies in the manufacturing sector need to innovate (Du Toit, 2003; Gault, 2010). Innovation generally leads to an increase in demand for skilled labour as opposed to unskilled labour and this has led to an increase in wages as skilled labour generally gets paid higher salaries compared to unskilled (Brandenburg et al., 2007; Stadler, 2003; Tether et al., 2005). This means acquiring formal education qualifications becomes necessary for employees. According to Brandenburg et al. (2007), tertiary education qualified science and engineering employees are a major source of innovative activities for companies in the manufacturing sector. Qualified employees are an important input for R&D where new knowledge is created and subsequently introduced in the form of new products and processes (Brandenburg et al., 2007). Highly educated employees fulfil regular activities more effectively and are more competent in the use and exploitation of new technologies compared to unskilled labour (Brandenburg et al., 2007). Medase (2020) also found that a higher level of educated workforce in a firm stimulates the capacity to comprehend, create and process information swiftly compared to those without education. Further training of employees is also crucial for innovation as it adds to the knowledge and capabilities of the workforce (Brandenburg et al., 2007). An organisational learning culture facilitates the employees' performance and increases their efficiency and effectiveness with innovation and creativity (Usman et al., 2011).

Medase (2020) studied the role of higher education qualifications in innovation performance in both manufacturing and service firms in Nigeria. The author used quantitative research, and the cross-sectional data were collected over the periods 2005-2007 and 2008-2010. Nigeria is a developing country in Africa and there would be likely commonalities to South Africa. One similarity between these countries is the low investment in R&D (as a percentage of total revenue) by the organisations in their respective manufacturing sectors (Grawe, 2009; Medase, 2020). Medase (2020) found a positive relationship between higher education qualifications of employees in the manufacturing sector and product innovation. In this work, employee qualifications are used as one of the factors for dynamic workforce capabilities and its impact on innovations in the South African metals industry is investigated.

Hypothesis 2A:

Null Hypothesis: There is no statistically significant relationship between employee education level and innovation at firm level in the South African metals industry.

Alternate Hypothesis: There is a positive relationship between employee education level and innovation at firm level in the South African metals industry.

2.9.2 *Tenure*

There are two types of workplace tenure that are studied in this work which are organisational tenure and position tenure. According to Liu et al. (2016) organisational tenure can be defined as “the length of employment one holds in an organisation” (Liu et al., 2016, p. 102). Employees with a long organisational tenure have more work experience and become more familiar with the processes of the organisation and its strategy (Liu et al., 2016). These employees drive innovation within the organisation as they have learned from past innovation problems and are more skilled in dealing with political behaviour in the workplace (Brandenburg et al., 2007; Liu et al., 2016). However, Liu et al. (2016) cautioned that employees in different stages of their careers do not always maintain high motivation to perform innovation, especially when employees approach the end of their careers, their enthusiasm and investment to engage in innovation will greatly decrease (Liu et al., 2016). Position tenure is defined as “the length of employment in a certain job or position” (Liu et al., 2016, p. 104). In manufacturing, employees need to accumulate a number of years’ experience in a certain position before they can master the manufacturing processes and technologies used. People who work for a longer period in their current job are likely to develop skills that are relevant and specific to the domain, thereby, tackling problems in a more focused and relevant way (Carmeli et al., 2006). Sibanda (2017) regards this as learning by doing. Coetzer (2007) also showed employees that work for smaller (10-49 full time equivalent employees) manufacturing companies in New Zealand preferred informal learning processes, such as on the job training, as opposed to formal academic training.

Hypothesis 2B:

Null Hypothesis: There is no relationship between employee tenure and innovation at firm level in the South African metals industry.

Alternate Hypothesis: There is a positive relationship between employee tenure and innovation at firm level in the South African metals industry.

2.9.3 *Demographic background attributes*

The Employment Equity Act, No. 55 of 1998 promotes diversity, in terms of age, sex, cultural, educational and ethnic background, in the workplace in South Africa such as the metals industry (South African Government Gazette, 1998). According to Østergaard et al. (2011), as the employees become more diverse (gender, age, ethnicity, and education) in a firm, so does the knowledge base of that firm and this leads to innovation. The authors used quantitative research and the data were collected using a questionnaire based on the innovation survey done on Danish firms. Innovation is an interactive process, where employees interact in groups and develop, discuss, modify and realise new ideas (Østergaard et al., 2011). Therefore, diversity in groups and competences in the workplace promotes innovation. Østergaard et al. (2011) studied the effect of age, gender, ethnicity and education diversity on innovation for firms in Denmark. The authors found the following (Østergaard et al., 2011):

1. An increase in gender balance (50-60%) is positive for the innovative performance of firms. The gender balance for South African firms tilts more towards males.

2. Age diversity had a negative effect on likelihood of the firm to innovate because diversity in age causes disagreements amongst employees which leads to lower innovative performance.
3. There was no relationship between diversity in ethnicity and innovation because the majority of the employees in their study were Danes. However, South Africa has a significantly diverse group of employees in terms of ethnicity. Yang and Konrad (2011) also found that ethnic diversity played an important role in innovation of organisations in Canada.
4. There was a positive effect of diversity in education among the employees with a higher education on the likelihood of introducing an innovation. This is influenced by the fact that most of the employees were highly educated which is not the case for the South African metals industry.

Woods et al. (2018) studied the effect of personality traits on innovative work behaviour for graduate trainees in the United Kingdom financial institutes. The innovative work behaviour consists of idea generation, idea promotion and suggestion implementation phases (Carmeli et al., 2006). In the idea generation phase, the individual recognises the problem and comes up with new solutions and ideas (Carmeli et al., 2006; Woods et al., 2018). In the idea promotion phase, the individual seeks to promote the idea or solution and garners support both inside and outside the organisation (Carmeli et al., 2006; Woods et al., 2018). In the suggestion implementation phase, the individual realises the idea or solution of producing a prototype or model of the innovation (Carmeli et al., 2006; Woods et al., 2018). The personality traits that were investigated by Woods et al. (2018) were openness and conscientiousness. Woods et al. (2018) found that employees with a high degree of openness were flexible in their thinking, curious and imaginative. This resulted in them having a higher likeliness to be innovative. However, there was a negative relation between innovativeness and conscientiousness because employees who are highly conscientious enjoy working in orderly, planned and dependable approaches (Woods et al., 2018). The current work does not investigate the personally traits of the innovative employees and only focuses on employees age, gender and ethnic background.

Hypothesis 2C:

Null Hypothesis: There is no relationship between employee demographic background attributes and innovation at firm level in the South African metals industry.

Alternate Hypothesis: There is a positive relationship between employee demographic background attributes and innovation at firm level in the South African metals industry.

2.10 Conclusion of Literature Review

Literature on innovation, theoretical frameworks and dynamic capabilities model was reviewed in this chapter. Innovation definition that is adopted in this work is "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (Oslo Manual, 2018, p. 20). Innovation involves extracting commercial (or social) value from new (or improved) products, systems or processes. Due to the unpredictable global environment, organisations need to constantly scan them in order to stay ahead of their competitors. This requires strategic management awareness by leaders in the organisation. Innovation will assist organisations to swim the tides of uncertainty that are brought by globalisation. Therefore, organisations need to have innovation as an intentional strategic objective if they are to survive and stay ahead of their competitors. This section gave an overview of various theoretical frameworks in innovation, but the focus of this work is on dynamic capabilities framework. This framework was defined by Teece et al. (1997) as a "framework that analyses the sources and methods of wealth creation used by private firms operating in environments of rapid technological change" (Teece et al., 1997, p. 509). The dynamic capabilities framework focuses on exploiting existing internal and external firm-specific competences to address the changing environment (Teece, 2007). This work aims to expand this framework by including dynamic workforce capabilities. Literature on factors that affect these dynamic workforce capabilities was present.

2.10.1 *Hypotheses*

The main research question in this work aims to explore the relationship between the employee factors (qualification, tenure and demographic background attributes) that make-up the dynamic workforce capabilities and firm level innovation in the South African metals industry. This is answered using regression analysis from data that were collected using a questionnaire. The hypothesis is that there is a positive relationship between dynamic workforce capabilities and innovation and this can be confirmed by a positive relationship between the employee factors (qualification, tenure and demographic background attributes) that make-up the dynamic workforce capabilities and firm level innovation. The following hypotheses are investigated in this study:

1. The first hypothesis is that a significant proportion of innovation ideas are generated by employees compared to managers. However, in order to determine this, the study will start by showing that there is product/process innovation in this particular industry. The hypotheses investigated are listed below.
   a. *Process/product innovation exists in the South African metals industry.*
   b. *There is a significant proportion of innovation ideas that are generated by employees compared to managers in the South African metals industry.*
2. The second hypothesis is that there is a positive relationship between employee factors (qualification, tenure and demographic background attributes) and firm level innovation in the South African metals industry.

   The hypotheses investigated are listed below.
   a. *There is a positive relationship between employee education level and innovation at firm level in the South African metals industry.*
   b. *There is a positive relationship between employee tenure and innovation at firm level in the South African metals industry.*

c. *There is a positive relationship between employee demographic background attributes and innovation at firm level in the South African metals industry.*

CHAPTER 3. RESEARCH METHODOLOGY

A research methodology defines specific procedures or techniques used to identify, collect, process and analyse information about a specific research topic. It is a framework that guides how the research should proceed and implies a concern for constructing a particular type of knowledge (Caelli et al., 2003). This section presents the research methodology used in this study. The research approach that is used is mixed research methods which combines quantitative and qualitative research methodologies (Guetterman & Fetters, 2018; Pluye & Hong, 2014; So et al., 2018). The aim of this work is to determine the relationship between employee experience factors (qualification, tenure, and demographic background attributes) and innovation at a firm level in the South African metals industry.

3.1 Research approach

The philosophical issue that this work focuses on is epistemological in nature. In the epistemological paradigm, the researcher is more concerned about the theory of knowledge that informs the research (Hall, 1990; Ochieng, 2009; Tuli, 2010). Epistemology is the study of limitations in knowledge in a particular field of study especially with regard to its methods, validity, and scope (Dana & Dumez, 2015). It is the distinction between justified belief and perspective. In this work, the aim is to expand the scope of knowledge in dynamic capabilities by including dynamic workforce capabilities. The researcher is independent from what is researched (Sukamolson, 2007). Hypothesis testing is used to determine the relationship between dynamic workforce capabilities and firm level innovation. The position that is taken is positivism since the predictions that there is a relationship between dynamic workforce capabilities and firm level innovation is tested using statistical methods (Tuli, 2010). According to Tuli (2010), “positivism is based on the assumption that there are universal laws that govern social events, and uncovering these laws enables researchers to describe, predict, and control social phenomena” (Tuli, 2010, p. 103). Regression statistics are used in this study to show a causal effect between the variables studied (Kavitha et al., 2016).

There are three research strategies that can be applied when conducting research. These are quantitative, qualitative and a combination of the two which is referred to as mixed methods (Creswell, 2009; Imenda, 2014; Migiro & Magangi, 2011; Pluye & Hong, 2014; So et al., 2018). According to Levitt et al. (2018) qualitative research describes a set of approaches that analyse data in the form of natural language (i.e., words) and expressions of experiences (e.g., social interactions and artistic presentations). Grossoehme (2014) stated that qualitative research focuses on eliciting people's stories based on their experiences. These stories can be expressed in conversations (interviews or focus groups), written texts (journal, prayers, or letters), or visual forms (drawings, photographs). It produces findings that cannot be obtained using statistical procedures or other means of quantification (Rahman, 2017).

Quantitative research employs experimental methods and quantitative measures to test hypothesis (Bashir et al., 2008; Golafshani, 2003). It quantifies the collection and analysis of data, and forms part of a deductive reasoning approach as it draws conclusions from general propositions or hypotheses (Rahman, 2017; Rossman & Rallis, 2011).

The mixed-method research strategy uses qualitative for one phase of a research study and the quantitative for another in order to understand a research problem comprehensively (Denscombe, 2008; Migiro & Magangi, 2011; Pluye & Hong, 2014; So et al., 2018). It encourages researchers to use multiple approaches to collecting and analysing data within a single study, recognising the limitations of using a single method (Migiro & Magangi, 2011). A sequential mixed research method is used in this study, and this involves more than one phase of data collection and analysis. Qualitative research is used to expand the results that would have been obtained from the quantitative research.

This study uses the mixed-method research approach to test for a relationship between employee experience factors that affect dynamic workforce capabilities, and innovation at firm level for organisations in the South African metals industry. It employs experimental methods and quantitative measures to test hypothesis (Bashir et al., 2008; Golafshani, 2003). It also emphasises the measurement and analysis of causal relationships between variables (Golafshani, 2003; Rahman, 2017). The benefit of quantitative research in this context is that it allows the researcher to measure the relationships under review (Bryman, 2012). This allows a detection of variations in different levels of impact of the independent variables, and gives a consistent yardstick of such variations (Bryman, 2012). The independent variables are employee qualification, tenure, and demographic background attributes, while the dependent variable is firm level innovation. Lastly, this approach allows the researcher to quantify the degree of the said relationships per the hypothesis (Bryman, 2012). In this context, quantitative research would be able to reveal to what extent a variable like an employee's level of education impacts firm level innovation.

Various researchers have also employed this method to study the impact of various factors on innovation (Adner & Helfat, 2003; Guarascio & Tamagni, 2019; Nguyen et al., 2016; Plank & Doblinger, 2018; Rothaermel & Hess, 2007; W. Zhang et al., 2019). The aim of the study by Rothaermel and Hess (2007) was to show that antecedents to innovation could be found at individual, firm and network levels using quantitative research. The data used were obtained from global pharmaceutical companies within biotechnology over a 21-year period, from 1980 to 2001. The dependent variable was the innovation output in terms of research publications (journals, conferences, and patents) and the independent variables were intellectual human capital, star scientists, R&D capability, alliance with new technology providers and acquisition of new technology firms. The authors found that the dependent variable was a positive function of the independent variables using p-statistics (p-test). Other statistics, such as descriptive statistics, bivariate correlation and regression analysis, were also used in the study by Rothaermel and Hess (2007). These statistics are also used in the current study to test for a relationship between dependent and independent variables. Ordinal variables from Likert scales were converted to continuous variables in order to conduct linear regression statistics (Lee, 2015).

According to Cornford and Smithson (2005), quantitative research involves the development of metrics that can be used to describe relationships between objects that are being studied. Since this study uses statistical analysis to determine the impact of workforce capabilities on firm level innovation, quantitative research is a more suitable methodology. A survey was sent to selected organisations within the South African metals industry to determine the source of innovation ideas (manager/workforce) to answer the first and the second research questions. This was a primary dataset as the researcher developed the survey and collected the raw data records from the observations (respondents) using Qualtrics (Lee, 2015). However, there was an intermediate step where data collected by HSRC, using the South African Business Innovation Survey 2014-2016, was analysed to determine if there is product and / or process innovation in this industry. Qualtrics is a web-based software that allows the user to create surveys and generate reports without having any previous programming knowledge. The filtered data of only organisations in the metals industry in South Africa given to the researcher by HSRC was not published or made available to anyone else before. Therefore, no work was previously done on this selected set of data.

Qualitative research was conducted, through interviews, with two individuals in selected organisations from the South African metals industry to get an in-depth understanding of their innovation activities. An interview is an “extendable conversation between partners that aims at having an ‘in-depth information’ about a certain topic or subject, and through which a phenomenon could be interpreted in terms of the meanings interviewees bring to it” (Alshenqeeti, 2014, p. 40). In the work, semi-structured one-on-one interviews were conducted. This type of interview was chosen as it allowed the researcher to probe and expand the interviewee's responses. Interviews, compared to questionnaires, are more powerful in eliciting narrative data that allows researchers to investigate people's views in greater depth (Alshenqeeti, 2014). They are interactive and the researcher can press for complete, clear answers and can probe into any emerging topics (Alshenqeeti, 2014). Hence, interviewing is expected to broaden the scope of understanding investigated phenomena, as it is a more naturalistic and less structured data collection tool. Bhardwaj et al. (2021) also used qualitative research to study the micro-foundations of dynamic capabilities for social enterprises in India. The advantage of using interviews is that it is interactive and the respondents get to give more insight about their responses (Rahman, 2017). The names of the three organisation that were used as case studies for the qualitative work were anonymised for ethical reasons. Case studies were also used by Khan et al. (2020) and Bhardwaj et al. (2021). A case study is a description and analysis of an individual matter or case (Starman, 2013). According to Yin (2018), a case study is a social science research method that is used to investigate a contemporary phenomenon in depth and in its real world context. Case studies are used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context (Crowe et al., 2011; Yin, 2018).

3.2 Research design

This research used a sequential explanatory research design as it tested for a causal relationship between variables since it first used quantitative research to conduct the statistical analysis and then used the qualitative research to explain the results obtained (Bambale, 2014; Grossoehme, 2014). The research strategy involved sending out a survey to various organisations in the metals industry in South Africa and analysing the data using regression statistics. This is typical for an explanatory research design (Bambale, 2014). The study by Rothaermel and Hess (2007) also used explanatory research design to determine the relationship between variables. Explanatory research attempts to find the causal connections between variables (Bambale, 2014).

The secondary data received from the HSRC were collected using a cross-sectional research design for a period of three years (2014 to 2016). This filtered secondary data for organisations in the metals industry in South Africa was only given to the researcher by HSRC and was not published or made available to anyone else before. Only curated data for all 41 535 organisations, across all sectors in South Africa, was made public or published before. Therefore, no work was previously done on this selected set of data. The primary data, which were received from the survey sent to the respondents, also used a cross-sectional research design and the period was three years (2019 to 2021). Cross-sectional design forms part of descriptive research design which seeks to either provide a snapshot of a situation as it occurs or identifies variables of a particular phenomenon based on their observation or examine relationships between variables (Creswell et al., 2003; Williams, 2007). The disadvantage of a cross-sectional study is that the timing of the snapshot is not guaranteed to be applicable over a different time period and any assertions about causality should be made cautiously (Pezeshkan et al., 2016). The three-year duration used in this study was determined based on the period length of the South African Business Innovation Survey 2014-2016 which was received with permission from the Human Sciences Research Council. The European Community Innovation Survey (CIS) survey of 2014 also uses a three year period in order to study innovation in Europe (Eurostat, 2020).

3.3 Data collection methods

This work starts by showing that process/product innovation exists in the South African metals industry using data that were received from the HSRC. Permission to use this data was granted by the HSRC. However, the data were already filtered by the HSRC in order to separate the metal producing/processing organisations from the rest of the firms. The names of the organisations were anonymised by the HSRC prior to giving the data to the researcher due to confidentiality agreements.

The next step was to investigate the sub-question which aims to understand the source of innovation ideas in the organisation within the South African metals industry. Non-managerial employees work closer to the technologies used in production processes and have a deeper understanding of internal products and processes, based on amount of time spent exposed to these. Therefore, understanding the employee experience factors that influence innovation is warranted. The work by Patti et al. (2004) showed that managers and employees had different perspectives on the influence of quality management systems on their organisation culture and performance. Other authors have also differentiated between employees and managers perspectives on drivers for productivity (Hasson et al., 2013; Patti et al., 2004; Sánchez-Vidal et al., 2012). However, this juxtaposition is warranted in this work as the two types of employees have different responsibilities within the organisations when it comes to innovation and idea generation. The managers are responsible and accountable for innovation in their firms since they develop strategies and provide a conducive environment for employees to be innovative (Kremer et al., 2019). The supportive role of the managers is crucial for employees to be innovative, and this was also confirmed by Ramus (2002) who observed that the supportive supervisory behaviours of the managers can increase the probability that employees generate innovative ideas. On the other hand, employees (nonmanagers) volunteer their innovative ideas to the organisations.

This work proposes that the workforce dynamic capabilities also influence innovation at firm level. Data were collected using a structured survey with close ended questions where respondents were asked to select answers from a predefined range of possible responses (Kalof et al., 2008). A structured survey carries the advantage that responses can be compared across respondents (Kalof et al., 2008). These organisations were randomly selected by the researcher based on personal knowledge and information gathered from various internet sources about organisations in the South African metals industry, since organisation names could not be obtained from HSRC because of confidentiality agreements signed.

A case study was conducted by interviewing, using semi-structured questions, two employees from three selected organisations to get an in-depth understanding of their innovation activities. This is the qualitative part of the current research. The organisations were selected based on relationships built with the researcher and due to the following approvals that were obtained:

- approval to conduct the studies by the organisations;
- get access to the interviewees;
- approved ethics clearance by the University of the Witwatersrand (Wits) Ethics Committee to conduct the studies in these selected organisations.

Further engagements were conducted with technical experts in the metals industry using conferences, exhibitions and trade show. These were informal conversations to understand their take on the topic of this thesis.

3.4 Population and sample

3.4.1 *Population*

The target population for this study consisted of organisations that are producing or processing metals in South Africa. These organisations fall under “Basic iron and steel, non-ferrous metal products, metal products and machinery” in the manufacturing sector data from statistics South Africa report (Statistics South Africa, 2019). Data for the quantitative study was received from two sources; namely the Human Sciences Research Council and from primary interviews with selected organisations in the South African metals industry. The population for the qualitative study were the three organisations (named Company A, Company B and Company C) where interviews were held with two employees per organisation.

3.4.2 *Sample and sampling method*

Data was received from the HSRC which had conducted research on innovation in South Africa. The HSRC filtered this data, prior to making it available to the researcher, in order to separate the metal producing/processing organisations from the rest of the firms that were surveyed. Therefore, the complete samples received from HSRC was 33 organisations.

For the primary research used to determine the source of innovation (manager/employees), a survey was sent to selective organisations in the South African metals industry. These organisations were selected based on knowledge by the researcher and information gathered from various internet sources about organisations in the South African metals industry. A probability sampling method was used where organisations which are selected for the sample were known (Rahman et al., 2022). This sampling method permits every organisation in the study to have an equal chance of being selected (Etikan & Bala, 2017; Rahman et al., 2022; Stratton, 2021). For the sample size, 36 organisations were selected. This sample covered a range of organisations who manufacturing and process metals, i.e. steel manufacturers and processors, aluminium and other light metal manufactures and processors, precious metal processing, foundries, packaging, tool manufacturing, valve manufacturing, etc. These organisations fall under the "basic iron and steel, non-ferrous metals products, metals products and machinery" division in the report by Statistics South Africa (Statistics South Africa, 2019). The samples used in this study was representative of this division. The sample was representative of the population in terms of the economic activities of the selected organisations.

The type of probability sampling that was used in this study for the quantitative method is the stratified sampling (Neyman, 1934). Stratified sampling allows for the population to be divided into more homogeneous subgroups which gives more reliable and detailed information about the sample (Etikan & Bala, 2017). The organisations were stratified based on their turnover and number of employees because large firms have more financial power to conduct process and/or product innovations compared to smaller firms. A survey was sent to sample organisations using Qualtrics (Lee, 2015). Responses were downloaded by the researcher and analysed using regression statistics.

Two employees from each organisation (Company A, Company B, and Company C) that were interviewed for this study served as the sample for the qualitative research. According to Carmichael and Cunningham (2017), selection of candidates is the first key step for interviews. The candidates for the interviews were not selected by the researcher but were nominated by their respective organisations. Therefore, the suitability of the candidates for these interviews was determined by the organisation where the case study was conducted, based on knowledge of their employees (Carmichael & Cunningham, 2017). The employees nominated by each organisation were one manager and one non-manager who were involved with research and development in their respective organisations. The choice of one manager and one employee was done for pragmatic reasons by the organisations. The managers were in senior positions (decision makers) and the non-managers were involved with research, development and innovation activities within their organisations and had experience in bringing innovative products or processes in their organisations in the past four years. The reason for selecting one manager and one nonmanager employee were based on the request by the researcher since the aim was to understand the perspectives of both these groups. However, the researcher had further open engagements with industry experts during various manufacturing exhibitions and conferences attended, such as the South African Institute of Mining and Metallurgy Conference 2023, Mining Indaba 2024, Mining Equipment Manufacturers of South Africa 2024, Southern African Steel Summit 2023, etc. The researcher also engaged experts from the Council for Scientific and Industrial Research (CSIR), which is a South African scientific research and development organisation; and The Department of Trade, Industry and Competition (**the dtic**), which is a department of the South African government responsible for commercial and industrial policy, as well as the development of program to support the industry.

3.5 The research instrument

A research data collection instrument is a tool designed for gathering relevant data required in a study, that can be analysed to provide credible answers to the established research questions (Bryman, 2012). The data collection instruments used in this research study were a self-administered questionnaire (quantitative) and interviews (qualitative). This work used data already collected by the HSRC and a questionnaire was also sent to selected organisations to expand on the data that was collected by the HSRC. The respondents who provided the data are representatives from various organisations within the South African business sector, including the manufacturing sector (Human Sciences Research Council, 2008). The data received from the HSRC was already filtered to reflect only organisations within the metals industry and this data was used to determine if there is product/process innovation in the South African metals industry.

The South African innovation national survey 2008, which was developed by the HSRC, is based on the European Union (EU)'s Community Innovation Survey (CSI) (Eurostat, 2020; Human Sciences Research Council, 2008). The CIS collects data about innovation activities from enterprises which form part of the EU science and technology statistics (Eurostat, 2020). The surveys are carried out every two years by EU member states and are also used by other countries to compare their innovation results (De Jong & Vermeulen, 2006; Eurostat, 2020; Frenz & Ietto-Gillies, 2009). A copy of the 2014 community innovation survey is attached in LIST OF APPENDECES

APPENDIX A: THE COMMUNITY INNOVATION SURVEY 2014 (Eurostat, 2020). This was the latest version that was available for downloading from the Eurostat website at the time of this study[1]. The CIS is designed to provide information on the innovativeness of sectors by type of enterprises, on the different types of innovation and on various aspects of the development of an innovation, such as objectives, sources of information, public funding or expenditure. The methodology recommendations for the community innovation survey are attached in APPENDIX B: THE COMMUNITY INNOVATION SURVEY 2016 METHODOLOGICAL RECOMMENDATIONS. The South African Business Innovation Survey 2014-2016 was adapted from the CSI survey and is attached in APPENDIX C: SOUTH AFRICAN BUSINESS INNOVATION SURVEY 2014-2016. The data was collected by the HSRC in the period of 2014 to 2016 and was made available by HSRC for this research purposes.

A questionnaire was sent via Qualtrics to select organisations within the South African metals industry in order to understand the source of innovation ideas (manager vs. workforce). This work is conducted to provide answers to the first research questions (who generates more innovation ideas between employees and managers in the South African metals industry?) and the second research question (what is the relationship between employee experience factors

[1] https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/bfcf3592-83a3-4066-ab70-f9a5cf492253

(qualification, tenure and demographic background attributes) that make-up the dynamic workforce capabilities and innovation at firm level?). The participants to the survey were sent a Participant Information Sheet for a survey which is attached in APPENDIX D: PARTICIPANT INFORMATION SHEET FOR A SURVEY. This is a cover letter that was sent with the survey to the respondents explaining what the research is about, what their rights are, and what was done with the data after it had been collected. A copy of the questionnaire is available in APPENDIX E: RESEARCH QUESTIONNAIRE. The questions asked do not solicit information about the respondent, but the respondent represents the organisation. Therefore, the important information required is about the organisation, the demographic information of the respondent is not crucial. The survey aims to first gather information about the organisation such as turnover and number of employees. This was used to group the firms into more homogeneous samples. Once innovation by the workers not management has been established, the next step is to determine the dynamic workforce capabilities that led to this innovation. Lastly, regression analysis was used to determine relationships between the variables. A summarised copy of the survey is available in APPENDIX F: SUMMARY OF THE RESEARCH QUESTIONNAIRE.

A case study was conducted with three organisations to validate the quantitative results. An anonymised copy of the request for permission to conduct interviews letter is shown in APPENDIX G: ANONYMISED COPY OF THE PERMISSION TO CONDUCT RESEARCH AT A COMPANY

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

University of the Witwatersrand,
Graduate School of Business Administration
2 St David's Place,
Parktown, Johannesburg
2050

Name of Representative at Company A
Address: Company A

June 2021

Dear Sir/Madam,

<u>Re: Permission to conduct research at Company A</u>

My name is Luyolo Mabhali and I am studying for a doctorate degree in the Graduate School of Business Administration at the University of the Witwatersrand, Johannesburg. I am seeking permission to do research at Company A.

I am conducting research on the effect of dynamic workforce capabilities on firm level innovation in the South African metals industry, under the supervision of Associate Professor Mjumo Mzyece. The aim of this research project is to expand the dynamic capability theory by showing a relationship between employee experience factors, which make-up the dynamic workforce capabilities, and firm level innovation in the South African metals industry. The proposed employee experience factors that will be considered in this work are qualification, tenure and demographic background attributes.

There is some work that has been done in terms of dynamic managerial capabilities, but less on the employee capability side. Also, the influence of the workforce on innovation was also studied by Rothaermel and Hess (2007) but the focus was on highly skilled employees such as scientists with advanced degrees. However, the majority of employees in the manufacturing sector in the Republic of South Africa do not fall under this category (Makgetla, 2014). This work aims to address this gap by proposing an expanded dynamic capabilities model that includes workforce capabilities. Your organisation is chosen as one of the innovative organisations within the metals industry in South Africa.

I would like to invite two individuals from your organisation to participate in this study. These individuals should be a manager (with direct reports) who has developed process or product innovation (new/improved) in the past five years and an employee (with no direct reports) who has developed process or product innovation (new/improved) in the past five years. The focus will be on product and process innovation that has been successfully implemented within the organisation’s operation or in the market. If these individuals agree, they will be interviewed and requested to answer questions about firm level innovation in South Africa. This will take approximately one hour and the interviews will be conducted online using MS Teams. Their responses will be audio recorded using a digital device. This recording will be stored in a password protected computer and only the researcher will have access to it. The data will be deleted after five years.

Participants will be asked to give their written consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous in the final thesis and all publications. Individual privacy will be maintained in all published and written data resulting from the study.

The results will be part of the doctorate thesis and will also be used for conference and other publications. If you wish to receive a summary of this thesis/conference/ journal publications, I will be happy to send it to you.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

All research data will be stored in a password protected computer and will be kept for five years, after which it will be destroyed.

I therefore request permission in writing to conduct my research at your organisation. The permission letter should be on your organisation's headed paper, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,
Luyolo Mabhali

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. Permission was received from all three organisations (Company A, Company B and Company C). These organisations identified two (2) employees within the operations who would participate in the interview process. Both employees from each organisation were sent a consent form, which they signed before they could be interviewed. A copy of the consent form is shown in APPENDIX H: CONSENT FORM FOR INTERVIEWS. Ethics clearance was approved by the Human Research Ethic Committee (Non-Medical) of the University of the Witwatersrand and a copy can be found in APPENDIX I: COPY OF ETHICS CLEARANCE.

Interviews explore experiences of individuals through a series of questions and answers (Grossoehme, 2014). The interviews in this study aided in getting more insight about the innovation that occurred in the selected organisations. Interviews can be structured interviews, in which an interview guide is used with pre-determined questions from which no deviation is permitted by the interviewer, or semi-structured interviews, in which an interview guide is used with pre-determined questions and potential follow-up questions (Grossoehme, 2014).

This work used semi-structured interviews and the interview questions were used to guide the conversation with the respondents. A set of questions were compiled by the researcher to guide the interview. The advantage of semi-structured interview questions is that it allows for in-depth probing while permitting the interviewer to keep the interview within the parameters traced out by the aim of the study (Alshenqeeti, 2014). The set of questions can be found in APPENDIX J: SET OF QUESTIONS USED FOR THE SEMI-STRUCTURED INTERVIEWS of this study. The presence of the researcher during the interviews meant that mutual understanding can be ensured and the researcher could rephrase or simplify questions that were not understood by interviewees (Alshenqeeti, 2014).

3.6 Procedure for data collection

In order to show that there is product/process innovation in the South African metals industry, secondary data was obtained from the HSRC. This data was collected by the HSRC using the questionnaire in APPENDIX C: SOUTH AFRICAN BUSINESS INNOVATION SURVEY 2014-2016. The data was processed by the HSRC in order to separate the organisations involved with metal production/processing from the rest of the businesses, before it was sent to the researcher. A separate questionnaire was then sent by the researcher to selected organisations in order to obtain primary data about the origins of the innovation ideas. This survey was sent using Qualtrics, an online cloud-based survey tool (Lee, 2015). The responses were collected and analysed using various statistical tools. The advantage of a questionnaire is that all respondents are asked the same set of questions and a large number of respondents can be reached in a more economical manner. However, misunderstanding or misinterpretation of the questions by the respondents is a valid disadvantage (Peytchev et al., 2010). To overcome this, a pilot study was conducted with five organisations to test the integrity of the questionnaire. These five organisations also became part of the actual larger 36 organisation sample used for this study.

A qualitative study was also conducted by interviewing two personnel from three different organisations to gain in-depth understanding of their innovation activities. The interviews were done using semi-structured one-on-one interactions in Microsoft Teams and these were recorded with permission from the interviewees. Cope (2010) recommended the use of a cellular phone as an audio recording device. However, the use of Microsoft Teams software had grown during the course of this study partly because of the non-contact legislative requirements to the impact of the COVID-19 pandemic (Adu et al., 2022; Dhanpat et al., 2022; Tran, 2021). The discovery and the spread of COVID-19 in the absence of a cure led to governments taking drastic measures, including the lockdown of large parts of society and social distancing resulting in behavioural changes (Thukral, 2021). This resulted in increased usage of online meeting platforms such as Microsoft teams (Adu et al., 2022; Dhanpat et al., 2022; Tran, 2021). The advantage of using Microsoft Teams is that it has a recording and transcription function (O'Sullivan et al., 2021). The recording function allows the researcher to review the data several times to help produce an accurate interview report. The data was then downloaded to a password protected computer.

3.7 Data analysis and interpretation

All data collected were analysed using regression statistics. Regression analysis is used to determine the relationship between a dependent variable and one or more independent variables (Kavitha et al., 2016; Lee, 2015). In this work, it was used to determine the relationship between employee experience variables (qualification, tenure, demographic background) and innovation. The statistics software that was used is the IBM SPSS statistics software.

Transcribing and interpretation of the recorded data was done by the researcher and no professional bodies/individuals were hired for this purpose. The main reasons were that the respondents had signed consent forms which prohibit the researcher from making the raw data available to other parties and the researcher was the one most familiar with the topic of this research. Coding of data transcripts was done through identifying themes across qualitative data by reading the transcripts until the researcher has a clear idea about the categories and themes that emerged (Cope, 2010; Deterding & Waters, 2021). Coding is about breaking data into smaller pieces and then recombining those pieces in order to identify and explore relationships and discover new connections (Coleman, 2022; Cope, 2010). For categorisation, data were examined and grouped based on similarities with each category assigned a code. For thematic coding, the data were assigned codes based on instances related to themes that are important to the research project such as source of innovation (managers/employees), as well as employee experience factors such as qualification, tenure and demographic background attributes (Cope, 2010). Other themes that emerged during interviews, that were not originally thought of by the researcher, were also noted. No analysis software was used in the qualitative component of this research.

3.8 Limitations of the study

The limitation of this study is that it is dependent on the honesty and accuracy of the answers given by the respondents in both the HSRC survey and the primary survey that was sent out. This work uses a survey with questions and hence may only provide insight based on what is asked. Respondents may not offer more insights than what the researcher has asked which makes the type of questions asked by the researcher a crucial element of this study. However, the qualitative section with three organisations provided an opportunity to limited organisations to elaborate on their responses. Though the sample size for this qualitative work was small, it was sufficient to support the quantitative work which had a sample of 36 organisations. The candidates interviewed were subject matter experts in their respective organisations and had implemented innovative solutions.

The purpose of the qualitative work was to give the respondents an opportunity to unpack the responses from the quantitative survey and this was achieved with this sample size. The findings in this work are only limited to the South African metals industry and might not be applicable in other industries.

3.9 Validity and reliability

Validity measures the ability of the instrument to measure what it was intended to measure (Coleman, 2022; Ghauri et al., 2020; Golafshani, 2003). It tests whether or not the final product truly portrays what it claims to portray or the degree to which a study reflects the specific concepts it aims to investigate (Alshenqeeti, 2014; Grossoehme, 2014). Reliability refers to the extent to which the measurement procedure results are consistent over time, and an accurate representation of the total population under study (Berry, 2002; Golafshani, 2003). It tests if the results are repeatable to see if the results of a study can be reproduced under a similar methodology (Grossoehme, 2014; Heale & Twycross, 2015; Noble & Smith, 2015). The validity and reliability of the data for this study is discussed briefly in the sub-sections below.

3.9.1 *External validity*

External validity is concerned with appropriateness of generalising the outcomes of the study to the rest of the population (Lusk et al., 2006). The results of this study should be studied in context of the metals industry within South Africa. Even within this industry, if different organisations are sampled, the results may differ.

For the interviews, consideration should be given to whether findings can be applied to other contexts, settings or groups (Noble & Smith, 2015).

3.9.2 *Internal validity*

Internal validity in this context refers to the ability of the research instrument to measure the independent variables in this study (Alshenqeeti, 2014; Anderson, 2017; Berry, 2002; Heale & Twycross, 2015). It is the extent to which an investigation is actually measuring what it is supposed to measure (Alshenqeeti, 2014). The questionnaire measures firm level innovation in the South African metals industry and employee experience factors using multi scale items to improve the robustness of the constructs. A questionnaire was validated using a pilot group of five organisations to determine if the questionnaire measured what it was intended to and to also determine if the understanding of the questions by the respondents was similar to that intended by the researcher. To test if respondents were reading the questions before answering, some of the Likert scale responses were arranged with the most positive answer (strongly agree) placed as the furthest answer to the left while in other questions it was the furthest answer to the right.

For interviews, the researcher acknowledges that the respondents for the interviews expressed their perspectives which may introduce potential bias especially since they were responding to this study in the context of their organisation (Coleman, 2022). In this part of the study, consistency is considered which relates to the ‘trustworthiness’ by which the methods have been undertaken and is dependent on the researcher maintaining a ’decision-trail’; i.e. the researcher’s decisions are clear and transparent (Noble & Smith, 2015). Therefore, interviewing two individuals in each organisation was crucial in validating the results obtained. The interviewees were also afforded the opportunity to review findings and give feedback as recommended in the study by Grossoehme (2014). This was done so that the interviewees could gauge if they see themselves in the words or conceptual model that is presented and to determine if there were any new insight from the interviews.

3.9.3 *Reliability*

Reliability measures the robustness and accuracy of the questionnaire that was used in the survey (Golafshani, 2003). It measures the extent to which a research instrument consistently has the same results if it is used in the same situation on repeated occasions (Lee, 2015). The coefficient Alpha, developed by Cronbach (1951), is the most commonly used index for estimating the reliability of measurement instruments such as scales, multiple item tests and questionnaires (Gwena & Chinyamurindi, 2018). The Cronbach's Alpha measures how accurately the respondents understand the questions in the questionnaire. A Cronbach's Alpha score greater than 0.65 shows high internal reliability and that the items in the scale are closely related (Lee, 2015; Shrestha, 2021). The reliability of the multiscale variables such as firm level innovation was determined by a statistical analysis of the data to determine the Cronbach's Alpha coefficient.

In qualitative research, reliability is sometimes referred to as dependability or consistency (Alshenqeeti, 2014; Coleman, 2022). Demonstrating reliability within a qualitative study is challenging because, unlike quantitative research, there are no available statistical tests for this purpose (Coleman, 2022). Conducting semi-structured interviews allows for greater control and uniformity within the interview process as it imposes structure to the questions asked. However, these interviews are prone to bias and can be unreliable, particularly when the researcher wishes to draw comparisons between data sets. To avoid this bias, the researcher had to perform the following actions as recommended by Alshenqeeti (2014):

1. Avoided asking leading questions during the interviews;
2. Avoided depending on recording but also took notes;
3. Avoided not giving the interviewee a chance to sum up and clarify the points they have made.

3.9.4 *Objectivity*

Objectivity is the extent to which research work is undistorted by the biases of the researcher (Yilmaz, 2013). The quantitative data for this research were collected using the survey which was analysed using statistics software and hence the perspective of the researcher was limited. However, semi-structured interviews were used for the qualitative data and the researcher was not a disinterested outsider who merely observed without interacting with participants but was affected and also affected the data (Grossoehme, 2014).

3.10 Ethical considerations

This research did not conduct any physical experiments on humans or animals. Ethic clearance was also received from the Wits Human Ethics Committee (R14/49 Mabhali). The Wits clearance certificate protocol number is H21/05/21. A copy of this clearance certificate is available in APPENDIX I: COPY OF ETHICS CLEARANCE. A confidentiality agreement was signed with all the respondents, and this was sent as part of the survey.

3.10.1 *Consent by respondents*

For the quantitative study, the consent form was sent to the respondents together with the online questionnaire using Qualtrics. Individuals in organisations cannot be contacted directly as data of interest are about the organisation and not themselves (respondents). They completed the survey as representatives for their organisations. Respondents were informed that by starting the questionnaire, they give consent that the information can be used in this study. However, respondents had an option of not completing the questionnaire should they not give consent.

3.10.1 *Harm or stress to the respondents*

The respondents were not harmed in any way during this study. There was no physical contact between the researcher and the respondents. The information solicited was not of personal nature and therefore did not pose any threat to the respondents or their respective organisations.

3.10.2 *Anonymity and protection of data*

Participants were informed in the survey that the information collected was to be treated as anonymous, and personal data were not requested. This ensured that only participants who gave consent could continue with the survey. No personal data of the respondents were requested and only information about their organisations was used. There was no mention of the respondents' names or the names of their organisations in the final report and only aggregate information on the sector (metals industry) was used. The primary data collected were seen by the researcher only and was only used in this study. The data were kept in a password protected computer and will be deleted after two years of completion of this study.

The consistency matrix used to align research questions, hypothesis, data collection, and data analysis is shown in Table 5 below. This consistency matrix only shows the quantitative part of this research. All the research questions were supported by the qualitative research and the semi-structured interview questions can be obtained in APPENDIX J: SET OF QUESTIONS USED FOR THE SEMI-STRUCTURED INTERVIEWS.

3.11 Conclusion of the research methodology

The research methodology for this study was introduced and justified in this chapter. This work used a mixed research strategy which combines quantitative and qualitative research. This research strategy was selected as it encourages researchers to use multiple approaches to collecting and analysing data within a single study, recognising the limitations of using a single method (Migiro & Magangi, 2011). It used quantitative research to understand the relationship between variables and interviews (qualitative research) to provide the respondents with an opportunity to explain and expand on the results achieved by the quantitative surveys. Two sets of data were used to show that the South African metals industry is innovative. These are the primary data which was collected by HSRC for innovative ideas implemented between 2014 and 2016), and the primary data which were received from the survey sent to the respondents about innovative ideas that were generated and implemented between 2019 to 2021. Semi-structured interviews were conducted with two employees from three organisations in order to expand and enrich the information received from the surveys. These interviews were conducted on-line using Microsoft Teams. Ethics clearance was also received from the Wits Human Ethics Committee (R14/49 Mabhali) and consent forms were signed for participation in the primary survey and also with all participants for the interviews. The following chapter presents the results from the surveys and interviews.

Table 5: Consistency matrix: research questions, hypothesis, data collection and data analysis

RQ #	State Research Question	Hyp #	State Hypothesis	Data collection detail	Data analysis method
1	Is there process/product innovation in the South African Metals Industry?	1A	Process/product innovation exists in the South African metals industry	Data were obtained from the HSRC which can be obtained in APPENDIX K: DATA RECEIVED FROM HSRC	Descriptive statistics
1	Who generates more innovation ideas between employees and managers in the South African metals industry?	1B	There is a significant proportion of innovation ideas that are generated by employees compared to managers in the South African metals industry	Quantitative study using the questionnaire in APPENDIX E: RESEARCH QUESTIONNAIRE	Descriptive statistics and supported by qualitative interviews
2	What is the relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry?	2A	There is a positive relationship between employee education level and innovation at firm level in the South African metals industry	Quantitative study using the questionnaire in APPENDIX E: RESEARCH QUESTIONNAIRE	Correlation and regression statistics
2	What is the relationship between the dynamic	2B	There is a positive relationship between employee tenure and	Quantitative study using the questionnaire in	Correlation and regression statistics

RQ #	State Research Question	Hyp #	State Hypothesis	Data collection detail	Data analysis method
	workforce capabilities and firm level innovation in the South African metals industry?		innovation at firm level in the South African metals industry	APPENDIX E: RESEARCH QUESTIONNAIRE	
2	What is the relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry?	2C	There is a positive relationship between employee demographic background attributes and innovation at firm level in the South African metals industry	Quantitative study using the questionnaire in APPENDIX E: RESEARCH QUESTIONNAIRE	Correlation and regression statistics
2	What is the relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry?	2D	There is a positive relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry	Quantitative study using the questionnaire in APPENDIX E: RESEARCH QUESTIONNAIRE Qualitative study by interviewing two employees from three different organisations.	Correlation and regression statistics

CHAPTER 4. PRESENTATION OF RESULTS AND FINDINGS

4.1 Introduction

This chapter presents the results obtained from this research study. It starts by presenting the results on the state of innovation (product/process) in the South African metals industry which was determined using the data obtained from the HSRC, this is followed by results received from the survey on the source of innovation ideas (manager vs employees) in the same industry, then presents results on the relationship between employee factors (qualification, tenure and demographic background attributes) and firm level innovation in the South African metals industry, lastly findings from the interviews are presented. The quantitative and qualitative results are presented separately.

4.2 Quantitative results pertaining to Hypothesis 1

The first hypothesis is that more innovation ideas are generated by non-managerial employees compared to managers in the South African metals industry. This was tested by asking organisation about the source of innovative ideas that were generated in their companies between 2019 and 2021. However, to determine this, the study will start by showing that there is product/process innovation in this industry.

4.2.1 *Is the South African metals industry innovative?*

Hypothesis 1A states that process and product innovation exist at firm level for organisations in the South African metals industry. In order to determine if the South African metals industry is innovative, the researcher used data received from the HSRC and primary data received from a survey that was sent to the respondents. The first step was to analyse the data received from the HSRC. The questionnaire that was used by the HSRC to collect the data is shown in APPENDIX C: SOUTH AFRICAN BUSINESS INNOVATION SURVEY 2014-

2016. The data from the HSRC were filtered by the HSRC so that only relevant results for this study, which is those processing or manufacturing metals, were left before being shared with the researcher. A copy of this data is shown in APPENDIX K: DATA RECEIVED FROM HSRC.

According to the HSRC report, the total number of respondents to the 2014-2016 survey were from 41 535 organisations across of sectors in South Africa including ICT, Banking, Mining, etc. (Sithole et al., 2021). Only 33 of these organisations were part of the metals industry in South Africa and the data and results from the 33 organisations had not been published and was only given to the researcher (anonymised) on request. Therefore, analysis of the data was conducted for the first time by the researcher and no prior work was done on it. From the data received from the HSRC, 25 of the 33 organisations in the metals industry implemented product or process innovation during the period between 2014 and 2016. This accounted for 75.8% of the overall organisations in the South African metals industry that participated in the study, which is almost ¾ of the sample. This is close to the results of 69.9% which were observed in the study by Sithole et al. (2021), using a complete set of results from the HSRC data. Of these 25 organisations who implemented product or process innovation in the metals industry, 17 developed the innovation in South Africa which constitutes 68%. The key variables of interest in this section are testing for the following:

1. Is the South African metals industry innovative?
2. Have organisations in this industry conducted product / process innovation in the period studies?
3. Where did this innovation originate from?
4. Was this innovation new to the market, industry, country or new to the world?
5. If the organisations surveyed have an intentional R&D strategy?
6. What is the R&D budget as a percentage of turnover?
7. What was the percentage increase in turnover due to the new or improved process or product that was introduced?
8. Is there a training budget and what is this training budget as a percentage of turnover?

9. Were there investments in new equipment?
10. Does the organisation have strategic partnerships or research collaborations with higher education institutes (tertiary institutes) or research councils?

The researcher conducted categorical frequency statistics using IMB SPSS statistics software on the data received from HSRC and the results are presented in Table 6 below. The results are similar to the ones discussed above as the following was observed:

1. There were 33 organisations in the South African metals industry which were sampled.
2. 75.8% of the organisations in the South African metals industry conducted product or process innovation between 2014 and 2016. This is slightly lower compared to the full set of data reported by Sithole et al. (2021) who showed that more than 82.8% of organisations in South Africa are involved in product or process innovation. The difference can be attributed to a smaller data set that was sampled for the metals industry.
3. Out of this 75.8%, 54.5% of the product or process innovations originated in South Africa and only 21.2% originated abroad. Originating abroad means the innovative products or processes were developed by organisations outside South Africa, but the South African company is also implementing this process or making these products.
4. 72.7% of the organisations conducted product innovation (brought new or improved products to market) of which 48.5% of this innovation originated in South Africa and 24.2% originated abroad. The complete dataset from the report by Sithole et al. (2021) showed that 48.2% of businesses in South Africa were involved in product innovation. The reduced results can be attributed to the fact that the study by Sithole et al. (2021) involved businesses in both the goods and services sector. When Moses et al. (2012) only isolated the manufacturing sector in South Africa, the percentage of organisations involved in product innovation increased to 59.8%. In terms of the origins of the product innovation, the trend observed within the metals industry is similar to the results observed by Moses et al.

(2012) as there was more local innovation as opposed to innovation which originated from abroad.

5. 48.5% of the organisations conducted process innovation (develop new or improved processes which they used within their operations) of which 30.3% originated from South Africa and 18.2% originated abroad. Some of the organisations that were sampled in the South African metals industry were involved in both product and process innovation. However, the study by Sithole et al. (2021) reported a lower number of 34.6% which can be explained by a larger dataset that involved organisations in various other sectors including manufacturers/suppliers of goods and services. When Moses et al. (2012) only isolated the manufacturing sector in South Africa, the percentage of organisations involved in process innovation remained low at 37.1%. In terms of the origins of the process innovation, the trend observed within the metals industry is similar to the results observed by Moses et al. (2012) as there was more local innovation as opposed to innovation which originated from abroad.

Table 6: Categorical frequency statistics

	Frequency	Percent	Valid Percent	Cumulative Percent
Product or Process Innovation				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	25	75.8	75.8	75.8
No	8	24.2	24.2	100.0
Total	33	100.0	100.0	
Origin of Product or Process Innovation				
	Frequency	Percent	Valid Percent	Cumulative Percent
RSA	18	54.5	54.5	54.5
Abroad	7	21.2	21.2	75.8
N/A	8	24.2	24.2	100.0
Total	33	100.0	100.0	
New or Improved Product				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	24	72.7	72.7	72.7
No	9	27.3	27.3	100.0
Total	33	100.0	100.0	
Origins of Innovative Product				
	Frequency	Percent	Valid Percent	Cumulative Percent
RSA	16	48.5	48.5	48.5
Abroad	8	24.2	24.2	72.7
N/A	9	27.3	27.3	100.0
Total	33	100.0	100.0	
New or Improved Process				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	16	48.5	48.5	48.5
No	17	51.5	51.5	100.0
Total	33	100.0	100.0	
Origin of Innovative Process				
	Frequency	Percent	Valid Percent	Cumulative Percent
RSA	10	30.3	30.3	30.3
Abroad	6	18.2	18.2	48.5
N/A	17	51.5	51.5	100.0
Total	33	100.0	100.0	

The data from HSRC also contained a breakdown of the product innovation in terms of the following:

1. New to the market
2. New to the company
3. New to the world
4. First only in South Africa but not new to the world
5. First within the metals industry in South Africa but not new to South Africa or the world

The breakdown of the product innovation is shown in Table 7. However, similar data for process innovation were not collected by the HSRC and hence cannot be analysed in this work. From the results in Table 7, the following could be observed:

1. 48.5% of the organisation stated that they introduced new or significantly improved products onto your market before their local competitors. These products may have already been available in other markets but not in South Africa.
2. 45.5% of the organisations stated that they introduced new or significantly improved products that were already available from their local competitors but new to the firm itself.
3. 24.2% of the organisations stated that they introduced products which were entirely new to the world. These are innovative products that were developed by the companies R&D team and did not exist anywhere else in the world before. The Global Innovation Index ranking for South Africa is 50 amongst the 132 economies rated, and 56th in terms of high-tech manufacturing (World Intellectual Property Organization, 2023). Therefore, the results that 24% of the products are new in the world is probable.
4. 21.2% of the organisations stated that they introduced products that were first in South Africa but not first in the world.
5. 18.2% of the organisations stated that they introduced products that were first in their industry within South Africa but not new to South Africa or to the world.

Table 7: Breakdown of product innovation in the South African metals industry

New to Market				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	16	48.5	48.5	48.5
No	8	24.2	24.2	72.7
N/A	9	27.3	27.3	100.0
Total	33	100.0	100.0	
New to Company				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	15	45.5	45.5	45.5
No	9	27.3	27.3	72.7
N/A	9	27.3	27.3	100.0
Total	33	100.0	100.0	
New to world				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	8	24.2	24.2	24.2
No	12	36.4	36.4	60.6
N/A	9	27.3	27.3	87.9
Don’t Know	4	12.1	12.1	100.0
Total	33	100.0	100.0	
New in SA				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	7	21.2	21.2	21.2
No	11	33.3	33.3	54.5
N/A	9	27.3	27.3	81.8
Don’t Know	6	18.2	18.2	100.0
Total	33	100.0	100.0	
New to industry				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	6	18.2	18.2	18.2
No	12	36.4	36.4	54.5
N/A	9	27.3	27.3	81.8
Don’t Know	6	18.2	18.2	100.0
Total	33	100.0	100.0	

The data for the metals industry which were received from the HSRC was not further stratified into turnover and number of employees since the results obtained were sufficient to show that there is product/process innovation within the South African metals industry as shown by 75.8% of the organisations (25 respondents) which confirmed their involvement in product/process innovation for the period of this study.

In the second step to determine if the South African metals industry is innovative, the researcher used the data received from the primary survey which was sent to the respondents using Qualtrics. The responded were asked to answer set of question based on innovative ideas implemented in their organisations between 2019 and 2021. The intention was to determine if the outcomes had changed from the innovative ideas implemented between 2014-2016 in the study by HSRC due to the impact of the coronavirus disease 2019 (COVID-19) pandemic (Mazzucato & Kattel, 2020). This primary survey can be seen in APPENDIX E: RESEARCH QUESTIONNAIRE. A total of 36 responses were received from the survey and responses to the question “Was your organisation involved in any product or process innovation activities between 2019 and 2021?” are summarised in Table 8 below.

From Table 8, it can be observed that 91.7% respondents to the study stated that their organisations were involved in product/process innovation between 2019 and 2021. These findings are slightly higher than those reported in this study for the data received from HSRC (75.8) and also higher compared to the results from the work by Sithole et al. (2021) who showed that 82.8% of organisations in South Africa are involved in product or process innovation. The difference can be attributed to the different data sets (number of respondents and actual organisations that responded to these two surveys). However, all these findings show that there is product/process innovation in the South African metals industry and therefore the first hypothesis that more innovation ideas are generated by employees compared to managers in the South African metals industry, can be investigated.

Table 8: Results from primary survey on state of innovation in the South African metals industry between 2019 and 2021

Innovation Implemented between 2019 and 2021				
	Frequency	Percent	Valid Percent	Cumulative Percent
No	3	8.3	8.3	8.3
Yes	33	91.7	91.7	100.0
Total	36	100.0	100.0	

The data from the primary survey were further analysed using excel to determine if there was a major shift in company turnover and headcount between the 2019, 2020 and 2021 data. The results can be observed in APPENDIX M: RESULTS ON TURNOVER AND HEADCOUNT PER ORGANISATION RECEIVED FROM THE PRIMARY SURVEY. From the calculated median and averages in Appendix M, it was observed that there was no major shift in turnover and headcount for all organisations in this study between the recorded periods. Therefore, the average turnover and headcounts were used for further analysis in the study. Descriptive statistics were conducted on the turnover and headcount data to determine the range for these variables and the results are shown in Table 9 below. Descriptive statistics are used to summarise a set of observations, in order to communicate the largest amount of information as simply as possible (Mishra et al., 2019). The mean is an average score for the sample and it is used to determine the centrality of the sample while standard deviation determines the spread of the data away from the average within which two thirds (66%) of the responses would lie (Lee, 2015).

Table 9: Results of the descriptive statistics on turnover and headcount.

	N	Minimum	Maximum	Mean	Std. Deviation
Average Turnover (R'M)	36	4	7667	790.19	1612.419
Average Headcount	36	11	4333	762.92	1209.401
Valid N (listwise)	36				

From the Table 9 above, it can be observed that the range for average turnover (R 4 million to R 7667 million) and headcount (11 – 4 333) was wide. Therefore, the data needed to be further stratified. According to Ayandibu and Houghton

(2017), and Olufunso et al. (2010), the South African manufacturing sector can be stratified into large, medium and small enterprises according to total number of employees, total annual turnover and total gross asset values as shown in Table 10 below.

Table 10: Definition of SMEs in the manufacturing sector in South Africa

Type of firm	Employees	Turnover	Gross asset value
Large	More than 200	Above R51 million	Above R19 million
Medium	51-200	Max R51 million	Max R19 million
Small	1-50	Max R13 million	Max R5 million

The results from the primary survey were also stratified based on their turnover and number of employees because large firms have more financial power to conduct process and/or product innovations compared to smaller firms. Larger firms generally have a greater variety of options than small firms in terms of resources, capabilities and power (Oerlemans et al., 2004; Sawers et al., 2008). However, small innovative firms are generally characterised as being flexible and having the ability to respond faster to changing needs and environments (Sawers et al., 2008). The total gross asset value was not investigated in this study since it was not a variable of interest as the focus was on process and product innovation. Stratified sampling allows for the population to be divided into more homogeneous subgroups which gives more reliable and detailed information about the sample (Etikan & Bala, 2017). The results of the stratified data are shown in Table 11 below. From this table, the majority of respondents (69.4%) worked for large companies, while SMEs made up 30.5% (19.4% classified as medium and 11.1% classified as small enterprises).

Table 11: Classification of respondents according to company size

Classification				
	Frequency	Percent	Valid Percent	Cumulative Percent
Large	25	69.4	69.4	69.4
Medium	7	19.4	19.4	88.9
Small	4	11.1	11.1	100.0
Total	36	100.0	100.0	

The medium and small enterprises were combined to create small and medium enterprise (SME) in line with the work by Ayandibu and Houghton (2017). Table 12 shows the results to the question “Was your organisation involved in any product or process innovation activities between 2019 and 2021?” for large enterprises and SMEs. The results show that 88% of large organisations were involved in innovation activities between 2019 and 2021, whereas for SMEs, all organisations tested claimed to have been involved in innovation during the period of interest in this study. To test the reliability of the results, the same question was asked differently. Table 13 shows results for when organisations were asked “Did your organisation introduce new or improved products or processes into the market (or inside the organisation's operations) between 2019 and 2021?”. The positive (“Yes”) and negative (“No”) responses were also swapped. The results are similar to those in Table 12, which shows that the respondents understood the questions and their responses are reliable. Only three organisations, which were all large, did not implement any innovation during the period on 2019-2022 in this study. These organisations were omitted from further analysis in this study since the topic of interest is on innovation.

Table 12: Results on implementation of innovation between large enterprises and SME

	Innovation Implemented		Percentage Yes	Total
	No	Yes		
Large	3	22	88%	25
SME	0	11	100%	11
Total	3	33	92%	36

Table 13: Results for testing if organisations implemented new or improved products or processes

	New or improved products or Processes		Percentage Yes	Total
	Yes	No		
Large	22	3	88%	25
SME	11	0	100%	11
Total	33	3	92%	36

Analysis was conducted to determine if the organisations in the South African metals industry have an intentional innovation strategy and the results are shown in Table 14. In this work, an intentional innovation strategy is defined as an innovation strategy that is embedded into the overall organisation strategy and is explicitly expressed as a strategic intent of the organisation. It involves the alignment of strategy with the capabilities of an organisation.

The results achieved are as follow:

1. 91% of large organisations stated that they have an intentional innovation strategy.
2. All SMEs who responded to the survey stated that they have an intentional innovation strategy.
3. In total, 94% of organisations in the South African metals industry who responded to the survey claimed that they have an intentional innovation strategy as part of their organisation strategy.

Based on the results above, it can be deduced that most organisations in the South African metals industry view innovation as critical, hence they have it as part of their strategy. A company's strategy relates to its future value creation plans and these plans should include innovation for financial sustainability (Sukhari & de Villiers, 2019). According to Sukhari and de Villiers (2019), the focus of strategy is on the precise formulation of a plan of action about the intentions of the company and achieving those goals taking into account the products it supplies, the customers it serves, the countries in which it operates, the activities it undertakes, as well as resource allocation. Only two organisations, which were both large, stated that they do not have innovation as an intentional company strategy.

Table 14: Results to determine if South African organisations have an intentional innovation strategy

	Intentional Innovation Strategy		Percentage Yes	Total
	Yes	No		
Large	20	2	91%	22
SME	11	0	100%	11
Total	31	2	94%	33

The actual R&D budget as a percentage of turnover varied between the organisations with large organisations investing more than SMEs as shown in Table 15. From this table, it can be observed that only larger organisations could invest more than 10% of their turnover into R&D budget. However, bulk of the organisations (large and SME) invested up to 10% of their turnover into the research and development budget. These findings are in line with the observations by Sawers et al. (2008) that large organisations have more resources and power as opposed to smaller organisations. It much be noted that both large firms and SMEs had a sizeable R&D budget as a percentage of their turnover. These results show that R&D should not be ignored within the metals industry and explains the R&D intensiveness of the new-to-the-world products, as well as local (as opposed to 'foreign') innovation. Respondents were also asked what the percentage increase in turnover was that the organisation received, due to the new or improved process or product that they introduced between 2019 and 2021, and the results are shown in Table 16. Most of the organisations gained between 1 and 10% increase in turnover due to new or improved products or processes that they introduced between 2019 and 2021. Therefore, there is an element of financial reward that most of these organisations achieved by implementing innovation which can be used as a measure of success of the innovative product/process in the market.

Table 15: Research and Development budget as a percentage of turnover

	R&D budget			Total
	1-5%	6-10%	>10%	
Large	11	6	5	22
SME	6	5	0	11
Total	17	11	5	33

Table 16: Percentage increase in turnover due to new or improved process or product

	Turnover increase due to implemented innovation				Total
	1-10%	11-20%	21-30%	>30%	
Large	15	3	2	2	22
SME	11	0	0	0	11
Total	26	3	2	2	33

Further training of employees is also crucial for innovation as it adds to the knowledge and capabilities of the workforce (Brandenburg et al., 2007). An organisational learning culture facilitates the employees' performance and increases their efficiency and effectiveness with innovation and creativity (Usman et al., 2011). The respondents were asked if their organisations had a training budget and all respondents (large organisations and SMEs) stated that this training budget existed in their organisations as shown in Table 17. Most of the organisations had a training budget in the 1-5% range of their company turnover, while no SME had a training budget above 5% of their turnover as shown in Table 18. According to the study by Ma et al. (2019) on 305 manufacturing firms across 13 economies across the world, both task-related training and employee participation improves firm level innovation in terms of the commercial success of new product development and the percentage of firm revenue from newly developed products.

Table 17: Responses to training budget within the South African metals industry

	Training Budget		
	Yes	No	Total
Large	22	0	22
SME	11	0	11
Total	33	0	33

Table 18: Training budget as a percentage of turnover

	Training Budget as percentage of turnover			
	1-5%	6-10%	>10%	Total
Large	17	3	2	22
SME	11	0	0	11
Total	28	3	2	33

According to Hall et al. (2009), investment in equipment enhances the likelihood of having both process and product innovation and has a positive impact on the productivity of organisations. The respondents were asked if their organisations invested in new equipment between 2019 and 2021 and the results are shown in

Table 19 below. From this table, it can be seen that most (88%) of the organisations invested in new equipment during the period of this study.

Table 19: Investment in new equipment

		Investment in new equipment		Percentage	Total
		Yes	No	Yes	
	Large	20	2	91%	22
	SME	9	2	82%	11
Total		29	4	88%	33

The respondents were asked if their organisations had research or innovation collaborations with higher education institutes (tertiary institutes) or research councils between 2019 and 2021, and the results are shown in Table 20 below. From this table, it can be observed that only 33% of the organisations formed strategic alliances or collaborations with higher education institutes or research councils.

Table 20: Strategic alliances or collaborations with Higher Education Institutes or Research Councils

		Alliance with HEIs and Research Councils		Percentage Yes	Total
		Yes	No		
	Large	10	12	45%	22
	SME	1	10	9%	11
Total		11	22	33%	33

4.2.2 *What is the proportion of innovation ideas generated by employees compared to managers in the South African metals industry?*

After understanding that the South African metals industry is innovative, the next step was to determine if managers or employees who are not managers generate most of these innovative ideas. This was done to address hypothesis 1B which states that more innovation ideas are generated by employees compared to managers in the South African metals industry. Respondents were asked to rate the following two statement on a Likert scale and the results are shown in Table 21 below.

1. Workforce creates the most innovative ideas in the South African metals industry compared to managers;
2. Managers creates the most innovative ideas in the South African metals industry compared to workforce.

Table 21: Results for source of innovation ideas in the South African metals industry

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
More ideas are created by workforce	1	1	3	9	22
More ideas are created by managers	0	17	8	9	2

The results from Table 21 were aggregated to combine the responses for “Strongly agree” and “Somewhat agree” to form the positive responses, while the “Strongly disagree” and “Somewhat disagree” responses were aggregate for the negative response. The results from this aggregation are shown in Table 22 below.

Table 22: Aggregated results for positive and negative responses

	Negative responses	Neutral responses	Positive responses
More ideas are created by workforce	2	3	31
More ideas are created by managers	17	8	11

From the results in Table 22, 31 of the 36 (86%) respondents answered positively to the statement that workforce creates the most innovative ideas in the South

African metals industry compared to managers. There were only 11 (30%) positive responses to the statement that managers create the most innovative ideas in the South African metals industry compared to workforce. The survey did not interrogate the type of innovative ideas that employee and managers generated, nor did it test for the financial impact of these ideas to the organisation. This can be tested for future work to evaluate the impact of each specific idea that was generated and implemented. Results of the descriptive statistics on the source of innovation ideas are shown in Table 23. From this table, it can be observed that the mean for "more innovation ideas come from workforce compared to managers" is higher (4.39) compared to the mean for "more innovation ideas come from managers compared to workforce", which is 2.89. Therefore, based on these means, the results show that there is significantly more innovative ideas generated by non-managerial employees compared to managers.

Table 23: Descriptive statistics on source of innovative ideas

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Workforce	36	1	5	4.39	.964
Manager	36	2	5	2.89	.979
Valid N (listwise)	36				

Respondents were asked to rate the following statement, using a Likert scale, for innovation ideas that were implemented in their organisations between 2019 and 2021:

1. Product idea came from workforce (excludes management with direct reports)
2. Product idea came from management (with direct reports)
3. Product idea came as joint effort from workforce and management
4. Process idea came from workforce (excludes management with direct reports)
5. Process idea came from management (with direct reports)
6. Process idea came as joint effort from workforce and management

The results for the origin (manager/workforce/joint) of the innovation ideas that were implemented in the organisations that responded to the survey are shown in Table 24 below.

Table 24: Results for source of innovative ideas implemented in organisations in the South African metals industry

Source of innovation	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Product idea came from workforce (excludes management with direct reports)	0	0	3	8	25
Product idea came from management (with direct reports)	10	14	12	0	0
Product idea came as joint effort from workforce and management	0	0	3	16	17
Process idea came from workforce (excludes management with direct reports)	0	0	3	18	15
Process idea came from management (with direct reports)	9	10	11	6	0
Process idea came as joint effort from workforce and management	0	0	7	16	13

The data for results in Table 24 contained categorical variables which are qualitative variables that have no numerical meaning, because a Likert scale was used. Categorical variables only represent membership in a group such as race, gender, etc.; and mathematical relations, such as equalities and inequalities, and operations, such as addition, subtraction, multiplication and division, cannot be used for such variables (Hernandez, 2021). Thus, in order to incorporate categorical variables in the analysis, either as factors or as response variables, they must be quantified in any way. One way of quantifying these categorical variables is to transform them into quantitative variables suitable for modelling or statistical analysis (Hernandez, 2021). In this work, arbitrary numbering (based on ranking) was used to assign numbers to the category variables as shown in Table 25 below. This was done to determine the arithmetic means of the responses.

Table 25: Numbers assigned to category variables

Response option	Number allocated
Not at all important	1
Slightly important	2
Moderately important	3
Very important	4
Extremely important	5

Comparison of means was conducted on the results and the outcomes are shown in Table 26 and Table 27. From the results in these tables, it can be observed that most innovation ideas are generated by employees (or joint efforts with manager) compared to management efforts. This can be deduced from the greater means (above 4) for ideas generated by employees (or joint effort with manager) compared to ideas generated by managers only (approx. 2). Therefore, more ideas are generated by employees (or joint efforts with managers) compared to managers only.

Table 26: Comparison of means for product innovation implemented in the respondent's organisations

Product innovation implemented in own organisation			
	Employees	Managers	Joint effort
Mean	4.61	2.06	4.39
N	36	36	36
Std. Deviation	.645	.791	.645

Table 27: Comparison of means for process innovation implemented in the respondent's organisations

Process innovation implemented in own organisation			
	Employees	Managers	Joint effort
Mean	4.33	2.39	4.17
N	36	36	36
Std. Deviation	.632	1.050	.737

Respondent were also asked the same questions, but they had to rate not innovation implemented in their organisation, but their general perspective of sources of innovation in the South African metals industry. The results are shown in Table 28 below.

Table 28: Results for source of innovative ideas in general for organisations in the South African metals industry

Source of innovation	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Product idea came from workforce (excludes management with direct reports)	0	3	2	9	22
Product idea came from management (with direct reports)	6	16	4	8	2
Product idea came as joint effort from workforce and management	6	7	6	10	7
Process idea came from workforce (excludes management with direct reports)	2	4	5	5	20
Process idea came from management (with direct reports)	4	20	4	6	2
Process idea came as joint effort from workforce and management	1	7	5	12	11

A comparison of means was conducted on the results of the respondents about their perspectives for origins of innovation in the South African metals industry and the results are shown in Table 29 and

Table 30. From the results in these tables, according to respondent's perspectives, more innovation ideas are generated by employees (or joint efforts with manager) compared to management efforts. This can be deduced from the greater means for ideas generated by employees, followed by ideas generated by joint efforts of employees and managers, and lower means for ideas generated by managers only.

Table 29: Source of product innovation ideas in the South African metals industry according to respondent's perspectives

Product innovation – idea generation in general			
	Employees	Managers	Joint effort
Mean	4.39	2.56	3.14
N	36	36	36
Std. Deviation	.934	1.182	1.397

Table 30: Source of process innovation ideas in the South African metals industry according to respondent's perspectives

Process innovation – idea generation in general			
	Employees	Managers	Joint effort
Mean	4.03	2.50	3.69
N	36	36	36
Std. Deviation	1.298	1.082	1.191

From the tables above, it was observed that the respondents believed that there is more innovation ideas generated by employees (or joint efforts between employees and managers) compared to ideas generated by managers only.

4.3 Qualitative findings pertaining to Hypothesis 1

The qualitative phase was conducted using semi-structured interview questions. Two employees (one manager with direct report and one non-manager) were interviewed from each of the three organisations (Company A, Company B and Company C). The first step was to determine through the interviews if there is product/process innovation in each organisation. This was to address hypothesis 1A which states that process and or product innovation exists at firm level for organisations in the South African metals industry. This was followed by questions on the first hypothesis that more innovation ideas are generated by employees compared to managers in the South African metals industry. This addressed hypothesis 1B which states that more innovation ideas are generated by employees compared to managers in the South African metals industry. Lastly, interviewees' perspectives on questions related to the relationship between employee factors and firm level innovation in the South African metals industry were asked. The findings are separated between insights from managers and non-managers per case study company.

4.3.1 *Case study at Company A*

The main production activities for Company A are the production of circulation or currency coins for the South African and international markets. The metals used in the manufacturing process include copper, brass, nickel, aluminium, bronze, stainless steel, and electroplated steel. Company A also produces collectable and investment products in precious metals such as gold, platinum, and silver. Two employees (one is a manager with subordinates and the other is a non-manager) were interviewed in this organisation and the following subsection presents the findings based on the perspectives of these employees. According to Carmichael and Cunningham (2017), candidates for interviews should be knowledgeable of the subject matter and the candidates selected by this organisation met this requirement. According to both employees who were interviewed from this organisation, Company A has an intentional innovation strategy which is aimed at delivering innovative products (and processes) to market.

The organisation has research and development facilities where product and process prototypes are developed. Most of the innovation work is done internally and there is little to no collaboration with higher education institutions (HEIs), government institutions and research councils within and outside of South Africa. The perception that came out strongly from employees interviewed from this organisation is that “HEIs move slowly and very rarely complete what they started to a point where it can be commercialised”. Therefore, the urgency felt by this organisation is not aligned to the timelines of the HEIs. The organisation also has a dedicated research and innovation budget which is used to bring new products and processes to market. However, the current focus in this organisation is not to be first in the world on product formats but to catch up to leading international competitors.

There is a formalised product realisation process where new products, which were first in the world, are developed. The innovation initiatives are not financially incentivised and are recognised as part of the scope of work for employees. This organisation brought new products to market during the period between 2019 and 2021. Even though the training budget exists in this organisation, there is no link between this budget and innovation activities. This budget is used mostly to enhance employees’ academic aspirations.

a) Findings from interviews on innovation idea generation with non-manager from Company A

The candidate who was interviewed is an African female who works in research and development at Company A. She has more than 11 years of experience within the metals industry in South Africa. According to this interviewee, more innovation ideas are generated by employees who are non-managers compared to employees who are managers at Company A. The interviewee further stated that this is not due to incapability of the manager but because “employees are the ones who face operational challenges and have to make a plan”. She further elaborated that “creative ideas or innovation does not always guarantee demonstratable or measurable values, so managers are reluctant to invest time in it”. This means managers spend more time concerned with productivity and output and less on implementing product or process changes until they are requested by the customers. The interviewee believes that this is a national trend within the metals industry in South Africa.

b) Findings from interviews on innovation idea generation with manager from Company A

The candidate who was interviewed is a white male who oversees product development in Company A. He has seven (7) years of experience within the metals industry in South Africa. The non-manager for Company A stated in the above section does not report to this manager. The interviewee expressed that innovation could come from employees and from managers. However, the product portfolio for the organisation is driven from market perspective and so managers, being closer to the market, have more input on the product portfolio. Employees are closer to the technologies used in production processes, which gives them an edge to generating more innovative product and process ideas than managers. The manager interviewed also stated that work experience, exposure to market events, competitor analysis and “good old fashion inspiration” are crucial in developing innovative ideas.

4.3.2 *Case study at Company B*

Company B is the largest valve manufacturer on the African continent and produces for the South African and international markets. These valves are mainly used in the water, effluent, and mineral processing markets. The main metal used in the valve manufacturing process is mild steel. Two employees (one is a manager with subordinates and the other is a non-manager) were interviewed in this organisation and the following subsection presents the findings based on the perspectives of these employees.

According to both employees, Company B has an intentional innovation strategy. However, most of the innovation implemented were in response to customer and market needs. The manager stated that "innovation comes from a customer or market need rather than a desire to be the pioneer in something". This manager further elaborated that innovation or engineering change at Company B comes from mainly needs rather than desires to make changes. The organisation has a research and development department which does prototypes which developed a new product between 2019 and 2021 that is currently performing successfully in the market. There are formal innovation workstreams which have annual key performance indicators (KPIs). Like Company A, Company B also has a training budget, but this is also driven from improving academic qualifications of employees rather than intentionally training for innovation. However, the design engineers are trained to enhance their design skills to improve quality of output and efficiency. The example given on this was the advanced computer-aided design (CAD) modelling programme.

The organisation does not generally collaborate with HEIs and research councils and one of the reasons is that "collaboration becomes tedious and assigning ownership of the new technology or invention is often the holdup". Therefore, clarifying the ownership of the intellectual property (IP) is key right from the start of the project. However, the organisation developed a patent with a university in South Africa in the past and this was one instance of a very successful relationship between the HEI and the organisation. The other challenge, as expressed by the non-manager, is that universities have the tendency to give projects from industry to students whose interests are to graduate (get academic qualification) and publish rather than taking new product to actual market. This mis-alignment results in reluctance from manufacturing organisations to collaborate with HEIs and research councils. According to the perspectives of the manager from this organisation, incentives from government programmes are leaning more towards small and medium enterprises and do not cater for large enterprises. This has led to the organisation not participating in these programs.

a) Findings from interviews on innovation idea generation with non-manager from Company B

The candidate who was interviewed is a white male who works in research and development at Company B. The candidate has more than 17 years working experience within the South African metals industry. According to the interviewee, employees who are not managers produce more innovation ideas compared to managers. Managers typically support the implementation of ideas rather than generating them. Managers are there for support and encouragement. These managers ensure that their employees are trained so that they can think outside the box and come up with innovative ideas. The interviewee stated that innovation in their organisation is mainly associated with changes in processes and designs, and non-managers are closer to that process compared to managers. According to the interviewee, “managers mainly deal with people, which is emotionally and time taxing, while employees who are non-managers deal with products or services”. Therefore, non-managers are much closer to the process to generate improvement ideas. To create innovative ideas, one needs to have “technical knowledge and be industry and customer-facing”. Therefore, even non-manager employees need to have these two aspects to generate innovative ideas that lead to financial success for the business. The interviewee also expressed that managers that are technically inclined and who are close to the process tend to also develop innovative ideas compared to managers who are less involved in the technical processes. In this regard, the interviewee differentiated between managers, and this aspect was not explored further in this study. However, it is an interesting observation that could be explored further in future studies.

b) Findings from interviews on innovation idea generation with manager from Company B

The candidate who was interviewed is a white male who works in the business development and international operations within Company B. He has more than 20 years of experience within the metals industry in South Africa. According to this manager, employees generate more innovative ideas. He further stated that "managers are not always expected to provide all the innovative ideas however they do need to have the capability to provide platforms for employees to think creatively and innovatively which is often more critical than the idea generation itself". Managers are contributing to new ideas by enabling employees to come up with creative thoughts. However, employees have an edge in creating ideas due to their process exposure and experience, which he called "ground-level experience". This manager did not elaborate on the implementation of the ideas. However, this is assumed since the interviews were based on ideas generated and implemented in their organisation. The interviewee felt that innovation should be engraved in the organisation's culture and not be seen as a "destination" or designation specific. This allows everyone in the organisation to be involved in contributing to new ideas. The interviewee believes that even though designation (manager or non-manager) plays a role, the educational background of the employee and their experience (which he called exposure) play a bigger role in innovative idea generation. This is further explored in the sections that deal with the second hypothesis in this study.

4.3.3 *Case study at Company C*

Company C is the largest producer of steel in Africa. It produces various steel types from raw materials such as iron ore, coal and scrap steel. The products also sold to the South African and international markets. Two employees (one is a manager with subordinates and the other is a non-manager) were interviewed in this organisation and the following subsection presents the findings based on the perspectives of these employees. According to these employees, there was product and process innovation in this organisation during 2019 and 2021.

This was mainly incremental innovation which the manager defined as "gradual or continuous improvements on an existing product or processes". Process innovation was more dominant in this organisation and is mainly driven by the need to improve efficiency in order to meet KPIs. The views from employees in this organisation are that there is mostly process innovation in the South African metals industry which is also driven by process efficiency requirements. The aim is to eliminate waste in the process and to develop optimum processes that deliver the required returns.

The organisation does not have a formal R&D budget, but there are funds available when there are innovative ideas that would lead to cost saving or process improvements. These innovative ideas typically come with capital investment requests and are approved by a panel based on the potential returns to the organisation. Company C is part of a multi-national organisation and benchmarking is encouraged in order to determine best practices and also to adopt innovations made by other organisations within the group. However, the employees interviewed felt that formalising R&D within the South African subsidiary, by creating a research and development division, would benefit the organisation. There are financial incentives, in terms of awards, given in recognition of successfully implemented innovations that have yielded positive returns (or cost savings) to the organisation. Training budget also exists for the development of employees. It is given to any employee who wishes to further their studies. However, this is not linked to innovation but is linked to the skill set required to achieve company KPIs.

Strategic alliances with HEIs and research councils are encouraged in this organisation. However, most of the interactions are more service based where the organisation uses these institutions in order to meet certain targets. An example given was when there are requirements for the organisation to conduct certain analysis, they would then outsource that to HEIs or research institutes and get the results back from these institutions.

a) Findings from interviews on innovation idea generation with non-manager from Company C

The candidate who was interviewed is an African female who works with product and process improvement projects in the production facilities at Company C. The candidate has more than 13 years working experience within the South African metals industry. According to this interviewee, non-managers develop more innovative ideas compared to managers. However, the managers are the ones that create the environment for the employees to think creatively. However, there are specialists that are more relaxed, and managers must push them or come with the ideas themselves (managers) since they have pressure from top management to produce cost savings. Managers are then forced to think deeper about innovative solutions compared to specialists like engineers. In this instance, managers create the idea, but it will still be implemented by the non-managers. Linking financial incentive to innovation promotes innovative thinking in employees and they come up with more product or process innovation ideas.

b) Findings from interviews on innovation idea generation with a manager from Company C

The candidate who was interviewed is an African male who oversees production facilities within Company C. He has more than seven (7) years of experience within the metals industry in South Africa but has also worked a further four (4) years within the mining industry in South Africa. According to this manager, employees who are non-managers create more innovative ideas compared to managers. At Company C, there are progress engineers in all production facilities whose main role is to develop innovative ideas on how to improve the production KPIs. Due to the focus on these KPIs, the engineers and employees pay more attention to the process and develop innovative ideas. Managers do sometimes come up with ideas, but they do not implement these ideas as the engineers and technicians are closer to the process for successful execution. Exposure, when presenting your ideas to top management, and financial incentives are what is driving employees who are non-manager to develop innovative ideas in Company C. Employees also feel a sense of pride when they know how much they have contributed to the success of the company and winning awards means that their peers are also made aware of each employee’s contribution.

4.3.4 *Summary of interview findings from non-managers’ insights on process and product innovation in the South African metals industry*

A common perspective from the three non-managers interviewed was that the South African metals industry is innovative. There was a good mix of experience (between 7 and 18 years) between these employees who are not managers. Their organisations had implemented product or process innovation between the 2019 and 2021 period. The common belief among these employees is that most innovative ideas are generated by non-manager employees compared to managers. This perspective was derived from both their present and past experiences. This is because employees who are not managers are the ones more exposed to process challenges and hence creativity is driven from finding alternative solutions.

According to these employees, managers spend more time focused on organisational deliverables that aim at meeting financial targets rather than looking at process or product changes, unless the changes are requested by the customers. Managers typically provide resources, remove obstacles, and facilitate so that workers are able to do the work that is required. They would spend lesser time on the process compared to the non-managers. The deeper understanding of internal products and processes, based on amount of time spent exposed to these, give the non-manager employees the edge to creating more innovative ideas. This is also supported by their technical knowhow, exposure to global expertise, knowledge gained from participation in previous problem-solving exercises. It must be stated that these employees were technical in nature, even though they are exposed to their organisation’s products and customers. It would be interesting to have the views of commercial employees who are the ones facing the customers on the same subject. But that was not the subject of this study and should be explored in further studies.

4.3.5 *Summary of interview findings from managers' insights on process and product innovation in the South African metals industry*

A common perspective from the three managers interviewed was that the South African metals industry is innovative. This perspective was derived from both their present and past experiences. The overarching perspective is that there is product and process innovation in the metals industry in South Africa. All managers narrated that their organisations have implemented these types of innovations between 2019 and 2021. The managers also believed that employees who are non-managers contribute to more innovation ideas compared to managers. However, the managers believed a conducive environment that enables employees to be creative and come up with innovative ideas, is typically created by management. Managers are also closer to the market, while employees are closer to the technologies. This means managers play a bigger role for new innovations to be implemented.

Innovation has a longer-term payback with a higher financial risk and therefore some managers become reluctant to invest in it as they have short-term returns in mind. This pushes such managers to focus more on current production outputs as opposed to thinking long-term. All organisations have a training budget; however, this was not linked to innovation. One of the drivers of the training budget is legislation and also the fact that organisations in South Africa can claim back the training expenses from the government which is a financial incentive to the organisations. There is little to no collaboration with HEIs and research councils. A summary of the results for hypothesis 1 is shown in Figure 3 below.

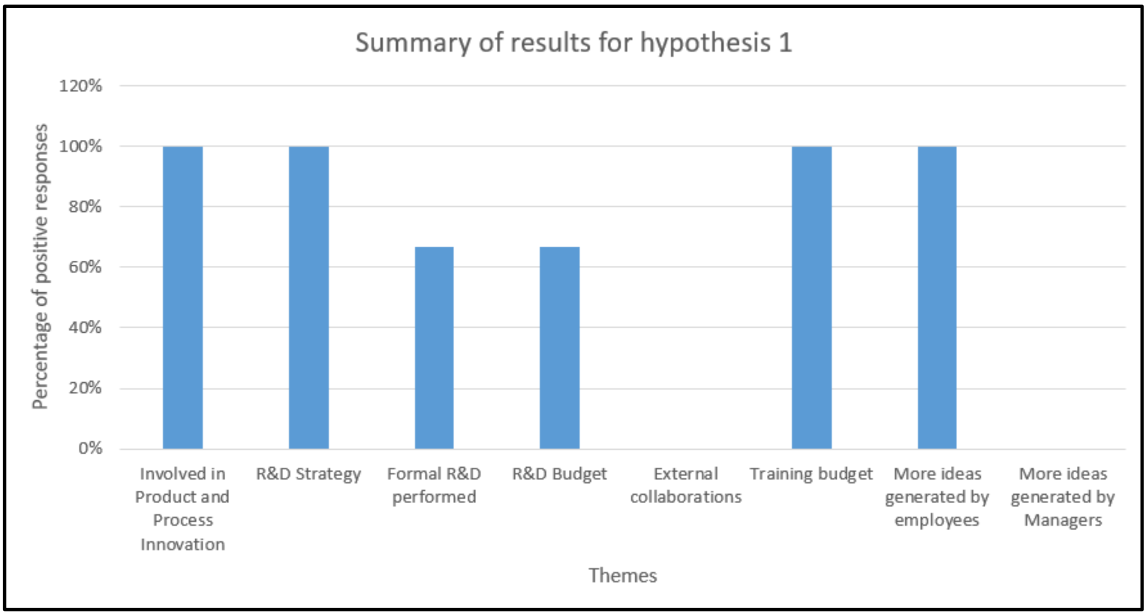

Figure 3: Summary of findings for the first hypothesis

4.4 Quantitative results pertaining to Hypothesis 2

The second hypothesis is that there is a positive relationship between employee factors and firm level innovation in the South African metals industry. This was tested using the primary data that were collected using Qualtrics and the results are shown in the following subsections. This addressed the following hypotheses:

Hypothesis 2A: There is a positive relationship between employee education level and innovation at firm level.

Hypothesis 2B: There is a positive relationship between employee tenure and innovation at firm level.

Hypothesis 2C: There is a positive relationship between employee demographic background attributes and innovation at firm level.

Hypothesis 2D: There is a positive relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry.

The variables used in this section are the following: following items were used for the innovation variable:

1. Firm-level innovation which is defined in section 4.4.1. This variable was developed by combining three items that interrogates the sources of product and process ideas that were generated.
2. Employee education level, which measure the education level of the employee's academic qualification.
3. Employee tenure, which was developed by combining the following:
   a) Number of years the employee spent in the organisation (job tenure);
   b) Number of years the employee spent in the same position in the organisation (position tenure);
   c) Total experience of the employee in that field, including experience acquired in other organisations (total work experience);
   d) Level of the employee position in the company structure (position level).
4. Employee demographic background attribute, which was developed by combining the following:
   a) Gender of the employee (gender);
   b) Age of the employee (age);
   c) Ethnic background of the employee (background).
5. Dynamic workforce capabilities, which was developed by combining the employee education, tenure and demographic background attribute variables.

4.4.1 *Firm level innovation variables*

The results for the sources of innovation were added to create a new variable called innovation variable and internal reliability was determined for these variables using Cronbach's Alpha statistics. Cronbach's Alpha is the estimator of internal consistency reliability of the sum or average of responses to the items (Viladrich et al., 2017). Only results for the following items were used for the innovation variable:

1. Product innovation ideas generated by employees, which is called the Product Employee variable in the tables in this section.
2. Product innovation ideas generated by joint efforts of employees and managers, which is called the Product Joint variable in the tables in this section.
3. Process innovation ideas generated by employees which is called the Process Employees variable in the tables in this section.
4. Process innovation ideas generated by joint efforts of employees and managers which is called the Process Joint variable in the tables in this section.

Ideas that were generated by managers only were not included since the main was to understand the effected of the three factors, education qualification, tenure, and demographic background, of non-managerial employee on firm level innovation in the South African metals industry. The focus was on ideas which were generated by these nonmanagerial employees and not those generated by managers. However, future work could incorporate the ideas generated by managers and compare the results between these two types of employees. As explained in the Conceptual Framework section, innovation ideas that originated from combined management and workforce efforts were attributed to employees in this study since the prevailing paradigm is top-down, so any instance of employee-level innovation, irrespective of whether it's wholly attributable to the employee(s), is a valid counterexample. Therefore, ideas generated by joint efforts were added as part of the innovation variable. The next step was to test for internal reliability of the responses to a multi-item scale using Cronbach's Alpha. For a good internal reliability, the Cronbach's Alpha should be greater than 0.65. Table 31 shows the internal reliability results for the innovation variables, based on innovation implemented in the organisations between 2019 and 2021. The Cronbach's Alpha was 0.681, which is greater than 0.65, meaning the results are reliable and that the different items making up the innovation variable are closely related.

Table 31: Internal reliability results for innovation variables

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.681	.691	4

The result for the item means and standard deviations for the innovation variables are shown in Table 32 below. The means for the variables were close, as observed in the table, which further supports that these variables could be combined to formulate the firm level innovation variable.

Table 32: Comparison of means for the innovation variables

Item Statistics			
	Mean	Std. Deviation	N
Product Employee	4.61	.645	36
Product Joint	4.39	.645	36
Process Employee	4.33	.632	36
Process Joint	4.17	.737	36

The results of the inter-item correlation matrix for the innovation variables are shown in Table 33. Inter-item correlations are an essential element in conducting an item analysis of a set of test questions. Inter-item correlations examine the extent to which scores on one item are related to scores on all other items in a scale (Piedmont & Hyland, 1993). It provides an assessment of item redundancy, which is the extent to which items on a scale are assessing the same content (Piedmont & Hyland, 1993; Silber et al., 2018). Ideally, the average inter-item correlation for a set of items should be between 0.20 and 0.40, suggesting that while the items are reasonably homogeneous, they do contain sufficiently unique variance so as to not be isomorphic with each other (Piedmont, 2014). When values are lower than 0.20, then the items may not be representative of the same content domain (Piedmont, 2014). If values are higher than 0.40, the items may be only capturing a small bandwidth of the construct (Piedmont, 2014). From Table 33, the inter-item correlations were 0.374 and 0.321, which are both between 0.20 and 0.40. This indicated that the variables used are reasonably homogeneous and further supports that these four variables can be combined to form one variable which is called firm level innovation variable in this work.

Table 33: Inter-item correlation matrix for the innovation variables

Inter-Item Correlation Matrix				
	Product Employee	Product Joint	Process Employee	Process Joint
Product Employee	1.000	.374	.747	.321
Product Joint	.374	1.000	.304	.281
Process Employee	.747	.304	1.000	.123
Process Joint	.321	.281	.123	1.000

The results of the item-total statistics for the innovation variables are shown in Table 34. From this table, it can be observed that the Cronbach's Alpha (0.681) will not improve if the Product Employee (0.474) or Product Joint (0.64) or Process Employee (0.586) variables are deleted. Removing the Process Joint variable would increase the Cronbach's Alpha from 0.681 to 0.730. However, this variable was not deleted as the resultant increase would not have been large.

Table 34: Item-total statistics for the innovation variables

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Product Employee	12.89	1.987	.674	.621	.474
Product Joint	13.11	2.387	.414	.173	.646
Process Employ	13.17	2.257	.511	.576	.586
Process Joint	13.33	2.400	.300	.166	.730

The scale statistics results are shown in Table 35 below. The mean for the firm level innovation variable is 17.50 and the standard deviation, which measures how far each value lies from the mean, is low (1.905).

Table 35: Scale statistics results for the innovation variables

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
17.50	3.629	1.905	4

4.4.2 *Hypothesis 2A – There is a positive relationship between employee education level and innovation at firm level*

Correlation and linear regression statistics were used to determine the relationship between employee education level and firm level innovation. The correlations results are shown in Table 36. In quantitative research, correlation is a statistical technique that shows how strongly two variables are related to each other or the degree of association between the two variables (Taylor, 1990). The correlation coefficient in Table 36 is 0.646 which is between 0.36 and 0.67, signifying a moderate positive correlation between the variables tested (Taylor, 1990). The positive value of the correlation coefficient indicates that a positive increase in employee education level would result in a positive increase in the innovation variable (Lee, 2015; Taylor, 1990). The correlation between these variables is significant at 0.01 level.

Table 36: Correlation statistic results for innovation variable and employee education level

Correlations			
		Innovation Variable	Education
Innovation Variable	Pearson Correlation	1	.646**
	Sig. (2-tailed)		<.001
	N	36	36
Education	Pearson Correlation	.646**	1
	Sig. (2-tailed)	<.001	
	N	36	36
**. Correlation is significant at the 0.01 level (2-tailed).			

Linear regression analysis was done in order to determine if employee education level was a good predictor for firm level innovation in the South African metals industry and the results are shown in Table 37 below. The independent variable was education and the dependent variable was the innovation variable. R-Squared is a statistical measure of fit that indicates how much of the variation in the dependent variable is explained by the independent variable (Lee, 2015). The R-squared value was 0.417 which indicates that 41.7% of the variation of innovation variable is explained by the education variable in this regression model.

Table 37: Regression analysis for innovation variable (dependent variable) and education (independent variable)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.646[a]	.417	.400	1.476
a. Predictors: (Constant), Education				

The results for the analysis of variance (ANOVA) in the regression model are shown in Table 38 below. The regression sum of squares is 52.920, while the total sum of squares is 127.000, which means the regression model explains about 52.920/127.000 (around 41.7%) of all the variability in the dataset. The residual sum of squares, which is the total variation in the dependent variable (innovation) that is left unexplained by the regression model, is 74.080. The F-value is used to test the hypothesis that the slope of the independent variable is zero (Lee, 2015). Significance F is the p-value for the null hypothesis which shows that the coefficient of the independent variable is zero and a low p-value indicates that a significant relationship exists between dependent (innovation) and independent (education) variables (Lee, 2015). From Table 38, the Significance F is low (<0.001) which indicates that the statistics were significant, and innovation could be explained by the education variable in this study.

Table 38: ANOVA results for innovation and education variables

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	52.920	1	52.920	24.288	<.001[b]
	Residual	74.080	34	2.179		

	Total	127.000	35			
a. Dependent Variable: Innovation Variable						
b. Predictors: (Constant), Education						

The ANOVA coefficients are shown in Table 39 below. The standard error provides the estimated standard deviation of the distribution of coefficients. It is the amount by which the coefficient varies across different cases. A coefficient much greater than its standard error (in this case 10.640 versus 1.414 for constant, and 1.680 versus 0.341 for education variable) implies a probability that the coefficient is not 0. The t-test assesses whether the observed differences between two sample means could have occurred by chance, or if there is a true difference (Coetzer, 2007). The t-statistics or t-value is equal to the coefficient divided by the standard error. The significance value (p-value) is low (<0.001) which suggests that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the independent (education) and dependent (innovation) variables.

Table 39: ANOVA coefficients table for innovation and education variables

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.640	1.414		7.527	<.001
	Education	1.680	.341	.646	4.928	<.001
a. Dependent Variable: Innovation Variable						

4.4.3 *Hypothesis 2B – There is a positive relationship between employee tenure and innovation at firm level*

Before the relationship between employee tenure and innovation could be explored, the employee tenure variable had to be determined. This was done using the responses from the primary survey. The respondents were asked to rate the importance of the following statements about the innovation ideas implemented in their organisation between 2019 and 2021 using a Likert scale:

1. Number of years the employee spent in the organisation (job tenure);

2. Number of years the employee spent in the same position in the organisation (position tenure);
3. Total experience of the employee in that field, including experience acquired in other organisations (total work experience);
4. Level of the employee position in the company structure (position level).

The employee tenure variable was created by combining (adding together) the responses from the four statements above and internal reliability was determined for these variables using Cronbach's Alpha statistics. The results for internal reliability are shown in Table 40 below. The Cronbach's Alpha was 0.770, which is greater than 0.65, meaning the results are reliable and that the different items making up the tenure variable are closely related.

Table 40: Internal reliability results for the tenure variables

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.770	.767	4

Table 41 shows that the comparison of means for the tenure variables and the means are close. The position level variable is the lowest (near neutral).

Table 41: Comparison of means for the tenure variables

Item Statistics			
	Mean	Std. Deviation	N
Job tenure	4.31	.710	36
Position tenure	4.33	.756	36
Total experience	4.36	.639	36
Position level	3.06	.630	36

The inter-item correlation matrix for the tenure variables is shown in Table 42 below. The values varied between 0.200 and 0.657.

Table 42: Inter-item correlation matrix for the tenure variables

Inter-Item Correlation Matrix				
	Job tenure	Position tenure	Total experience	Position level

Job tenure	1.000	.657	.568	.408
Position tenure	.657	1.000	.571	.200
Total experience	.568	.571	1.000	.303
Position level	.408	.200	.303	1.000

The item-total statistics are shown in Table 43. The Cronbach's Alpha (0.770) would be lower if the variables were removed, except for position level. However, the change is low if this variable (position level) is removed (0.770 vs 0.817).

Table 43: Item-total statistics for the tenure variables

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Job tenure	11.75	2.364	.726	.541	.626
Position tenure	11.72	2.435	.614	.499	.693
Total experience	11.69	2.733	.621	.403	.692
Position level	13.00	3.257	.352	.190	.817

The scale statistics in Table 44 shows that the mean for the tenure variable is 16.06 and the standard deviation is 2.110.

Table 44: Scale statistics results for the tenure variables

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
16.06	4.454	2.110	4

After the tenure variable was determined, the relationship between this employee tenure variable and firm level innovation was determined using correlation and regression statistics. The correlations results are shown in Table 45. The correlation coefficient is 0.888 which signifies a strong positive correlation between the innovation and tenure variables. The correlation between these variables is significant at 0.01 level.

Table 45: Correlation statistic results for innovation and tenure variables

Correlations			
		Innovation Variable	Tenure Variable
Innovation Variable	Pearson Correlation	1	.888**
	Sig. (2-tailed)		<.001
	N	36	36
Tenure Variable	Pearson Correlation	.888**	1
	Sig. (2-tailed)	<.001	
	N	36	36
**. Correlation is significant at the 0.01 level (2-tailed).			

Linear regression statistics were conducted, and the results are shown in the tables below. The independent variable was tenure, and the dependent variable was the innovation variable. From Table 46, the R-squared value was 0.789 which indicates that 78.9% of the variation of innovation variable is explained by the tenure variable in a regression model.

Table 46: Regression analysis for innovation and tenure variables

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.888[a]	.789	.783	.887
a. Predictors: (Constant), Tenure Variable				

The results for the analysis of variance (ANOVA) in the regression model are shown in Table 47 below. The regression sum of squares is 100.232, while the total sum of squares is 127.000, which means the regression model explains about 100.232/127.000 (around 78.9%) of all the variability in the dataset. The F-value is 127.310 and the Significance F value is low (<0.001) which indicates that the statistics were significant, and innovation could be explained by the tenure variable in this study.

Table 47: ANOVA results for innovation and tenure variables

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	100.232	1	100.232	127.310	<.001[b]
	Residual	26.768	34	.787		
	Total	127.000	35			
a. Dependent Variable: Innovation Variable						
b. Predictors: (Constant), Tenure Variable						

The ANOVA coefficients table is shown in Table 48 below. The coefficient (B) was greater than its standard error which implies a probability that the coefficient is not 0. The t-value is 4.021 for the constant and 11.283 for the tenure variable. The significance value is low (<0.001) which indicates that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the tenure and innovation variables.

Table 48: ANOVA coefficients table for innovation and tenure variables

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.626	1.151		4.021	<.001
	Tenure Variable	.802	.071	.888	11.283	<.001
a. Dependent Variable: Innovation Variable						

4.4.4 *Hypothesis 2C – There is a positive relationship between employee demographic background attributes and innovation at firm level*

The respondents were asked to rate the importance of the following statements about the innovation ideas implemented in their organisation between 2019 and 2021 using a Likert scale:

1. Gender of the employee (gender);
2. Age of the employee (age);
3. Ethnic background of the employee (background).

The employee demographic background attribute variable, which has been shortened to demographic variable, was determined by combining the responses from these statements. The results for the reliability statistics are shown in Table 49 below. The Cronbach's Alpha was 0.755 which shows that the results are reliable and that the different items making up the employee demographic background attribute variable are closely related.

Table 49: Reliability statistics for the demographic variables

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.755	.755	3

The results for the comparison of means for the demographic variable are shown in Table 50. The means for the three variables that makeup the demographic variable, were close.

Table 50: Comparison of means for the employee demographic background attribute variables

Item Statistics			
	Mean	Std. Deviation	N
Gender	2.72	1.233	36
Age	3.19	1.238	36
Ethnic background	3.81	1.215	36

The results for the inter-item correlation matrix are shown in Table 51 below. The values were close and varied between 0.448 and 0.615.

Table 51: Inter-item correlation matrix for the demographic variables

Inter-Item Correlation Matrix			
	Gender	Age	Ethnic
Gender	1.000	.448	.459
Age	.448	1.000	.615
Ethnic	.459	.615	1.000

The item-total statistics are shown in Table 52 below. The Cronbach's Alpha (0.755) would not significantly improve if any of the demographic variables were removed. Therefore, these variables were retained and added to make the employee demographic background attribute variable (or demographic variable).

Table 52: Item-total statistics for the demographic variables

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Gender	7.00	4.857	.505	.255	.761
Age	6.53	4.371	.622	.413	.629
Ethnic	5.92	4.421	.631	.420	.619

The scale statistics in Table 44 shows that the mean for the demographic variable is 9.121 and the standard deviation is 3.020.

Table 53: Scale statistics results for the demographic variables

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
9.72	9.121	3.020	3

After the employee demographic background attribute variable was determined, the relationship between this employee demographic background attribute variable and firm level innovation was determined using correlation and regression statistics. The correlations results are shown in Table 54. The correlation coefficient is 0.914 which signifies a strong positive correlation between the innovation and employee demographic background attribute variables. The correlation between these variables is significant at 0.01 level.

Table 54: Correlation statistic results for innovation and demographic variables

Correlations			
		Innovation Variable	Demographic Variable
Innovation Variable	Pearson Correlation	1	.914**
	Sig. (2-tailed)		<.001
	N	36	36
Demographic Variable	Pearson Correlation	.914**	1
	Sig. (2-tailed)	<.001	
	N	36	36
**. Correlation is significant at the 0.01 level (2-tailed).			

Liner regression statistics were conducted, and the results are shown in the tables below. The independent variable was the demographic variable, and the dependent variable was the innovation variable. From Table 55, the R-squared value was 0.835 which indicates that 83.5% of the variation of innovation variable is explained by the tenure variable in a regression model.

Table 55: Regression analysis for innovation and demographic variables

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.914[a]	.835	.830	.785

a. Predictors: (Constant), Demographic Variable

The results for the analysis of variance (ANOVA) in the regression model are shown in Table 56 below. The regression sum of squares is 106.058, while the total sum of squares is 127.000, which means the regression model explains about 100.232/127.000 (around 83.5%) of all the variability in the dataset. The F-value is 172.186 and the Significance F value is low (<0.001) which indicates that the statistics were significant, and innovation could be explained by the employee demographic background attribute variable used in this study.

Table 56: ANOVA results for innovation and demographic variables

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	106.058	1	106.058	172.186	<.001[b]
	Residual	20.942	34	.616		
	Total	127.000	35			
a. Dependent Variable: Innovation Variable						
b. Predictors: (Constant), Demographic Variable						

The regression coefficients table is shown in Table 57 below. The coefficient (B) was greater than its standard error which implies a probability that the coefficient is not 0. The t-value is 26.634 for the constant and 13.122 for the tenure variable. The significance value is low (<0.001) which indicates that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the tenure and innovation variables.

Table 57: ANOVA coefficients table for innovation and demographic variables

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	11.896	.447		26.634	<.001
	Demographic Variable	.576	.044	.914	13.122	<.001

a. Dependent Variable: Innovation Variable

4.4.5 *Hypothesis 2D – There is a positive relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry*

The dynamic workforce capabilities of interest in this study were the employee education level, work tenure and demographic background attributes. The first stage was to analyse the combined effect of the education, tenure and demographic variables on firm level innovation in the South African metals industry. The workforce capability variable was developed by combining (adding) the education, tenure, and demographic variables. The values used for the tenure and demographic variables were the average (not the summed totals) as the aim was to get all the variables to have the same maximum as the education variables which is five (5). The results for the reliability statistics for these workforce capabilities are shown in Table 58 Table 58: Reliability statistics for the workforce capability variablesbelow. The Cronbach's Alpha was 0.790 which shows that the results are reliable and that the different items making up the dynamic workforce capabilities variable are closely related.

Table 58: Reliability statistics for the workforce capability variables

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.790	.824	3

The results for the comparison of means for the workforce capabilities variables are shown in Table 59 below. The mean for employee demographic background variable is the lowest (3.241) compared to education (4.083) and tenure (4.014).

Table 59: Comparison of means for the workforce capabilities variable

Item Statistics			
	Mean	Std. Deviation	N
Education	4.083	.732	36
Tenure	4.014	.528	36
Demographic	3.241	1.007	36

The results for the inter-item correlation matrix are shown in Table 60 below. The values varied between 0.441 and 0.845.

Table 60: Inter-item correlation matrix for the education, tenure and demographic variables.

Inter-Item Correlation Matrix			
	Education	Tenure	Demographic
Education	1.000	.441	.541
Tenure	.441	1.000	.845
Demographic	.541	.845	1.000

The item-total statistics are shown in Table 61. From this table, it is evident that the Cronbach's Alpha (0.790) would only improve if the education variable was deleted. However, this was not done since the improvement was low.

Table 61: Item-total statistics for education, tenure and demographic variables

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Education	7.255	2.190	.525	.293	.820
Tenure	7.324	2.346	.766	.715	.679
Demographic	8.097	1.155	.783	.750	.590

The scale statistics in Table 62 show that the mean was 11.338 and the standard deviation was 1.965.

Table 62: Scale statistics for the education, tenure and demographic variables

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items

11.338	3.863	1.965	3

The results for the correlations are shown in Table 63 below. The correlation coefficients are positive for education (0.646), tenure (0.888) and demographic (0.914) against innovation.

Table 63: Correlation statistics for innovation, education, tenure and demographic variables

Correlations					
		Innovation	Education	Tenure	Demographic
Innovation	Pearson Correlation	1	.646**	.888**	.914**
	Sig. (2-tailed)		<.001	<.001	<.001
	N	36	36	36	36
Education	Pearson Correlation	.646**	1	.441**	.541**
	Sig. (2-tailed)	<.001		.007	<.001
	N	36	36	36	36
Tenure	Pearson Correlation	.888**	.441**	1	.845**
	Sig. (2-tailed)	<.001	.007		<.001
	N	36	36	36	36
Demographic	Pearson Correlation	.914**	.541**	.845**	1
	Sig. (2-tailed)	<.001	<.001	<.001	
	N	36	36	36	36
**. Correlation is significant at the 0.01 level (2-tailed).					

The education, tenure and demographic variables were combined to create the workforce capability variable. As shown in Table 58, the Cronbach's Alpha was 0.790. The correlation was high and positive as shown by the correlation coefficient of 0.947 in Table 64 below. The correlation statistics between innovation and workforce capability variables was significant at 0.01 level.

Table 64: Correlation between innovation and workforce capability variables

Correlations			
		Innovation	Dynamic Capability
Innovation	Pearson Correlation	1	.947**
	Sig. (2-tailed)		<.001
	N	36	36
Dynamic Capability	Pearson Correlation	.947**	1
	Sig. (2-tailed)	<.001	
	N	36	36
**. Correlation is significant at the 0.01 level (2-tailed).			

Linear regression statistics were conducted, and the results are shown in the tables below. In Table 65, the independent variables were demographic, education, and tenure variables, while the dependent variable was the innovation variable. The R-squared value was 0.918 which indicates that 91.8% of the variation of innovation variable is explained by the tenure variable in a regression model.

Table 65: Regression results for demographic, education, tenure and innovation variables

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.958[a]	.918	.910	.14305
a. Predictors: (Constant), Demographic, Education, Tenure Variables				

Linear regression was also conducted using dynamic capability as the independent variable and innovation as the dependent variable. The results are shown in Table 66 below. The R-squared was 0.897, which is high and positive showing the dynamic capability variable is a good predictor for firm level innovation.

Table 66: Regression results for the dynamic capability and innovation variables

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.947[a]	.897	.894	.15526
a. Predictors: (Constant), Dynamic Capability Variable				

The ANOVA results for the demographic, education, and tenure variables as predictors for innovation are shown in Table 67 below. The significance value is low (<0.001) which shows that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the dependent (innovation) and the independent (demographic, education, and tenure) variables.

Table 67: ANOVA results for demographic, education, tenure and innovation variables

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7.283	3	2.428	118.630	<.001[b]
	Residual	.655	32	.020		
	Total	7.938	35			
a. Dependent Variable: Innovation						
b. Predictors: (Constant), Demographic, Education, Tenure						

The ANOVA results for the dynamic capability variable as predictors for innovation are shown in Table 68 below. The significance value is low (<0.001) which indicates that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the dependent (innovation) and the independent (dynamic capability) variables.

Table 68: ANOVA results for dynamic capability and innovation variables

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7.118	1	7.118	295.268	<.001[b]
	Residual	.820	34	.024		
	Total	7.938	35			
a. Dependent Variable: Innovation						
b. Predictors: (Constant), Dynamic Capability						

The regression coefficients for education, tenure, and demographic as predictors for innovation is shown in Table 69 Table 57below. The coefficient (B) was greater than its standard error which implies a probability that the coefficient is not 0. The t-values were all significant since the significance values were low (<0.001) which indicate that there is a significant linear relationship between the independent (education, tenure and demographic) and the dependent (innovation) variables.

Table 69: Regression coefficients for the demographic, education, tenure and innovation variables

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.591	.264		6.033	<.001
	Education	.145	.039	.224	3.701	<.001
	Tenure	.378	.086	.419	4.405	<.001
	Demographic	.208	.048	.439	4.327	<.001
a. Dependent Variable: Innovation						

The regression coefficients for the dynamic capability variable as predictors for innovation is shown in Table 70 Table 57below. The coefficient (B) was greater than its standard error which implies a probability that the coefficient is not 0. The t-values were all significant since the significance values were low (<0.001) which indicate that there is a significant linear relationship between the independent (dynamic capability) and the dependent (innovation) variables.

Table 70: Regression coefficients for the dynamic capability and innovation variables

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.773	.154		11.546	<.001
	Dynamic Capability	.229	.013	.947	17.183	<.001
a. Dependent Variable: Innovation						

In the primary survey, the respondents were asked to rate statements related to dynamic capabilities and firm level innovation. The results are shown in Table 71 below. The respondents somewhat agreed or strongly agreed on the first four positive statements about a positive relationship between workforce capabilities and firm level innovation, while they did not agree with the last negative statement about managers being more innovative than non-managerial employees.

Table 71: Responses on dynamic capabilities and source of innovation from the primary survey

Statement	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Stat_1 - Dynamic capabilities are a requirement for innovation	0	0	5	15	16
Stat_2 - Workforce capabilities have an impact on innovation	0	0	2	20	14
Stat_3 - Workforce capabilities have a greater impact on firm-level innovation compared to managerial capabilities	0	2	2	14	18
Stat_4 - Employee who are not manager (these include specialists) introduce more innovative ideas compare to managers	0	2	4	8	22
Stat_5 - Managers introduce more innovative ideas compare to employee who are not managers (including specialists)	7	18	2	9	0

The means for the statements are shown in Table 72 below. From these means, it can be observed that statement 4 (employee who are not managers introduce more innovative ideas compared to managers) had the largest mean, while statement 5 (managers introduce more innovative ideas compared to employees who are not managers) had the lowest mean. Therefore, according to the respondents, employees create more innovative ideas than managers in the South African metals industry. These findings are in line with the results that were observed in Table 21.

Table 72: Comparison of means for the results on dynamic capabilities and source of innovation from the primary survey

Report					
	Stat_1	Stat_2	Stat_3	Stat_4	Stat_5
Mean	4.31	4.33	4.33	4.39	2.36
N	36	36	36	36	36
Std. Deviation	.710	.586	.828	.903	1.073

The respondents were asked to rate statements about the important workforce factors that influence firm level innovation, and the results are shown in Table 73 below. The respondents selected the positive results for all statements except employee ethnic background.

Table 73: Responses on important workforce factors that influence firm level innovation

Statement	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Stat_6 - Education is an important workforce capability for innovation	1	0	0	20	15
Stat_7 - Ethnic background is an important workforce capability for innovation	7	16	2	9	2
Stat_8 - Employee's demographic attributes play an important workforce capability for innovation	5	5	2	20	4
Stat_9 - Employee tenure in the organization is an important workforce capability for innovation	0	3	5	6	22
Stat_10 - Employee position tenure in the organization is an important workforce capability for innovation	1	4	3	8	20
Stat_11 - More innovation ideas are generated by employees compared to managers in the South African metals industry	1	1	7	6	21
Stat_12 - Qualification, tenure and demographic attributes all have a positive relationship with firm-level innovation in the South African metals industry	0	1	5	10	20

The means for the statements in Table 73 are shown in Table 74 below. The mean for the statement (ethnic background is an important workforce capability for innovation) is the lowest and below the neutral scale of 3. This means that according to the respondents, ethnic background is not important when it comes to firm level innovation. The rest of the statements had a positive response (greater than 3).

Table 74: Comparison of means for the important workforce factors that influence firm level innovation

Report							
	Stat_6	Stat_7	Stat_8	Stat_9	Stat_10	Stat_11	Stat_12
Mean	4.33	2.53	3.36	4.31	4.17	4.25	4.36
N	36	36	36	36	36	36	36
Std. Dev.	.756	1.230	1.268	1.009	1.159	1.052	.833

4.4.6 *Implementation of firm level innovation*

The definition of innovation used in the work was that “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (Oslo Manual, 2018, p. 20). Therefore, even though the focus of this work was not on implementation but on idea generation the idea needed to be implemented in order to fit this definition. The respondents were asked to rate statements about the characteristics of the team that successfully implemented the innovative idea in their organisation between 2019 and 2021. The results are shown in Table 75 below.

Table 75: Characteristics of a team that successfully implemented the innovative idea in the respondent’s organisations between 2019 and 2021

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Char1: Diversity of the team	0	2	5	12	17
Char2: Education qualifications of the team	0	5	10	15	6
Char3: Average tenure of the team in the organization	1	0	10	13	12
Char4: Tenure of the innovation lead in the organization	0	5	12	14	5
Char5: Number of years in the same position for the innovation lead	0	4	10	9	13
Char6: Position level of the innovation lead in the organization	0	5	13	10	8
Char7: Team gender balance	15	8	11	2	0
Char8: Team age mix/balance	5	7	16	8	0
Char9: Team ethnic mix	7	3	14	8	4

The mean of the results for the team characteristics are shown in Table 76 below. The results for the following team characteristics were below the neutral value of 3:

- Position level of the innovation lead in the organisation
- Team gender balance
- Team age balance
- Team ethic mix

The team characteristics that showed positive results (above 3) are the following:

- Diversity of the team
- Education qualification of the team
- Average tenure of the team in the organisation
- Tenure of the innovation lead in the organisation
- Number of years in the same position for the innovation lead
- Position level of the innovation lead in the organisation

The mean values for team age balance and team ethnic mix were close to 3 (neutral response).

Table 76: Means values for the results on team characteristics for innovative idea implemented in respondent's organisations

Report									
	Char1	Char2	Char3	Char4	Char5	Char6	Char7	Char8	Char9
Mean	4.22	3.61	3.97	3.53	3.86	3.58	2.00	2.75	2.97
N	36	36	36	36	36	36	36	36	36

Std. Dev	.898	.934	.941	.910	1.046	.996	.986	.967	1.253

The respondents were asked to rate statements about their perspective and to rate the characteristics of the team that would be able to successfully implement innovative ideas in the South African metals industry. The results are shown in Table 77 below. The results showed a similar trend in the results for characteristics of the teams that implemented innovation in the respondent's organisations.

Table 77: Ideal Characteristics of a team that would successfully implement innovation in the South African metals industry

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Char1: Diversity of the team	0	0	10	15	11
Char2: Education qualifications of the team	0	1	6	18	11
Char3: Average tenure of the team in the organization	0	4	12	12	8
Char4: Tenure of the innovation lead in the organization	0	4	9	16	7
Char5: Number of years in the same position for the innovation lead	1	0	11	15	9
Char6: Position level of the innovation lead in the organization	0	3	15	10	8
Char7: Team gender balance	15	12	7	2	0
Char8: Team age mix/balance	10	6	11	9	0
Char9: Team ethnic mix	7	7	8	10	4

The mean of the results for the ideal team characteristics are shown in Table 78 below. Again, the team gender balance, team age balance and team ethnic mix had the lowest means. The highest means were for diversity in the team, education qualification of the team, number of years in the same position of the innovation lead, average tenure of the team in the organisation, and position level of the innovation lead in the organisation.

Table 78: Means of the ideal team characteristic to implement innovation in the South African metals industry

Report									
	Char1	Char2	Char3	Char4	Char5	Char6	Char7	Char8	Char9
Mean	4.03	4.08	3.67	3.72	3.86	3.64	1.89	2.53	2.92
N	36	36	36	36	36	36	36	36	36
Std. Dev.	.774	.770	.956	.914	.899	.931	.919	1.158	1.317

4.5 Qualitative findings pertaining to Hypothesis 2

A qualitative study was conducted by interviewing two employees from three organisations (Company A, Company B and Company C) to determine the interviewees' perspectives (based on their exposure and experiences) about the relationship between employee factors and firm level innovation in the South African metals industry. This section presents the findings from these interviews. These interviews were conducted in order to address the following hypotheses:

Hypothesis 2A: There is a positive relationship between employee education level and innovation at firm level.

Hypothesis 2B: There is a positive relationship between employee tenure and innovation at firm level.

Hypothesis 2C: There is a positive relationship between employee demographic background attributes and innovation at firm level.

Hypothesis 2D: There is a positive relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry.

The findings are separated based on the case study company and the views were not separated between managers and non-managers.

4.5.1 *Feedback from Insights of employees from Company A*

The employees (manager and non-manager) from this organisation believe that product and process innovation is very crucial for the sustainability of their organisation as it plays a big role in terms of "product, technology, and equipment advancement". Education of the employees, which is defined as tertiary or post-matric (grade 12) qualification, plays a pivotal role in idea generation and is highly recommended in this organisation. Individual development plans are used to identify skills gaps, and a training budget is used to upskill the employees to close the gaps identified. One employee stated that "employees with tertiary level of education can generate a broader range of ideas and innovation" compared to employees without a tertiary qualification. Employees who have tertiary education have an advantage in that they have the theoretical concepts which aid in understanding the work that they do. In contrast, employees without a tertiary qualification can only assist an organisation to survive but not to thrive. However, education qualification alone does not make an employee innovative but needs to have some form of complementary experience and exposure. To create innovative ideas, employees also need to be motivated and empowered. The work by Ramaswamy (2009) also showed a symbiotic relationship between managers and employees since it is crucial for managers to create a culture of transparency and empowerment in the workplace in order for organisations to co-create value with their employees. However, employee motivation is also influenced by a number of things including organisational culture, company policies, management and leadership culture (Fusch et al., 2020; Pelders & Nelson, 2019). The level of education "helps to expose the employee to a wider field and enables them to recognise areas for improvement or innovative products easily" as one employee put it. Education also helps in the execution of the development of that specific innovation. In this organisation, innovative ideas are treated based on the type of innovation. However, product innovation is difficult to get off the ground as it seems to be driven from a Sales and Marketing point of view, which is looking at what other companies are doing instead of their own creative team.

The downside of education is that "it tends to make normalised people as they have the same training, think the same way, and do things the same way due to their background training". Therefore, education diversity in qualifications and training institutions is more crucial. This means organisations should avoid recruiting employees from only one tertiary institution but aim for diversity with regards to recruiting from various tertiary institutes. The manager further elaborated by using various universities in South Africa and stated that "students who were all taught by the same professor will tend to view technical problems in a similar manner". Therefore, to achieve diversification in thinking, organisations need to recruit from broader institutions and not focus on only one or two of these.

The influence of employee tenure on firm level innovation depends on the type of position. Some positions, such as specialists, requires a skill that is attained over a longer period and therefore longer tenure leads to greater expertise and knowledge in that field. According to employees from this organisation, the total work experience is rated higher in determining if the employee will come up with innovative ideas. Employees with experience understand what the market is looking for and can develop ideas for product enhancement more easily. Total years in the same organisation but in different positions is also important as it diversifies the employee's experiences. However, the employees felt that spending too much time in the same position is least important as "it could lead to performance complacency", and this can diminish the quality and quantity of work the employee produces, including their ability to identify innovative ideas. The level of the position within the organisational structures has no impact on innovation as innovation should be at the best interest of everyone, irrespective of level of employee position. It is however clear that knowledge and levels of education has become a vital element of innovation.

Young people have more appetite and energy to try new creative things compared to the older generation. They are also used to the latest technologies and tend to be academically driven. They come into new organisations with the relevant tertiary education for the field that they are employed in. Therefore, they are more likely to create innovative ideas compared to the older generation. Younger employees may tend to have stronger academic skills, but be socially inexperienced, whereas the older employees are often less at ease with new technologies, even when they are open to using technology, "they may experience age-related challenges such as technology-related barriers". Younger people generate more ideas; however, experience is crucial with implementation and older generations are more likely to succeed in implementing these ideas due to their deeper understanding of the organisational culture and the history they have within the organisation.

According to the employees from this organisation, gender is not important in creating innovative ideas. However, gender "diversity" does increase innovation efficiency. One employee from this organisation stated that "the benefits of women's inclusion in R&D teams are vital for enhancing innovation efficiency through their capability to improve information processing, communication, project planning, and administrative work”.

Family background also plays a role in making one innovative. This is especially true of how you were raised, what you were exposed to, and the availability of resources when you were growing up. A mix of people from various ethnic backgrounds is crucial for the implementation of the innovation as it brings variation in capacities, perspectives, and mental models. Having a pool with a mixed ethnic background can increase the skill diversity of work teams, encourage knowledge transfers, and enable interactions that lead to new knowledge combinations. According to one employee from this organisation,” the ethnic background should involve both racial and cultural background”. Another employee from this organisation felt that “white employees are more likely to create innovative ideas and that would be influenced by how they experienced the world since they are most likely raised in a higher income household where they are also encouraged to make mistakes”. African males are less likely, compared to their white counterparts, to speak up and make suggestions to older management in South Africa.

The employees from this organisation believe that education, tenure, and demographic background attributes are sufficient capability to measure workforce innovation capacity in the metals industry. These employees believe that the dynamic workforce capabilities should be defined as the ability of employees to see what is needed to address certain challenges in the business and come up with ideas to address these challenges and to execute and evaluate the solutions that are available. However, these need to be supported by process exposure and understanding, abilities to analyse and process data, availability of required technologies and exposure to lean management principles. The employees further stated that “commitment, perseverance, tenacity, eagerness, and hunger for growth are key employee characteristic for success in the innovation space”. Further support, at the organisation level, such as conducive environment, company strategy, and availability of resources (funds, equipment, and materials) is also key. Company culture that allows people to make mistakes and not be blamed was also highlighted as a key enabling factor for firm level innovation in the South African metals industry.

4.5.2 *Feedback from Insights of employees from Company B*

The employees (manager and non-manager) from Company B stated that there is product and process innovation in their organisation, and they believe that this is applicable to the entire metals industry in South Africa. These employees believe that there is a positive relationship between education and firm level innovation. As one employee put it “the more you get educated, the more likely you will come up with innovative ideas and improvements as you want to implement the new knowledge that you learned”. Employees without matric are mostly working as operators where there are fewer complexity requirements, and they don’t need to make decisions. Therefore, they don’t always get opportunities to suggest changes and improvements to processes and products. The contribution of these employees is mostly on sustaining the company but less on the growth of the company. According to one employee from this organisation, “education is extremely important for innovation at every level, tertiary education provides the platform or baseline of the intelligence that the organisation runs at. On the other hand, post-graduate education is required to understand theories and principles in which products perform and to improve on product performances”. Therefore, educated employees give more feasible innovative ideas compared to employees without tertiary qualifications.

Age is important for innovation and younger employees are more inclined to give process-related innovative ideas compared to older generations. Younger employees bring a fresh perspective, which is priceless. This perspective, guided by tenure and experience in the product or process being discussed, can result in extremely useful and innovative ideas. Older employees are more interested in keeping things stable and not changing processes and products since they are less comfortable in doing that. However, these employees understand the product the most and are in a better position to make product innovations than younger employees. These older employees need to be “caring” about the organisation for them to think and create ways to improve the output of their organisations.

Total work experience in complementary industries is crucial to be innovative as the experiences gained gives one a more holistic view of the product value chain and the relevant technology landscape. New employees coming from other companies might bring different ways of doing things that they have learned from their previous companies. However, “employees who have stayed too long in one organisation tend to be set in their ways and this might hinder innovation” as one employee put it. One employee stated that education needs to be coupled with experience. Hence, an individual with an educational theory, complemented by relevant practical experience, is most likely to create innovative ideas. Position tenure, or employees who have been in the same position for a long period, are better for bouncing ideas off as these individuals have generally seen what works and what does not, by bouncing ideas and including these employees, they are automatically engaged and begin to contribute to the discussion around innovation for that particular product or process and their contributions are extremely valuable.

Employees from this organisation believe that education, tenure, and demographic background attributes are sufficient to measure workforce innovation capacity in the metals industry. These dynamic capabilities should allow a business to ‘change’ or ‘adapt’ to the rapidly changing business environments. However, according to one employee from this organisation, “a transient advantage environment, at an organisational level, which focuses on innovation and understands change should also be considered when looking at dynamic workforce capabilities”. Transient advantage was introduced by McGrath (2013) as a business strategy that accepts that competitive advantages are often short lived and businesses need to take up new strategic initiatives based on short term or transient advantages. Company culture which allows people to try new things without fear of “being beaten with a stick” was also highlighted as a requirement at company level in order to foster and promote innovation. Employees attitude was also identified as key to innovation and “poor attitude destroy the entire team morale and stun the growth of innovative ideas in the team" as stated by the manager from this organisation. There was no further dynamic workforce capabilities suggested by the employees from this organisation.

4.5.3 *Feedback from Insights of employees from Company C*

The employees (manager and non-manager) from this organisation believe that education is an important tool for employees to develop ideas. Employees need to continuously learn to have new skills that they can apply and be innovative. Tertiary education gives employees a background in the principles of their chosen fields and these employees tend to understand and interpret challenges using both experience and education training. This gives them an edge when it comes to producing innovative ideas.

Total work experience which has been gained from various organisations is more important for innovation compared to just tenure in one organisation. This is because "employees who have spent too many years in one organisation become complacent and do not want to try new things as they have a history of other company failures" as the manager stated. Employees who come from other organisations can use previously gained experiences and skills to solve current problems in their organisations. However, tenure is also important for employees to develop innovative ideas as people who have spent time in the company understand the processes and products better and hence can make more innovative suggestions. The employees from this organisation also believed that people who stayed in one position for too long tend to be complacent and relaxed to such an extent that they don't contribute to new innovative ideas. However, these employees are "much better at implementing the ideas once these ideas have been created and a structured implementation plan has been developed". This is because these employees understand the organisation processes and know what to do to get support for their projects.

According to employees from this organisation, demographic background attributes of the employees do not play a major role when it comes to the creation of innovative ideas. The important thing is for employees to have the will to resolve challenges that the organisation is facing and for these employees to want to see their organisation succeed. The employees stated that gender is the least important as both males and females have created innovative ideas in their organisations. Gender mix is only important for a team that implements an innovative idea.

According to one employee from this organisation, “white employees are more likely to be more creative compared to Africans and this could have something to do with their upbringing”. The employee believes that white people are encouraged at a young age to think outside the box compared to their African counterparts. Indians are also typically more outspoken and would be more likely to give suggestions compared to Africans. However, the second employee did not share the same sentiments. The second employee felt that “racial mix is only important for implementation as it allows employees to be free since there are mixed genders and mixed races”. Therefore, all employees will feel like they “belong” to the team and time will be spent productively in implementing the solution rather than starting by trying to understand each other. The first employee also stated that a diverse team is needed for the successful implementation of any innovative project. There should be diversity in gender, tenure, and demographic backgrounds. Diversity in terms of educational background is more important though as this ensures diverse skills are brought into the project. Employees from this organisation also believed that education, tenure, and demographic background attributes were sufficient to measure workforce innovation capacity in the metals industry. A supportive environment, supported by rewards programs, was highlighted as crucial for innovation by the employees in this organisation.

4.5.4 *Summary of insights on the relationship between employee factors and firm level innovation in the South African metals industry*

From the interviews, it can be deduced that there is product and process innovation in the South African metals industry. One of the key drivers for this innovation is the education level of the employees. There is a positive relationship between education and firm level innovation. The common reason given for this is that educated employees understand the theoretical background and related principles about the work that they do. However, education needs to be complemented by relevant experience. In order to create innovative ideas, employees need to use their previous experiences (work and social). With education and work experience, employees are most likely to generate more feasible ideas which would lead to innovation. Therefore, there is a higher probability of getting suggestions that would lead to innovation from these employees compared to employees without tertiary education.

Another key outcome is that younger employees seem to have more appetite and energy to try new creative things compared to the older generation. However, experience is required to make meaningful suggestions as with age comes experience. What was common is that motivation is more important, and organisations need to create an environment where employees are motivated and where employees want to strive. This environment should also be made safe for all demographics to be innovative.

All the employees who were interviewed agreed that education, tenure, and demographic background attributes were sufficient indicators of the South African metals industry's workforce capability for innovation. These dynamic capabilities should be part of the innovation strategy of the organisation in response to changing environments. The attitude of employees towards education was another highlighted trait which should be considered for innovation. Company culture that allows people to make mistakes and not be blamed was also highlighted as a key enabling factor for firm level innovation in the South African metals industry. Financial rewards were also seen as a good incentive for employees to be innovate. A summary of the findings for the second hypothesis are summarise in Table 79 below.

Table 79: Summary of themes that came out of interviews for the second hypothesis

Hypothesis 2: Themes	Yes	Maybe	No
Employee education important for innovation	x		
Employee position important for innovation		x	x
Employee work experience in current important for innovation	x		
Employee total career in the field important for innovation	x		
Employee total career in other fields important for innovation	x		
Younger employees more innovative than older ones	x		
Older employees more innovative than younger ones			x
Employee gender important for innovation		x	x
Employee ethnic background important for innovation			x
Employee diversity important for innovation	x		

4.6 Insights from industry experts

The researcher had informal engagements with industry experts to determine their views on the innovativeness of the metals industry in South Africa, employee participation in the innovation process and collaborations between the various stakeholders in this industry. **The dtic** is a department of the South African government responsible for commercial and industrial policy, as well as the development of program to support the industry. It has sector desks nine sector desks who have a dedicated role of driving industrialisation in South Africa (South African Government, 2024). Of these sector branches, at five are involved with organisations in the metals industry, namely Automotives, Aerospace and Defense, Primary Minerals and Processing, Metals Fabrication and Rail, and Capital Equipment sector desks. Some organisations participate in programmes and incentive schemes offered by these sector desks and response from industry stakeholders in conferences and exhibitions is that the selection criteria and administrative requirements are what restrict them from participation. The department also has eight master plans, of which two, steel and metal fabrication, automotives (and components), are relevant to the metals industry. Therefore, government support is available for the metals industry in South Africa to be innovative.

Though there is this support from government, the foundries industry has been in shrinking in South Africa, from 450 foundries in the 1980s to 170 foundries in 2014, and further down to 123 in 2020 (Phiri et al., 2023). This metal foundry industry in South Africa is a key supplier of castings used in the manufacturing sector, including the mining and automotive industries. Therefore, more interventions are required to resuscitate these industries, and innovation would be at the centre of these intervention as it typically results in better, more efficient and higher quality products and operations. According to experts in the industry, revival efforts will not only require government interventions, but innovative efforts from the employee that drive efficiencies in their operations. The challenge, as stated by one industry expert, who has vast experience as a chairmen of various industry advisory panels, is that "organisations in the metals industry are more inward focussed and concentrate on their operational needs, rather than implementing solutions that address the needs of their customers". Therefore, innovators need to understand the overall perspective of their market.

The experts agree that there is innovation in the South Africa metals industry. Some of the innovative solutions mentioned included industry deep-level mining, refurbishment of high value components in power generation and innovative solutions for components production. These innovations are driven by unique sector challenges, such as electricity availability in South Africa, increased labour costs, international competitors, quality and costs. In general, the experts agree that employees are crucial to firm-level innovation and the volunteering of ideas by these employees should be encouraged and rewarded by the organisations. One expert stated that "an engaged employee is more likely to contribute to driving innovation within their organisation". However, decisions makers (executives and managers) play a pivotal role in creating an environment for employees to play in the innovation space.

According to an expert who works at a research institute in South Africa, there is a high level of collaboration between R&D organisations and HEIs, with no considerable industry involvement. The expert further elaborated that "industry has some reluctance in investing time and money into research activities and looking for innovative ways with research institutes and HEIs due to long timelines and costs associated with these activities". The solution is to have these activities led from the industry front and supported by the R&D institutes and HEIs.

4.7 Summary of the results and findings

The quantitative and qualitative results pertaining to the two research questions were presented in this section. The first stage was to determine if there is product and / or process innovation in the South African metals industry using the data received from the HSRC. The results from this data showed that 25 of the 33 organisations in the metals industry implemented product or process innovation during the period between 2014 and 2016. This equated to 75.8% of the overall organisations in the South African metals industry that participated in the HSRC study, which is almost ¾ of their sample in this industry.

The second step was to determine if the South African metals industry is innovative, using primary data received from the survey which was sent to the respondents using Qualtrics. This survey was conducted using the period between 2019 and 2021 with the intention of determining whether the outcomes had changed from the 2014-2016 period investigated using the HSRC data. The results showed that 33 out of 36 organisations, which is 91.7% of the respondents to the study, implemented product and / or process innovation between 2019 and 2021. Interviews with managers and non-managers from three organisations within the South African metals industry also confirmed that product and process innovation existed in their organisation during the same period. However, the demographics of these managers (two African female, one white female) and non-managers (two white male and one African male) were not representative of the South African demographic and the researcher did not have control over this since the organisations selected the individuals to be interviewed. However, the interviewed employees' demographics does not have material impact in these results since the subject was based on objective findings, i.e. did their organisations implemented product and / or process innovation between 2019 and 2021.

Once this was determined, the next step was to test the first hypothesis on who generated more innovative ideas between managers and employees who are non-managers within this period. The quantitative data from the primary survey showed that non-management employee generate more innovative ideas compared to managers. This was also confirmed by both the managers and non-managers during the interviews. One of the main reasons was that employees who are non-manager spend more time working on products and processes, which gives them an edge in generating improvement ideas. However, managers create the required environment and culture, which makes it conducive for employees to think creatively and come up with innovative ideas.

The results for the second research question were split into four hypotheses, which are listed below.

1. There is a positive relationship between employee education level and innovation at firm level.
2. There is a positive relationship between employee tenure and innovation at firm level.
3. There is a positive relationship between employee demographic background attributes and innovation at firm level.
4. There is a positive relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry.

All these hypotheses were tested and proven true using various statistics and were also confirmed true by the interviews conducted. During the quantitative component of the results, firm level innovation variable was determined by combining product and process innovation ideas that were generated by non-managerial employees and those generated by joint efforts of managerial and non-managerial employees. The Cronbach's Alpha for these firm level innovation variables was 0.681, which is greater than 0.65, meaning the results are reliable and that the different items making up the innovation variable are closely related. A positive relationship was observed between employee education level variable and firm level innovation variable, and the correlation coefficient was 0.646. From the regression analysis, the R-squared value was 0.417 which indicates that 41.7% of the variation of firm level innovation variable is explained by the education variable in that regression model. Interviews with both the manager and non-manager confirmed, based on the perspectives of the interviewees, that there is a positive relationship between employee education level and firm level innovation variables. Education of the employees, which was defined as a tertiary or post-matric (grade 12) qualification during the interviews, played a pivotal role in idea generation in all three organisations and was highly recommended. Employees who have tertiary education have an advantage in that they have the theoretical concepts which aid in understanding the work that they do. Individual development plans were used to identify skills gaps and a training budget was used to upskill the employees to close the gaps identified in all three organisations.

The tenure variable was determined by combining the number of years the employee spent in the organisation (job tenure), number of years the employee spent in the same position in the organisation (position tenure), total experience of the employee in that field, including experience acquired in other organisations (total work experience), and level of the employee position in the company structure (position level). The Cronbach's Alpha was 0.770, which is greater than 0.65, meaning the results are reliable and that the different items making up the tenure variable are closely related. A positive relationship was observed between tenure variable and firm level innovation variable. The correlation coefficient was 0.888, which signifies a strong positive correlation between the innovation and the tenure variables. The correlation between these variables was significant at 0.01 level. The R-squared value was 0.789 which indicates that 78.9% of the variation of innovation variable is explained by the tenure variable in that regression model. Feedback from the interviews was that employees with experience understand what the market is looking for and can develop ideas for product enhancement more easily. Total work experience in complementary industries was also identified as crucial to be innovative as the experiences gained gives one a more holistic view of the product value chain and the relevant technology landscape.

The employee demographic background attribute variable was determined by combining the gender of the employee (gender), age of the employee (age), and Ethnic background of the employee (background). The Cronbach's Alpha was 0.755 which shows that the results are reliable and that the different items making up the employee demographic background attribute variable are closely related. A positive relationship between employee demographic background attribute variable and firm level innovation variable was observed. The correlation coefficient was 0.914 which signifies a strong positive correlation between the innovation and employee demographic background attribute variables. The correlation between these variables is significant at 0.01 level. The R-squared value was 0.835 which indicates that 83.5% of the variation of innovation variable is explained by the tenure variable in that regression model. Feedback from the interviews was that younger employees have more appetite and energy to try new creative things compared to the older generation. One perspective from the interviews was that younger employees are more inclined to generate process-related innovative ideas, while older employees understand the product the most and are in a better position to generate product-related innovative ideas. Interviewees also felt that family background plays a role in making one innovative. This is especially true of how you were raised, what you were exposed to, and the availability of resources when you were growing up. However, a mix of employees with different genders, age and ethnicity is only crucial for the implementation of the innovation.

The dynamic workforce capabilities of interest in this study were the employee education level, work tenure and demographic background attributes. The workforce capability variable was developed by combining (adding) the education, tenure, and employee demographic variables. The Cronbach's Alpha was 0.790, which shows that the results are reliable and that the different variables making up the dynamic workforce capabilities variable are closely related in this study. The correlation was high and positive as shown by the correlation coefficient of 0.947. The correlation statistics between innovation and workforce capability variables was significant at 0.01 level. The R-squared value was 0.918 which indicates that 91.8% of the variation of innovation variable is explained by the tenure variable in that regression model. The analysis of variance (ANOVA) statistics was conducted, and the results showed a significance value that was low (<0.001) which indicates that there is 95% confidence that the slope of the regression line was not zero and there was a significant linear relationship between the dependent (firm level innovation) and the independent (dynamic workforce capability) variables. Feedback from the interviews also confirmed that employee education level, work tenure and demographic background attributes are key for employee (non-manager) firm level innovation.

CHAPTER 5. DISCUSSION OF THE RESULTS AND FINDINGS

5.1 Introduction

To recap, the purpose of this work is to expand the literature on the dynamic capabilities framework, which was introduced by Teece and Pisano (1994), by including workforce capabilities which are influenced by employee experience such as qualification, tenure and demographic background attributes. Teece (2007) defined the higher order capabilities which are necessary for firm level dynamic capabilities as sensing and shaping capabilities, seizing capabilities, and managing threats and reconfigurations. This work focuses on sensing capability which involves identifying and assessing emerging opportunities (Čirjevskis, 2019). Bhardwaj et al. (2021) defined the dynamic sensing capability in an organisation as the ability to direct internal research and development, decide on new technologies, bring suppliers and contributors innovation, identify target market segments, and recognise customer needs. However, this definition focuses on the organisation level and not on the employees in the organisation. According to a review by Fallon-Byrne and Harney (2017), there is little understanding of the mechanisms determining the origin and evolution of dynamic capabilities, while the role of employees has been neglected. This work proposes that employee experiences such as education, tenure and demographic background are dynamic workforce capability that have a positive influence on firm level innovation.

According to Teece (2007), the ability of individuals and organisations to create and discover new opportunities relies on access to information and the ability to recognise, sense, and shape developments. Odetunde (2019) introduced a three-phase model for innovation which involves creativity (idea generation), innovation (idea implementation) and innovation adoption. This work focused on the idea generation phase as it looked at innovative ideas generated by the workforce. However, only ideas that were eventually implemented (i.e., new product brought to market or process implemented within the firm's operation) formed part of the scope of this study. The definition of innovation that is used during this work comes from the Oslo Manual (2018). The fourth edition of the Oslo Manual defines innovation as “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (Oslo Manual, 2018, p. 20). This definition is also used by Keresztes and Endresz (2020). The focus is only on a new (or improved) product or process that has either been brought to market or used within the firm’s operations (Gault, 2018; Keresztes & Endresz, 2020). In this study, innovation needs to only be new to the firm but not necessarily to the industry, the country, nor the world because South Africa as a developing country still needs to catch up to the worlds technological frontier (Almeida & Fernandes, 2008; Edler & Fagerberg, 2017).

This chapter discusses the results and findings which were obtained in this study within the context of the literature. It starts by discussing the results on the product and process innovation within the South African metals industry, this is followed by a discussion of the results on who generates more innovative ideas between managers and non-managers in this industry, then lastly discusses results on the relationship between employee factors (qualification, tenure, and demographic background attributes) and firm level innovation in the South African metals industry. The quantitative and qualitative results are not discussed separately but are rather discussed by the research question they were designed to answer.

5.2 Discussion pertaining to Hypothesis 1

The first hypothesis of this research is that more innovation ideas are generated by employees compared to managers in the South African metals industry. However, to determine this, this research started by investigating if there was product/process innovation in this industry. Therefore, the discussion of the first hypothesis starts by focussing on the state of innovation in the South African metals industry and only focuses on the source (manager/employee) of the innovative idea after this. The results for the following two hypothesis are discussed in this section:

Hypothesis 1A: Process / product innovation exists at firm level for organisations in the South African metals industry.

Hypothesis 1B: More innovation ideas are generated by employees compared to managers in the South African metals industry.

5.2.1 *State of product and process innovation in the South African metals industry*

This section discusses the results that address the following hypothesis:

Hypothesis 1A:

Null Hypothesis – There is no process/product innovation of innovation in the South African metals industry.

Alternate Hypothesis – Process/product innovation exists in the South African metals industry.

Manufacturing has generally been described and accepted as a catalyst for economic growth and development all over the world as it provides a platform to produce goods and services, while facilitating job creation for the country (Afolabi & Laseinde, 2019). The manufacturing industry in South Africa makes up a large portion of the South African economy and it accounts for over 18% of the national gross domestic product (Chimucheka et al., 2019; Du Toit, 2003; South African Government, 2003). It has traditionally been resource based and heavily dependent on minerals which are mainly exported in primary metal (or ore) form. This, according to Oerlemans and Pretorius (2006), limits the country from beneficiating its vast mineral resources. Due to its large contribution to GDP, innovation is required to grow this sector and hence reduce unemployment in South Africa (South African Government, 2003). Chandran Govindaraju et al. (2013) also showed that innovation is a major driver for economic growth and firm performance for organisations in Malaysia, which is also a developing country like South Africa. However, the GDP contribution of the manufacturing sector in Malaysia is 31.6%, which is larger than that of the manufacturing sector in South Africa (Chandran Govindaraju et al., 2013). The GDP contribution of the manufacturing sector in South Africa in 2020 was 12%, while it was 23% in Malaysia during the same period (Ling et al., 2020; Loewald, 2020; Trading Economics, 2019). However, the GDP contribution of the South African manufacturing sector is similar to the 12% GDP contribution of same sector in Nigeria, which is the top ranked country in Africa by GDP followed by South Africa, during the same period (Afolabi & Laseinde, 2019; Trading Economics, 2019, 2023). The south African government has various industrial policies to stimulate innovation in this industry. **The dtic** has five of the nine sector desks, and two of the eight directly supporting the metals industry (South African Government, 2024).

Innovation is important for business survival and most organisations conduct product or process innovation (Hamel, 2006; Hanaysha et al., 2022; Srisathan et al., 2020; Y. Zhang et al., 2019). The definition of innovation that is used during this work comes from the Oslo Manual (2018). The fourth edition of the Oslo Manual defines innovation as “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (Oslo Manual, 2018, p. 20). Organisations need to constantly develop and introduce new or improved products to the market, whilst also improving their internal processes to become more efficient (Hanaysha et al., 2022; Sithole et al., 2021; Srisathan et al., 2020). A study by Sithole et al. (2021), using the HSRC data which were gathered from 41 535 organisations in South Africa on innovation conducted between 2014 and 2016, showed that 69% of the organisations in this industry participate in innovation activities. Earlier results by Moses et al. (2012) showed that 65.4% of the organisations in South Africa were innovative between 2005 and 2007. This shows an upward trend between these periods but the focus was on the entire manufacturing sector. Sithole et al. (2021) then focused on product and process innovation only and the percentage of organisations involved in these types of innovation increased to 82.8%. Product innovation is defined as the introduction (to the market) of a good or service that is new or significantly improved with respect to its characteristics or intended uses (Moses et al., 2012; Oslo Manual, 2018). With product innovation, a firm can strategically differentiate its products offering in the marketplace, thereby satisfying market demands, building customer loyalty, and improving its overall performance (Toga, 2017). Process innovation is defined as the implementation of a new or significantly improved production or delivery method (Moses et al., 2012; Oslo Manual, 2018). It is concerned with the renewal of means of production within an organisation and drives the performance of the organisation by improving productivity and lowering production costs (Moses et al., 2012; Toga, 2017).

The focus of this work is only on the metals industry and not the entire manufacturing sector in South Africa. Hypothesis 1A states that process and or product innovation exists at firm level for organisations in the South African metals industry. Therefore, the HSRC data, which were also used by Sithole et al. (2021), was further filtered to only 33 organisations that produce or process metals and this became the sample used in this study. The results from this sample showed that 75.8% of the organisations in the South African metals industry were involved in product and process innovation between 2014 and 2016. The difference in percentage achieved in this study compared to the 82.8%. achieved by Sithole et al. (2021) for the full manufacturing sector can be attributed to a smaller data set that were sampled for the metals industry only and the different types of organisations that make up the manufacturing sector (e.g. petroleum, food and beverages, wood and paper production, etc.). However, the 75.8% positive responses (3/4 of the sample) were sufficient to show that the South African metals industry was innovative during that period as evident in its involvement in product and process innovation. These findings are also supported by the research conducted by Toga (2017) on the South African steel industry.

The results from the HSRC data on metals industry also showed that 54.5% of the product innovations originated in South Africa and only 21.2% originated abroad. However, most of the product innovations were not new to the world as shown by a low percentage (24.2%) of the organisations that stated that they introduced products which were entirely new to the world. The work by Medda (2020) also showed that innovation acquired from other companies has a positive impact on process innovation within the organisation even though that work did not find any conclusive results on product innovation. Some of the respondents during the interviews in the current study stated that firms in the South African metals industry are mainly involved with incremental innovation and not radical innovation. This finding was also observed by Oerlemans et al. (2004), Oerlemans and Pretorius (2006) and Almeida and Fernandes (2008) who concluded that this incremental innovation is mainly done in an imitation mode by copying and making minor changes to products from advanced countries. During the interviews, one of the interviewees from Company C also stated that organisations in the South African metals industry are more interested in “gradual or continuous improvements on an existing product or processes”. One of the reasons, as stated by an interviewee from Company A, was that South African organisations in the metals industry are trying to catch up to their European counterparts and are more reactive to markets rather than leading market changes. This could be attributed to the lower levels of R&D investment and overall low (1.6%) GDP growth projections for South Africa.

Organisations in the metals industry in South Africa are mainly involved in closed innovation even though there are some elements of open innovation when it comes to product innovations they put to market, as the products are suggested or developed in response to the customer and market needs. This is supported by their involvement in mainly incremental innovation as stated above, little collaboration with other organisations when it comes to innovation initiatives as confirmed during the interviews, and mainly using internal resources for research and development activities. This is supported by the research finding of Almirall and Casadesus-Masanell (2010) and Dost et al. (2020). Even though this sector did invest in research and development (R&D) as confirmed by the interviews, the investment as a percentage of turnover is low compared to firms in the manufacturing sector of developed countries in the West. R&D budget as a percentage of turnover was used in this study because the work by Bogliacino (2014) had shown that increasing R&D expenditure and intensity results in increased turnover for organisations and increased employment opportunities.

Open innovation integrates ideas that are generated by external sources such as suppliers, collaborators, and customers with internal R&D (Almirall & Casadesus-

Masanell, 2010; Lazzarotti & Manzini, 2009; Von Hippel, 2010). In this study, the findings obtained during interviews showed that all organisations were involved in innovation in response to customer market needs rather than the desire to pioneer something. However, the organisations that were part of the survey and those interviewed highlighted that their firms were not collaborating with other organisations within or outside this industry to develop innovative products or processes. The research and development on product prototypes, for all organisations interviewed, was done internally with limited to no collaboration with HEIs, government institutions and research councils within and outside of South Africa. This is classical of a more closed innovation approach as opposed to a more open innovation approach. The South African metals industry should aim to increase its innovation openness by collaborating more with other stakeholders such as partners, customers, suppliers, and competitors. These interactions with other stakeholders are crucial for these organisations to stay abreast with new technologies and innovations since they tend to purchase technologies or imitate products from developed countries (Almeida & Fernandes, 2008; Oerlemans & Pretorius, 2006). According to Almirall and Casadesus-Masanell (2010), open innovation also tends to result in product innovations that are better aligned to customer expectation. The work by Manzini et al. (2017) found that factors that drive the companies toward closed innovation are high levels of R&D investment, high emphasis on radical innovation, high technology intensity, and globalisation. However, the findings in this research did not confirm this since the South African metals industry practiced more closed innovation even though their level of R&D investment was low, the emphasis was more on incremental innovation and their activities required less technologically intense equipment.

The researcher investigated the state of innovativeness of the metals industry in South Africa between the period of 2019 to 2021 in order to compare to the results achieved from the 2014 to 2016 period. A primary survey was sent to 36 respondents to understand if their organisations were involved in product or process innovation between 2019 and 2021. The results from the primary survey showed that 91.7% of the 36 respondents stated that their organisations were involved in product or process innovation between 2019 and 2021. The difference

(75.8% vs 91.7%) can again be attributed to the different data sets (number of respondents and difference in actual organisations that responded to the two different surveys), different study periods (2014-2016 and 2019-2021). However, both surveys results were positive meaning that the South African metals industry is innovative. Interviews conducted also confirmed these findings. This is also aligned to the findings by other authors such as Oerlemans et al. (2005), Gaglio et al. (2022), and Kahn et al. (2022) to name but a few.

The results from the primary survey were stratified based on their turnover and number of employees because large firms have more financial power to conduct process and/or product innovations compared to smaller firms. This is contrary to the work by Ayandibu and Houghton (2017) and that of Olufunso et al. (2010) who stated that the South African manufacturing sector should be stratified into large, medium and small enterprises according to total number of employees, total annual turnover and total gross asset values. Gross asset values were not used in this study as control variables since the focus was more on the workforce rather than the organisation itself. The results showed that the majority (69.4%) of respondents in the survey worked for large organisations, while SMEs made up 30.5%. Stratified sampling allows for the population to be divided into more homogeneous subgroups which gives more reliable and detailed information about the sample (Etikan & Bala, 2017). Larger firms generally have a greater variety of options than small firms in terms of resources, capabilities and power (Sawers et al., 2008). However, small innovative firms are generally characterised as being flexible and having the ability to respond faster to changing needs and environments (Sawers et al., 2008).

The stratified survey results show that 88% of large organisations were involved in innovation activities between 2019 and 2021, whereas for SMEs, all organisations tested claimed to have been involved in innovation during the period of interest in this study. This is contrary to the study by Oerlemans et al. (2004) which found that larger organisations in the South African manufacturing and service sectors had higher innovation rates compared to their smaller counterparts. The period investigated by Oerlemans et al. (2004) was 1998 to 2000. These opposing results could be due to differences in the industries investigated (metals industry versus manufacturing and service sector). Smaller organisations are also more flexible to implement innovative changes since there is less structural layers for decision making compared to larger organisations (Sawers et al., 2008). Therefore, they are able to respond faster to changing needs and environments (Sawers et al., 2008). This was also supported by the work of Fallon-Byrne and Harney (2017) who highlighted the importance of flexible structures and empowered employees in supporting innovation in organisations. Larger firms generally have greater resources and more options to develop capabilities compared to small firms (Sawers et al., 2008). This was supported by some interviewees who stated that managers and owners in SMEs are more entrepreneurial and do not have to deal with as much red tape, or be weighed down by complicated management structures as compared to larger organisations. Matekenya and Moyo (2022) also showed that innovation is crucial for SMEs' development and growth in South Africa.

Smaller/low growth firms are not able to spend too much on formal R&D activities due to a lack of funds which could be the reason for their low survival rate (Matekenya & Moyo, 2022). More support needs to be provided to smaller firms with lower sales growth, given the large financial outlay required for R&D expenditures. These firms are encouraged to introduce new products and methods of production that do not require major financial outlays due to lack of funding for R&D (Matekenya & Moyo, 2022). In South Africa, there has been an increase in government support for SMEs over the years which is aimed at assisting smaller firms to innovative in order to survive (Booyens, 2011; Matekenya & Moyo, 2022; Peters & Naicker, 2013; Rahman et al., 2016).

In order to actively participate in the innovation activities, organisations need to adopt innovation as part of their strategy (Kankisingi & Dhliwayo, 2022; Lee et al., 2019; Vermaak & Steyn, 2014). Around 94% of the organisations stated during the primary survey that they have an intentional innovation strategy as part of their organisation strategy. An intentional innovation strategy means that there is a conscious and purposeful search for innovation opportunities within the organisation (Nybakk & Jenssen, 2012). During the interviews, all interviewees from the three organisations confirmed that their organisations have innovation as part of their company strategy which is explicitly expressed in the internet websites homepages of these organisations. These strategies are translated into formal innovation programs as stated by interviewed employees from all three organisations. The results have also shown that organisations in the South African metals industry (large and SMEs) invest a minimum of 5% of their turnover as R&D budget. These findings are contrary to the work of Matekenya and Moyo (2022) who found that SMEs in South Africa do not have sufficient funds to engage in formal R&D activities. The sample used for case study interviews was very small (three organisations) and perhaps the results would be different if other organisations, especially small and micro enterprises, were sampled for the case study. R&D activities could also result in sunk costs for the organisations especially when there is persistence in developing products that do not meet the market needs (Mañez & Love, 2020). Perhaps this could be one of the reasons for lack of formal R&D programs that was discovered by Matekenya and Moyo (2022). According to Bogliacino (2014) decrease in financial returns or productivity after research and development could also be due to other fixed factors such as talent. Therefore, the employees within the firm are crucial in order to gain the envisaged returns from the innovation processes.

The interviewees also stated that there was informal innovation happening outside the formal funded research processes in their organisations. Informal innovation is based on embodied technological change or tacit knowledge accumulation, without formal research (Bogliacino, 2014). The findings from the interviews showed that the ideas generated, which results from these informal innovations, were discovered during problem-solving, interactions with new technologies, and interactions with stakeholders, especially customers. These findings are in support of the results from the work by Almeida and Fernandes (2008) that interaction with new technologies results in new innovations for organisations in developing countries, and is more crucial than formal R&D processes. According to Hall et al. (2009), investment in equipment enhances the likelihood of having both process and product innovation and has a positive impact on the productivity of organisations. In this study, 88% of the organisations invested in new equipment during the period between 2019 and 2021. However, these organisations were mainly engaged in internal research and innovation, with little to no collaboration with HEIs and Research Councils. Therefore, only internal resources to the organisation are responsible for generating, developing and implementing innovations. This means organisations within the metals industry in South Africa are mainly involved in closed innovation (Almirall & Casadesus-Masanell, 2010; Dost et al., 2020). Contrary to that, open innovation integrates ideas that are generated by external sources such as suppliers, collaborators and customers with internal research and development (R&D) (Almirall & Casadesus-Masanell, 2010; Lazzarotti & Manzini, 2009; Von Hippel, 2010). During the interviews, one of the reasons for little to no collaborations between organisations in the South African metals industry and HEIs was that "collaboration becomes tedious and assigning ownership of the new technology or invention is often the holdup". According to Almirall and Casadesus-Masanell (2010), the protection of intellectual property (IP) by the organisation is one of the typical signs of closed innovation. However, conducting internal R&D and engaging in closed innovation is not a disadvantage for the organisations. This was also confirmed by the study by Medda (2020), using European manufacturing companies from France, Germany, Italy, Spain, and the UK, which showed that internal R&D has a positive and significant effect on the probability to introduce product innovations, process innovations, or both innovations together. Therefore, since this work focused on product and process innovation, the fact that organisations within the metals industry in South Africa conducted internal research with little to no outside collaborations would not have a significant impact on them being innovative.

This section showed that there is product and process innovation within the metals industry in South Africa. These findings were supported by results from the HSRC data, the primary survey, the interviews, and literature. Therefore, the null hypothesis, which states that there is no process/product innovation in the South African metals industry is rejected, and the alternate hypothesis which states that process/product innovation exists in the South African metals industry is accepted. The following section discusses the results on who generates more innovative ideas between managers and non-managers in this industry.

5.2.2 *Idea generation in the South African metals industry*

In this work, the higher order dynamic capability of interest is the sensing capability which refers to the ability of a firm to identify threats locally and abroad. It involves scanning, creation, learning, and interpretive activity across technologies and markets (Pasamar et al., 2015). It also involves research activity and the probing of customer needs and technological possibilities (Teece, 2007). This is related to the idea generation phase in the five-phase innovation model by Mariello (2007) and later on in the three-phase innovation model by Odetunde (2019). However, only ideas that have been implemented (i.e., new product brought to market or process implemented within the firm's operation) were considered as part of the scope of this work. The implementation of ideas is in line with the second phases in Odetunde (2019)'s model. It is also associated with the seizing capability which refers to the ability of the organisation to mobilise resources to deliver value and shape new markets (Teece, 2007). The last phase of the three-phase model by Odetunde (2019), which is innovation adoption, is not considered in this work and this phase in associated with the performance and continued use of the innovation in the market. This work did not test for performance of the innovation over a period of time to determine adoption as the focus was on implementation (bringing a product / process to market or implementing a process within the organisation's operations). Hausman and Stock (2003) explained that adoption of innovation requires a long-term relationship between the firm and its customer. Adoption of the innovations from the South African metals industry in the market could be tested, for future work, using the three key performance indicators (KPIs) for innovation which were developed by Banu (2018). These KPIs are the performance of the innovation; the relationship between actual financial resources needed, projected budget and expected experimental results, and the increase in innovation success rate by identifying as many external channels as possible for accessing expertise in critical areas of the project (Banu, 2018).

The focus of the research by Banu (2018) was on performance (actual vs budgeted) of the innovation but does not explicitly explore input factors for the innovation. This work focuses on the dynamic workforce capabilities as a critical input factor for firm level innovation in the South African metals industry. This section discusses the results that address the following hypothesis:

Hypothesis 1B:

Null Hypothesis: There are fewer innovation ideas generated by employees compared to managers in the South African metals industry.

Alternate Hypothesis: There are more innovation ideas generated by employees compared to managers in the South African metals industry.

According to Gupta and Singhal (1993) people, not products, are the major assets for innovative companies. The origin of these innovative ideas was investigated in this work. The work by Meister and Willyerd (2021) also showed that employees are crucial for innovation in organisations, and companies should develop strategies to attract, develop, engage and retain these employees. A survey was sent to 36 respondents asking who creates more innovative ideas between managers (employees with direct reports) and the workforce (non-managers or employees without any direct report). The results were that 31 out of the 36 respondents responded that the workforce creates the most innovative ideas in the South African metals industry compared to managers. When the respondents were asked if managers in their organisations created more ideas than employees who are non-managers in their organisations, the percentage of positive responses came down to 30% (11 positive responses). Therefore, it could be concluded that more innovative ideas are generated by the workforce compared to managers in the South African metals industry. The results also showed this to be true for both product and process innovations. The results from the comparison of means on product and process innovation implemented in the respondent's organisations were greater (above 4) for ideas generated by employees (or joint effort with manager) compared to ideas generated by managers only (approx. 2).

Managers still play a crucial role as internal change agents that need to promote the implementation of new ideas by creating a supportive climate for creativity and managing the innovation process (Kremer et al., 2019; Rajiani & Ismail, 2019; Volberda et al., 2014). In this work, innovation ideas that originate from combined management and workforce efforts are attributed to employees since the prevailing paradigm is top-down, so any instance of employee-level innovation, irrespective of whether it's wholly attributable to the employee(s), is a valid counterexample (Monyepao & Uwizeyimana, 2018; O'Brien, 2019). The interviews also confirmed that more innovative ideas are generated by the workforce compared to managers from all three organisations. The main reason was that employees who are not managers are more exposed to operational challenges and hence creativity is driven from finding alternative solutions. This typically results in the development and implementation of more efficient production processes. The deeper understanding of internal products and processes, based on amount of time spent exposed to these, give the non-manager employees the edge to creating more innovative ideas. This is also supported by their technical knowhow, exposure to global expertise, knowledge gained from participation in previous problem-solving exercises. These findings are in agreement with the work by Felstead et al. (2020) who also showed it was the employees who come up with ideas about improving the work processes that they use daily, products they make and services they provide to customers. As employees interact with the products and processes within the organisation, they gain considerable skills and acquire significant knowledge through their interactions with technology, materials, the market, customers and users (Echebiri et al., 2021; Hammond et al., 2011; Høyrup, 2010; Tirabeni & Soderquist, 2019). This gives the employees more opportunities to generate innovative ideas compared to their managers as confirmed from the survey and during the interviews. The work by Gupta and Singhal (1993) also showed that people are the most valuable resources for innovation. Høyrup (2010) also showed that employee-driven innovation is crucial for the success of organisations and that organisations should aim to understand the importance of employees in driving product and process innovations. However, the results that employees who are non-managers generate more innovative ideas than managers in the South African metals industry in this study are a novel contribution to literature as, according to the author's knowledge, no other researcher has investigated this before.

The results from this study show that managers typically support the implementation of ideas rather than generating them. They also create a conducive environment by supporting and encouraging employees to develop innovative ideas. The supportive role of the managers is crucial for employees to be innovative, and this was also confirmed by Ramus (2002) who observed that the supportive supervisory behaviours of the managers can increase the probability that employees generate innovative ideas. Some of the key requirements for managers to develop innovative employees (or teams) according to Kremer et al. (2019) are developing the right group norms, designing teams strategically with innovation in mind, managing interactions with other employees outside the team, showing support as a leader, displaying organisational support, and using performance management effectively to measure and reward innovation efforts. Mariello (2007) also stated that screening of ideas should be transparent, so employees are more comfortable in contributing more ideas. Ideas should be progressed based on commercial success potential rather than the role or influence of the employees. During the interviews in this study, empowerment, involvement, and transparency were some of the specific practices that the interviewees felt were necessary in order to foster innovative behaviours in their organisation. Empowerment gives people the feeling that they possess a certain degree of autonomy and feel less constrained by the rules (Gottlieb et al., 2021; Isaacs et al., 2022; Jonas, 2010). These employees become more efficient in executing their roles. The work by Ramaswamy (2009) also showed that it is crucial for managers to create a culture of transparency and empowerment in the workplace in order for organisations to co-create value with their employees.

Managers also work within the context of the organisation. The results from the interviews showed that the organisation also needs to create an environment that supports the creativity of employees and to provide resources necessary to exploit any opportunities available. According to Gupta and Singhal (1993), successful companies create competitive advantage in the marketplace through innovation and creativity. Such companies are innovative and creative not by accident as they effectively manage human resources to create and market new products and services. Successful innovation-based companies have learned how to manage, motivate and reward these employees for generating innovative ideas (Gupta & Singhal, 1993). However, innovation has a longer-term payback with a higher financial risk and therefore some managers become reluctant to invest in it especially if they have short-term returns in mind as expressed during the interviews. Research by Nybakk and Jenssen (2012) has also shown that innovation can be risky and that failure is one of the most likely outcomes. This pushes managers to focus more on current production outputs to drive revenues as opposed to thinking long-term by implementing innovative ideas. In order to reduce the potential negative impact of innovation on costs, Mariello (2007) also suggested that screening of ideas should be transparent and innovative ideas should be progressed based on potential commercial success rather than the role or influence of the senior employees and leaders. Innovation should also be incorporated in the recruitment policies as stated by (Gupta & Singhal, 1993). During the interviews, it was observed that all organisations had a training budget. Employee training should be considered as a measure of human capital (Børing, 2017). However, this training budget was not linked to innovation but was done to comply to legislative requirements in South Africa, even though various authors had shown that training has a significantly positive relationship with innovation (Bauernschuster et al., 2009; Børing, 2017; Dostie, 2018; Kesen, 2016). Another reason was that organisations in the metals industry in South Africa could claim back the training expenses from the government under the skills development levy and this financial incentive was one of the drivers for the training budget (Kraak, 2008; South African Revenue Services, 2023).

This section discussed the results on the source of innovation in the South African metals industry. The hypothesis was that more innovation ideas are generated by employees compared to managers in this industry. Therefore, the null hypothesis, which states that there are fewer innovation ideas generated by employees compared to managers in the South African metals industry, is rejected and the alternate hypothesis which states that there are more innovation ideas generated by employees compared to managers in the South African metals industry is accepted.

5.3 Discussion pertaining to Hypothesis 2

The purpose of this work was to expand the literature on the dynamic capabilities framework to include dynamic workforce capabilities within the conceptual framework of innovation. The proposition was that the dynamic workforce capabilities are made up of employee experiences. The employee experiences of interest in this work were education qualification, tenure, and demographic background attributes. Therefore, the second hypothesis that was investigated in this study was that there is a positive relationship between employee factors (qualification, tenure, and demographic background attributes) and firm level innovation in the South African metals industry. This relationship was tested using a quantitative analysis of the data received from the primary survey, and qualitative findings from the interviews with employees from three organisations within the metals industry in South Africa. The quantitative and qualitative results are discussed in this section.

Before the results for the second hypothesis are discussed, it is worthwhile to recap on some of the research that influenced this work. Organisational capabilities were defined by Winter (2003) as the ability of the organisation to effectively manage resources such as employees to gain an advantage over competitors. However, the internal and external environments to the organisation are constantly changing and therefore these capabilities need to also be dynamic in order to respond to these changes (Dawson, 2000; Teece & Pisano, 1994; Varsani, 2018). The theory of dynamic capabilities draws upon concepts such as innovation, organisational learning and knowledge management which are key mechanisms for organisational change (Fallon-Byrne & Harney, 2017). The dynamic capabilities framework was defined by Teece et al. (1997) as a “framework that analyses the sources and methods of wealth creation used by private firms operating in environments of rapid technological change” (Teece et al., 1997, p. 509). Teece (2009) offered another definition, which is slightly modified in comparison to the earliest definition, and defined dynamic capabilities as “high-level activities that link to management’s ability to sense and then seize opportunities, navigate threats, and combine and reconfigure specialized and co-specialized assets to meet changing customer needs, and to sustain and amplify evolutionary fitness, thereby building long-run value for investors" (Teece, 2009, p. 54). This definition restricts the responsibility to sense and then seize opportunities on the managers, not the non-managerial workforce. It was also supported by various authors who expanded the dynamic capabilities framework by including the dynamic managerial capabilities (Adner & Helfat, 2003) (Ambrosini & Altintas, 2019; Heubeck & Meckl, 2021; Huy & Zott, 2019; Schwarz et al., 2020; Teece, 2018). This work aims to remove this restriction to only managers and expand literature to include the dynamic workforce capabilities. These dynamic workforce capabilities are only explored within the limits of the sensing capability and further work can be conducted to investigate if they would be applicable to other higher order capabilities such as seizing and reconfiguration capabilities. A recent study by Wang et al. (2024) also looked to explore this gap in literature by looking at impact of the employee dynamic capabilities on employee digital performance in China. However, their focus is more employee digital performance, which is the utilisation of digital technologies by the employees, in Chinese small and medium enterprises engaged in digital operations (Wang et al., 2024). Therefore, the profile and technologies used by these organisations are different to those use by organisations in the metals industry in South Africa.

Yuan and Woodman (2010), showed that employee innovative behaviour, which is involved with developing, adopting, and implementing new ideas for products and work methods, is an important asset that enables an organisation to succeed in a dynamic business environment. Innovative behaviour was defined by Lukes and Stephan (2017) as the "behaviours through which employees generate or adopt new ideas and make subsequent efforts to implement them" (Lukes & Stephan, 2017, p. 4). It is concerned with behaviours that employees need to introduce and apply new ideas, products, processes, and procedures to their roles, work units, and organisation. Bani-Melhem et al. (2018) also studied the impact of workplace happiness, co-worker support and job stress on employee innovative behaviour. The authors found that workplace happiness is the most significant determinant of employees' innovative behaviour, while co-worker support plays a significant mediating role. Job stress alone was not a significant mediator and only played a mediating role when combined with co-worker support. The current work focuses on employee related capabilities which are crucial in developing innovative ideas within the South African metals industry. The previous section proved that there is firm level innovation in the South African metals industry. This section then investigates the effect of these dynamic workforce capabilities on firm level innovation in the South African metals industry. The results for the following two hypotheses are discussed in this section:

Hypothesis 2A: There is a positive relationship between employee education level and innovation at firm level.

Hypothesis 2B: There is a positive relationship between employee tenure and innovation at firm level.

Hypothesis 2C: There is a positive relationship between employee demographic background attributes and innovation at firm level.

Hypothesis 2D: There is a positive relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry.

5.3.1 *Education as a dynamic workforce capability that affects firm level innovation in the South Africa metals industry*

This section discusses the results about the relationship between employee education and firm level innovation in the South African metals industry. The hypothesis tested was the following:

Hypothesis 2A:

Null Hypothesis: There is no statistically significant relationship between employee education level and innovation at firm level in the South African metals industry.

Alternate Hypothesis: There is a positive relationship between employee education level and innovation at firm level in the South African metals industry.

The discussions on the first hypothesis have concluded that the South African metals industry is innovative, and more innovation ideas are generated by the workforce (non-managers) compared to managers. This section also showed that a training budget is available in this industry even though it is not specifically targeted for innovation activities. The technical nature of the product and process in the South African metals industry is metallurgical in nature. Therefore, science and engineering qualifications play a major role in the development of innovative products and processes in this industry. For the statistical analysis of the relationship between employee education and firm level education, the variable for firm level had to be determined first. The Cronbach's Alpha, which is the measure of internal consistency for a closely related set of items, was 0.681 which is greater than 0.65, meaning the results are reliable and that the different items making up the innovation variable are closely related (Lee, 2015; Shrestha, 2021).

Correlation and regression statistics were used to determine the relationship between employee education level and firm level innovation. The correlation coefficient achieved was 0.646 signifying a moderate positive correlation between the variables tested (Coetzer, 2007; Taylor, 1990). The positive value of the correlation coefficient indicates that a positive increase in employee education level would result in a positive increase in the innovation variable (Lee, 2015; Taylor, 1990). The correlation between these variables is significant at 0.01 level (2-tailed). Therefore, a positive relationship between employee education level and innovation at firm level in the South African metals industry was achieved in this work. The use of correlation statistics to determine the relationship between employee education as a method to stimulate new ideas or creativity among their staff and enterprises' innovation activities was also conducted by Børing (2017) though in Norwegian firms. The similarity between this work and that of Børing (2017) is the focus on idea generation in term of innovation and not the other phases of innovation such as implementation and adoption of the innovation that were mentioned in the three-phase model by Odetunde (2019). This work also focused only on product and process innovation. However, Børing (2017) saw employee education as the outcome of the organisation training initiatives, while in this work employee education is seen as the tertiary education qualifications that the employee possesses. This work does not test if this education qualification was acquired prior to joining the organisation or through the use of the organisation’s training budgets. However, the results during the primary survey confirmed that all (100%) organisations who made up the sample had a training budget. This was also confirmed during the interviews. Further training of employees was also shown to be crucial for innovation by Brandenburg et al. (2007) as it adds to the knowledge and capabilities of the workforce. Therefore, a training budget promotes a learning culture within the organisation which facilitates the employees’ performance and increases their efficiency and effectiveness with innovation and creativity (Usman et al., 2011). According to Klein and Knight (2005), organisational characteristics that together enhance the likelihood of successful implementation of innovation, include a strong, positive climate for implementation; management support for innovation implementation; availability of financial resource; and a learning orientation. Therefore, learning culture is promoted at an organisation, rather than individual level. However, an organisational learning culture also promotes employees to acquire further education and training. In this work, employee education was tested as one of the workforce capabilities, not organisational learning culture or budget, since this education happens at an individual level.

The findings by Børing (2017) were that there is a positive relationship between education and firm level innovation. These findings are similar to those observed from the correlation results in this work. According to Taylor (1990), correlation coefficients between 0.36 and 0.67 are considered as moderate. Therefore, the correlation statistics observed were moderately positive since the correlation coefficient was 0.646. The findings from the interviews conducted during this research also confirmed that employee education is crucial and has a positive impact on the generation of innovative idea by the employees. Medase (2020) also found that a higher level of educated workforce in a firm stimulates the capacity to comprehend, create and process information swiftly compared to those without education. This was supported by the findings that employees who have tertiary education understand the theoretical concepts underpinning the work that they do, during the interviews. This gives them an advantage of suggesting more feasible ideas compared to employees without post high school qualifications in the South African metals industry. This is in line with the findings by Oerlemans and Pretorius (2006) that the greater the percentage of highly educated employees in South African firms, the higher its innovative outcomes will be.

The regression analysis was conducted on the results for the primary survey to determine if employee education level was a good predictor for firm level innovation in the South African metals industry. The regression statistics are used to infer a causal effect between the variables studied (Bambale, 2014; Kavitha et al., 2016). The R-squared value was 0.417 which indicates that 41.7% of the variation of innovation variable is explained by the education variable in this regression model. R-Squared is a statistical measure of fit that indicates how much of the variation in the dependent variable is explained by the independent variable (Lee, 2015). In this work, the regression model explained about 41.7% of all the variability in the dataset. This was acceptable since the results of the analysis of variance (ANOVA) test gave a low (<0.001) significance F which indicates that the statistics were significant, and innovation could be explained by the education variable in this study. The F-value is used to test the hypothesis that the slope of the independent variable is zero (Lee, 2015). Significance F is the p-value for the null hypothesis which shows that the coefficient of the independent variable is zero and a low p-value indicates that a significant relationship exists between dependent (innovation) and independent (education) variables (Lee, 2015). Therefore, the regression statistics showed that an increase in employee education would result in an increase in firm level innovation in the South African metals industry. The use of regressions statistics to derive a casual-effect was also done by Rothaermel and Hess (2007) to show that antecedents to innovation could be found at individual, firm and network levels using quantitative research.

The downside of education, which was highlighted during the interviews, is that it tends to make people to be normalised as they have the same training, think the same way, and do things the same way due to their background training. Therefore, education diversity in qualifications and training institutions is more crucial. This means organisations should avoid recruiting employees from only one tertiary institution but aim for diversity with regards to recruiting from various tertiary institutes. The work by Mohammadi et al. (2017), using organisations in Sweden, also showed that having more workforce diversity in terms of both ethnic background and educational disciplinary background is positively correlated to the share of a firm's turnover generated by radical innovation. Individuals with diverse backgrounds are able to perform more information processing and make deeper use of the information, which is important to accomplish complex tasks such as implementation of innovative ideas. Mohammadi et al. (2017) also shows that having more external collaborations does seem to reduce the importance of educational background diversity. However, in the South African metals industry, there is little to no collaborations between organisations, HEIs and research councils. Therefore, diversity in education backgrounds becomes important in this industry. According to Bello-Pintado and Bianchi (2018), there is a positive relationship between workforce education and innovation performance. The authors found that formal educational background of the workforce was one of the main indicators of a firm’s internal capabilities and it is one of the most important source of knowledge and expertise in firms (Bello-Pintado & Bianchi, 2018).

The majority of employees in the metals industry in South Africa are unskilled and semiskilled workers (Makgetla, 2014). These employees without tertiary qualifications are mainly involved with routine production work as production operators. These employees also contribute to process innovations based on the knowledge they have of specific processes. For these employees, on the job training to enhance their skills is crucial as was also observed by Børing (2017). However, this training is mainly done to improve their productivity. The study by Børing (2017) also showed a positive relationship between on the job training and productivity of employees. In this industry, these employees are less interested in formal degrees and are more interested in informal learning that will make them more efficient in doing their day-to-day jobs. This finding was also observed by Coetzer (2007) while studying the manufacturing companies in New Zealand. The innovative ideas from the employees typically come through informal processes, such as informal discussions, rather than set formal processes within their organisation. Therefore, these ideas from the employees are most likely to be presented by the technicians and engineers they work with to the formal business structures and processes. Employees such as operators are closer to technicians and engineers since they work with them on a day-to-day basis and because of the higher power distance culture in the South African manufacturing sector which makes lower ranking individuals less likely to approach their managers (Kwantes et al., 2018; Rinne et al., 2012).

There has been a rise in the percentage of skilled labour in the South African manufacturing sector which is driven by the current legislations which require grade 12 as a minimum qualification for work purposes and the reliance on skill biased technologies procured from developed countries (Edwards, 2004; Leibbrandt et al., 2010). This has given the metals industry access to skilled employees with tertiary education qualifications. The majority of employees engaged with product and process innovation are the ones with tertiary qualification, even though they don’t have advanced post-graduate qualification like those in pharmaceutical industries and research councils Rothaermel and Hess (2007). This is because the focus of the organisations in the metals industry in South Africa is on improving productivity and revenues, not patents and journal publications (Almeida & Fernandes, 2008). This was also highlighted by the lack of collaboration with HEIs and research councils which was one of the findings during the interviews. The primary survey also showed only 33% of the organisations formed strategic alliances or collaborations with HEIs or research councils. Some of the reasons given during the interviews were lack of clarity on ownership of the intellectual property, HEIs assigning students to projects who need to publish the results as part of their university requirements and the slower pace at which HEIs develop solutions while organisations need quicker responses in order to be ahead of their competitors in this industry. These are some of the reasons that have landed the South African metals industry to more closed innovation (Almirall & Casadesus-Masanell, 2010; Dost et al., 2020).

This section has shown that employee education, as a dynamic workforce capability, has a positive impact on firm level innovation in the South African metals industry. Therefore, the null hypothesis, which states that there is no statistically significant relationship between employee education level and innovation at firm level in the South African metals industry, is rejected and the alternate hypothesis which states that there is a positive relationship between employee education level and innovation at firm level in the South African metals industry is accepted. Since employee education has a positive effect on firm level innovation, employees need to constantly develop themselves by learning new skill, using the available training budgets, so that they can develop more innovative ideas. As one employee put it during the interviews, “the more you get educated, the more likely you will come up with innovative ideas and improvements as you want to implement the new knowledge that you learned”. Education also helps the employees to have a wider view of their field and enables them to recognise areas for improvement or innovative products easily. Employee education and training supports the creation of knowledge, competencies and experiences enabling organisations to improve their innovation capabilities needed to sustain themselves (Ngibe & Lekhanya, 2019).

5.3.2 *Tenure as a dynamic workforce capability that affect firm level innovation in the South Africa metals industry*

This section discusses the results about the relationship between employee tenure and firm level innovation in the South African metals industry. The hypothesis tested was the following:

Hypothesis 2B:

Null Hypothesis: There is no relationship between employee tenure and innovation at firm level in the South African metals industry.

Alternate Hypothesis: There is a positive relationship between employee tenure and innovation at firm level in the South African metals industry.

The tenure variable was created by combining the variables for the number of years the employee spent in the organisation (job tenure), variable for number of years the employee spent in the same position in the organisation (position tenure), variable for total experience of the employee in that field, including experience acquired in other organisations (total work experience) and the variable for level of the employee position in the company structure (position level). According to Gagliardi et al. (2023) employee tenure has a positive impact on productivity especially in positions which are characterised by a certain degree of routineness and low job complexity. This would be particularity true for skilled and unskilled operators in the metals industry in South Africa. Tenure also gives these employees a level of job security, resulting in higher organisational commitment and engagement. A long tenure in this industry usually underpins extensive tacit and firm-specific knowledge (Auer et al., 2004). This is needed for these employees to start engaging with innovation ideas for product and process improvements (Auer et al., 2004). Educated employees typically need less tenure before they contribute to innovative idea generation processes because they come with the theoretical background of their field of specialisation as confirmed during the interviews in this study. The current work did not measure the length of these tenure variables and the respondents in the primary survey were only asked to rate their importance for firm level innovation. The Cronbach's Alpha for the four variables above that were used to create the tenure variable was 0.770, which is greater than 0.65, meaning the results are reliable and that the different items making up the tenure variable are closely related (Lee, 2015; Shrestha, 2021). After the tenure variable was determined, the relationship between this employee tenure variable and firm level innovation was determined using correlation and regression statistics.

The results yielded a correlation coefficient of 0.888 which signifies a strong positive correlation between the innovation and tenure variables which was significant at 0.01 level (2-tailed). The positive value of the correlation coefficient indicates that a positive increase in tenure variables would result in a positive increase in the innovation variable (Lee, 2015; Taylor, 1990). This correlation coefficient (0.888) was much higher compared to a weaker positive effect ($r = 0.04$) which was observed by Liu et al. (2016) when analysing the effect of organisational tenure on employee innovative behaviour. The main difference is that the tenure variable in this study took into consideration job tenure, position tenure, total work experience and position level, whereas the organisation tenure in the work by Liu et al. (2016) only considered job tenure. Liu et al. (2016) also concluded that status hierarchy (position level) and position tenure have an influence in this relationship. Increase in the employees position tenure has a positive influence on firm level innovation until the employee reaches five years in the role, then it has a negative influence to innovation as the employee becomes complacent (Liu et al., 2016). This was also confirmed by the work by Ul Haq et al. (2017) who found that employees with less organisation tenure are more innovative, though the cut-off in length of innovation was not mentioned by the authors. To change habitual routines and employees becoming complacent, organisations need to look at their culture, policies and procedures as well as implement effective change management (Fusch et al., 2020). Ul Haq et al. (2017) also found that perceived failure tolerance, communication openness, work discretion, and reward fairness have a moderating effect at a company level on this relationship. However, the five-year duration does not hold true for employees in the South African metals industry as the employees who were interviewed had expressed that they engaged with innovation and idea generation even though they all had longer than five years tenure.

During the interviews, the findings were that employees master their roles and enhance their skill with time. Therefore, longer tenure would lead to greater expertise and knowledge in a particular field which leads to employees generating more innovative ideas. The total work experience was rated highest by all interviewees in terms of importance for employees to generate innovative ideas in their organisations. However, it was highlighted that the experience should be gained from complementary industries as this gives the employee a more holistic view of the product value chain and the relevant technology landscape. The work by Bogers et al. (2018) showed that diverse work history only has a positive impact at higher levels of educational diversity and not for routine work done by unskilled employees. Therefore, for educated employees who work in the innovation space in the South African metals industry, diverse tenure is important for idea generation. Hammond et al. (2011), who also found a positive relationship between education and job tenure with innovation, and a positive relationship between job discretion with innovation. Job discretion is associated with autonomy and empowerment which allows employees to make more independent decisions. As individuals gain knowledge and experience, they build a larger and more integrated repository of response possibilities, which include ideas, facts, and cognitive scripts, from which to draw creative problem solving ideas (Hammond et al., 2011).

According to Gagliardi et al. (2023), the positive relationship between tenure and productivity in manufacturing industries is up to 11 years for unskilled and semiskilled employees doing routine and less complex jobs. After this period, these employees become less motivated and engaged leading to reduced probabilities of generating innovative ideas. This was also concluded by Auer et al. (2004) who discussed that a higher share of long-tenured workers appear to be detrimental for productivity, stressing the need to rely on new, updated, knowledge from the outside. Liu et al. (2016) also showed that employees in different stages of their whole career do not always maintain high motivation to perform innovation, especially when the employees approach the end of their careers, their enthusiasm and investment to engage in innovation greatly decreases. In this work, the length of tenure required for employees to generate innovative ideas was not investigated. However, the key output is that there is some level of tenure required for employees to understand the processes and products enough to generate innovative ideas. Future work can interrogate what this length of tenure is for educated, semi-skilled and unskilled employees within the South African metals industry is since this length would differ between these groups of employees.

This work did not focus on the variable that makes up employee tenure independently, but the focus was on the joint effect of job tenure, position tenure, total work experience and position level. In the regression statistics the independent variable was tenure (created by combining job tenure, position tenure, total work experience and position level), and the dependent variable was the innovation variable. The R-squared value was 0.789 which indicates that 78.9% of the variation of innovation variable could be explained by the tenure variable in a regression model. Therefore, this study has shown that there is a strong positive correlation between the employee tenure variable and firm level innovation in the South African metals industry. From the ANOVA regression model and the ANOVA coefficients, the F significance value is low (<0.001) which indicates that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the tenure and innovation variables. This section has shown that employee tenure has a positive influence on firm level innovation, especially idea generation, in the South African metals industry. These results were statistically significant, as shown with both the correlation and regression statistics, proving that employee tenure was important for firm level innovation in the South African metals industry. Therefore, the null hypothesis which states that there is no relationship between employee tenure and innovation at firm level in the South African metals industry is rejected and the alternate hypothesis, which states that there is a positive relationship between employee tenure and innovation at firm level in the South African metals industry, is accepted.

5.3.3 *Employee demographic background as a dynamic workforce capability that affect firm level innovation in the South Africa metals industry*

This section discusses the results about the relationship between employee demographic background and firm level innovation in the South African metals industry. The hypothesis tested was the following:

Hypothesis 2C:

Null Hypothesis: There is no relationship between employee demographic background attributes and innovation at firm level in the South African metals industry.

Alternate Hypothesis: There is a positive relationship between employee demographic background attributes and innovation at firm level in the South African metals industry.

Employees in the South African metals industry are diverse in terms of age, sex, cultural, educational and ethnic background due to requirements to comply to the Employment Equity Act, No 55 of 1998 (South African Government Gazette, 1998). As the workforce becomes diverse in terms of gender, age, ethnicity, and education in an organisation, so does the knowledge base of that firm and this leads to innovation (Østergaard et al., 2011). The employee demographic background attributes of interest in this work were gender, age, and ethnicity. These three attributes (age, gender and race) were referred to as biographical groups in the work by Martins and Coetzee (2011). However, in this study they are referred to as dynamic employee demographic background attributes because these employees are working and they need to be engaged, enthusiastic and energetic in order to generate innovative ideas in a dynamic work environment which constantly changes. Purc and Laguna (2019) explained that employees' self-enhancement values are positively related to their innovative behaviour, while conservation and self-transcendence values are negatively related to innovative behaviour. Self-enhancement values are associated with one's need to achieve and succeed. These employees would be engaged and enthusiastic about their work.

The Cronbach's Alpha for the employee demographic background variable, made from combining age, gender and ethnicity, was 0.755 which shows that the results were reliable and that the different items making up the employee demographic background attribute variable were closely related. Østergaard et al. (2011) also studied the effect of age, gender, ethnicity, and education diversity on innovation for firms in Denmark. Education was considered as a separate dynamic employee capability in the current work and not combined with age, gender, and ethnicity. The results from the work by Østergaard et al. (2011) showed that an increase in gender balance (50-60%) had a positive influence for the innovative performance of firms. The percentage gender balance for South African firms tilts more towards males and it would be interesting to see the optimum percentage gender balance for firm level innovation in this industry as future work. The findings from the interviews in this study were that gender mix is crucial for implementation of innovation not idea generation. Similar conclusions were made by Teruel and Segarra (2017) who showed that gender-diverse teams increase the probability of innovating, and this capacity is positively related to team size. Gender diversity, in both the R&D department and the total workforce, has a larger positive impact on the probability of carrying out product and organisational innovations in larger teams than it does in smaller teams (Teruel & Segarra, 2017). In this study, 22 (66.7%) organisations were large and 11 (33.3%) were SMEs. The feedback from the interviewees in this study was that gender does not play a role in idea generation as both sexes have generated innovative ideas in the organisation that were sampled. However, the work by Zastempowski and Cyfert (2021) showed that the female gender of the entrepreneur had a positive impact on the product and process innovativeness of small enterprises. In contrary, Proudfoot et al. (2015) showed that males create more ideas than females because creativity is more associated with stereotypically masculine characteristics such as daring and self-reliance, compared to stereotypically feminine characteristics such as cooperativeness and supportiveness. This was not observed in this study as the findings from the interviews were that both genders are involved in generating innovative idea and that gender mix (not male or female) is more important for ideas generation and innovation. This was also supported by the studies various other authors such as Díaz-García et al. (2013), Horbach and Jacob (2018) and Na and Shin (2019).

One of the findings from the interviews was that younger employees generate more innovative ideas compared to older ones. The respondents attributed this to the higher appetite and energy of younger employee to try new creative things compared to the older generation. Pingle and Sharma (2013) also found that young employees bring fresh ideas, perspective and creativity needed for innovation. These younger employees typically come into new organisations with the relevant tertiary education for the field that they are employed in and are used to the latest technologies required for product and process innovations. Meyer (2007) also concluded that younger employees are more likely to adopt new technologies compared to the older workforce. However, the work by Østergaard et al. (2011) showed that age diversity had a negative effect on likelihood of the firm to innovate because diversity in age causes disagreements amongst employees which leads to lower innovative performance. The views from the interviews were different as the respondents believed that age diversity plays a crucial role in firm level innovation in the South African metals industry. The work by Bhardwaj et al. (2021) showed that in order to have dynamic capabilities, firms need to have the ability to recognise and exploit opportunities. Therefore, idea generation and implementation are crucial for firm level innovation.

In this study, the respondents highlighted that younger employees generate more ideas while experience is crucial for implementation and older generations are more likely to succeed in implementing these ideas due to their deeper understanding of the organisational culture and the history they have within the organisation. Therefore, for the success of innovation, a mix of younger and older employees is recommended. Similar findings were observed by Hammermann et al. (2019) and by Selvaraj (2015) who called the mix of younger and older employees, age diversity. Older employees bring two types of experience to an organisation. The first is “general human capital” and it consists of such things as knowledge, skills, learned capabilities, and patterns of behaviour acquired through a lifetime of work and working. Individuals can take this type of human capital with them from employer to employer because it has value to many, and employers who seek it can “buy” it in the labour market. A second type is “firm-specific human capital.” It consists of knowledge, social networks, mastery, and know-how generated through the experience of working in one organisation with its suppliers, customers, technology, proprietary processes, and intellectual capital and, of course, with one’s co-workers. Firm-specific human capital is valuable to one organisation, and it is “built” through tenure (years of service) with the employer. Therefore, these employees are also crucial for innovative outcomes of the organisation.

South Africa has a significantly diverse group of employees in terms of ethnicity and cultural backgrounds (Adams et al., 2012; Adams et al., 2014; Valchev et al., 2013). According to Adams et al. (2012), the four ethnic group classification used in South Africa are African, Coloured, Indian, and White ethnic groups. In this work, ethnic background relates to this ethnic group classification. The findings from the interviews were that family background plays a role in idea generation as it impacts on how one is raised, what they were exposed to, and the availability of resources when they were growing up. However, a mix of people from various ethnic backgrounds is crucial for the implementation of the innovative ideas as it brings variation in capacities, perspectives, and mental models (Koomson et al., 2022; Quintana-García et al., 2022). As stated during the interviews, diversity in the team ethnic backgrounds results in increased skills diversity of work teams, encourage knowledge transfers, and enable interactions that lead to new knowledge combinations. Yang and Konrad (2011) also found that ethnic diversity plays an important role in the innovation of organisations in Canada. The study by Mohammadi et al. (2017) also confirmed this and showed that multi-cultural teams are better positioned to contribute to firms' innovation performance. However, diversity is also a challenge for firms since it might also lead to conflict, distrust and negative effects for out-of-the-group members (Bello-Pintado & Bianchi, 2018). During the interview, one respondent highlighted this and stated that organisations need to create an environment where employees are motivated and where they want to strive. This environment should also be made safe for all ethnic background and demographics to be innovative. Diversity in ethnic background is critical in South Africa especially in order to eliminate the high levels of workplace bullying based on socio-demographic characteristics (Cunniff & Mostert, 2012). An environment that supports and rewards innovation had been created in the organisations that were part of this study as confirmed by their employees during the interviews. Therefore, diversity in employee ethnic backgrounds is expected to improve idea generation and innovation.

The employee demographic background variable was determined by combining the gender, age, and ethnicity variables. As stated earlier in this section, the Cronbach's Alpha for the employee demographic background variable was 0.755 which shows that the results were reliable and that the different items making up the employee demographic background attribute variable were closely related. Correlation statistics were performed between the innovation and employee demographic background attribute variables. The correlation coefficient as 0.914 which signifies a strong positive correlation between the innovation and employee demographic background attribute variables. This correlation was significant at 0.01 level (2-tailed). Therefore, it could be concluded in this study that the employee demographic background variable had a positive relationship to firm level innovation within the South African metals industry. The regression statistical analysis resulted in a R-squared value of 0.835 which indicated that 83.5% of the variation of innovation variable could be explained by the tenure variable in that regression model. The significance F value was low (<0.001), indicating that the statistics were significant, and innovation could be explained by the employee demographic background attribute variable used in this study.

The coefficient (B) was greater than its standard error which implies a probability that the coefficient is not 0. The t-value is 26.634 for the constant and 13.122 for the tenure variable. The significance value as low (<0.001) which indicates that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the tenure and innovation variables. This section has shown that employee demographic background attributes have a positive influence on firm level innovation, especially idea generation, in the South African metals industry. These results were statistically significant, as shown with both the correlation and regression statistics, proving that employee demographic background attribute variable made by combining of employee gender, age and ethnicity, was important for firm level innovation in the South African metals industry. Therefore, the null hypothesis which states that there is no relationship between employee demographic background attributes and innovation at firm level in the South African metals industry is rejected and the alternate hypothesis, which states that there is a positive relationship between employee demographic background attributes and innovation at firm level in the South African metals industry, is accepted.

5.3.4 *Effect of dynamic workforce capabilities on firm level innovation in the South African metals industry*

Organisations need to constantly adapt to ever changing external environments to survive and this makes the innovative behaviour of the employees in an organisation very critical as they need to innovate their products, methods and operations of the organisation (Li & Zheng, 2014). According to Østergaard et al. (2011), innovation should be an interactive process that involves communication and interaction among employees in a firm and draws on their different qualities from all levels of the organisation. This work focused on the effect of dynamic workforce capability on firm level innovation in the South African metals industry and this section discusses the results achieved. The focus on employees who are non-managers, which are termed workforce in this work, and who do not have direct reports. In this work, the dynamic workforce capability variable was created by combining the education, tenure and employee demographic background variables which were discussed in the earlier sections above. These capabilities were selected based on the definition of workforce diversity which is the ways that people differ which can affect a task or relationship within an organisation such as age, gender, race, length of service, education, religion, and culture (Munjuri & Maina, 2013; Ongori & Agolla, 2007; Pelders & Nelson, 2019). Initially, correlation and regression statistics were conducted with education, tenure and demographic background as independent variables, while the dependent variable was the innovation variable. Then later, statistics were performed using dynamic workforce capability as the independent variable with innovation as the dependent variable. The main reason was to confirm if combining the variables to form dynamic workforce capability had a statistical difference compared to the multivariant statistical results. The correlation coefficients between the three independent variables with innovation were all positive (education: 0.646, tenure: 0.888 and employee demographic background: 0.914). The conclusion was that firm level innovation was correlated to the diversity in employee background (0.914), followed by tenure (0.888) and least correlated to the employee education (0.646). All the correlation results were significant at the 0.01 level (2-tailed). The Cronbach's Alpha for the new dynamic workforce capability variable was 0.790 which shows that the results are reliable and that the different items making up the dynamic workforce capability variable, which are education, tenure, and employee demographic background variables, are closely related. An improved correlation coefficient of 0.947 was achieved for the new dynamic workforce capability variable and firm level innovation. This statistic was also significant at the 0.01 level (2-tailed). These results showed that an increase in the dynamic workforce capabilities of employees, by either improving their education, tenure, or demographic background variables, would result in a positive firm level innovation for process and products within the South African metals industry.

In the regression statistics, the independent variables were education, tenure and demographic background variables, while the dependent variable was the innovation variable. The R-squared value was 0.918 which indicates that 91.8% of the variation of innovation variable is explained by the tenure variable in a regression model. The significance value from ANOVA is low (<0.001) which shows that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the dependent (innovation) and the independent (education, tenure, and demographic background attributes) variables (Lee, 2015; Shefer & Frenkel, 2005). The t-values were all significant since the significance values were low (<0.001) which indicate that there is a significant linear relationship between the independent (education, tenure, and demographic background) and the dependent (innovation) variables. The R-squared achieved from the regression statistics with one independent variable (dynamic workforce capability) was 0.897, which is high and positive showing the dynamic capability variable is a good predictor for firm level innovation. The significance value from ANOVA is low (<0.001) which indicates that there is 95% confidence that the slope of the regression line is not zero and hence there is a significant linear relationship between the dependent (innovation) and the independent (dynamic capability) variables (Lee, 2015). The t-values were all significant since the significance values were low (<0.001) which indicate that there is a significant linear relationship between the independent (dynamic capability) and the dependent (innovation) variables (Nurdyansyah, 2019).

These results in Table 73 from the primary survey where respondents were requested to rate the importance of certain capabilities for firm level innovation. The respondents rated employee education, tenure, and demographic background attributes (in this rating order) as critical workforce capabilities for firm level innovation in the South African metals industry. This was also confirmed during the interviews as all interviewees believed that education, tenure, and demographic background attributes were sufficient capability to measure workforce innovation capacity in the South African metals industry. Education was perceived to be the most important, followed by tenure and lastly employee demographic background attributes. A similar order was observed for the team that implements this innovative idea once it has been generated. During the interviews, it was also confirmed that diversity in terms of educational background is more important as this ensures diverse skills are brought into the organisation and specific projects. These findings support the results from Mohammadi et al. (2017) who found that workforce diversity in higher education and ethnicity resulted in superior organisational performance for radical innovation. However, the most common type of innovation that was observed in the South African metals industry is incremental innovation (based on the findings of this work). Mohammadi et al. (2017) also found that diversity in higher education becomes less important when the organisation has strategic alliances with other collaborators. This was not the case in this study as most (77%) of the organisations which were sampled did not have these strategic alliances. Organisations within the metals industry in South Africa are mainly involved in closed innovation and characterised by mainly using internal resources for generating, developing and implementing innovations (Almirall & Casadesus-Masanell, 2010; Dost et al., 2020). This elevated the education requirement for innovation within these organisations to be the most important dynamic workforce capability for innovation. Therefore, these findings show that organisations in the metals industry in South Africa need to hire employees with tertiary qualifications in order to be innovative. Where this is not possible, they need to collaborate more with other institutions such as collaborators, HEIs and research councils.

During the interviews, one common theme was that employees need to be motivated in order to generate innovative ideas and the other was that the organisation needs to create an environment conducive for these employees to be innovative. Some of the key characteristics of employees who have generated successful innovative ideas in the organisations within the South African metals industry are commitment, perseverance, tenacity, eagerness, and hunger for growth. Most of these characteristics can be built during the pursuit of tertiary education qualifications and also during work interactions for more tenured employees. The studies by Hammond et al. (2011) and Jordaan (2012) are also in agreements with these findings and also identified more openness to new experiences, having intellectual curiosity, imagination, independence, and sensitivity to the arts as critical for employees to be innovative and generate ideas. Employees attitude was also identified as key to innovation and “poor attitude destroy the entire team morale and stun the growth of innovative ideas in the team” as stated by the manager from this organisation. These finding are similar to the conclusions by Osman et al. (2016) who found a strong positive correlation between employee’s attitude and firm level innovation. Aragon et al. (2017) further stated that this employee attitude towards innovation is shaped by the organisational values and leadership. Therefore, if there is effort from leadership of the organisations within the metals industry in South Africa to promote and support innovation, supported by organisational culture and values, then innovative idea generation will be promoted even further. Leaders should create an environment where employees are motivated and want to strive and develop (Walumbwa et al., 2011). This environment should also be made safe for all demographics to be innovative as highlighted during the interviews. Innovation should be part of the organisational strategy and be diffused at all levels of the organisation. This should be supported by availability of resources (funds, equipment, and materials), rewards programs, and general human resource practises that are pro-innovation. The organisation culture should allow people to make mistakes and not be blamed as this would enable people to try new things without fear of “being beaten with a stick”.

5.4 Conclusion

This section has shown that product and process innovation exists in the South African metals industry. This innovation is more closed compared to open innovation. Most on the innovation is conducted by internal resources with little to no collaboration with other institutions such as HEIs and research councils. There is a fair level of investment into research and development which is also supported at the organisation strategic level. These organisations have an R&D budget as well as training budget, even though these two are not linked. Most of the innovative ideas are generated by the workforce which was defined as non-managerial employees within the firms. This workforce is closer to the products and processes which gives them the edge in suggesting ideas that have a higher chance of success in the market or internally. However, managerial support as well as supporting organisational culture is required for these employees to generate innovative ideas. The research question, which sought to understand who generates more innovation ideas between employees and managers in the South African metals industry, was then answered. The findings are that employees (non-managers) generate more innovative ideas as opposed to managers within the South African metals industry.

The second research question sought to understand the relationship between employee experience factors (qualification, tenure and demographic background attributes) that make-up the dynamic workforce capabilities and innovation at firm level. Various hypotheses were tested for each of the employee experience factors and the conclusion was that each of the qualification, tenure and demographic background attributes had a positive correlation with firm level innovation on their own. Regression analysis also yielded positive results which were statistically significant. The dynamic workforce capability variable was developed by combining the qualification, tenure and demographic background attributes. A positive correlation was found for this dynamic workforce capability variable and innovation. The positive value of the correlation coefficient also showed that a positive change in the dynamic workforce capability variable results in a positive change in the firm level innovation in the South African metals industry. Therefore, a positive relationship between employee experience factors (qualification, tenure and demographic background attributes) that make-up the dynamic workforce capabilities and innovation at firm level was proved.

CHAPTER 6. CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

The current research focused on innovation, which is defined as “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (Oslo Manual, 2018, p. 20). However, it was only limited to ideas generated for new or improved products within the context of the South African metals industry. The aim was to expand the literature on the dynamic capabilities framework, which was introduced by Teece and Pisano (1994), to include workforce capabilities which are influenced by employee experience such as qualification, tenure and demographic background attributes.

This chapter presents the conclusion based on the results and the discussion. It integrates the key findings for each research question and draws conclusions based on these key findings. It starts by drawing conclusions based on the first research question, which aims to determine who generates more innovation ideas between employees and managers in the South African metals industry, followed by the conclusions based on the second research question, which aims to determine the relationship between employee experience factors (qualification, tenure and demographic background attributes) that make-up the dynamic workforce capabilities and innovation at firm level, then recommendations and suggestions for further research are suggested.

6.2 Conclusions regarding research question 1 (sub-research questions)

The South African metals industry is involved in product and process innovation as shown by the results from both the data received from HSRC and the primary survey that was sent to 36 respondents. The results from the HSRC data showed that 75.8% of the sampled organisations were involved in product and process innovation between 2014 and 2016, while the results from the primary survey showed an improved percentage of 91.7% for the period of 2019 to 2021. Therefore, the conclusions are that organisations in the South African metals industry are innovative and generate product and process innovations. Similar findings were also presented by other authors such as Oerlemans et al. (2005), Moses et al. (2012), Toga (2017), Sithole et al. (2021), Gaglio et al. (2022), and Kahn et al. (2022). Most (94%) of the organisations in this study confirmed that they have adopted innovation as part of their company strategy. This industry is mainly involved in closed innovation, characterised by the use of internal resources for innovation with little to no collaborations with other firms. The South African metals industry is mature and mainly involved in incremental innovation rather than radical innovation as confirmed during the interviews. These findings are in support of the research by Almeida and Fernandes (2008) who concluded that this incremental innovation is mainly done in an imitation mode by copying and making minor changes to products from advanced countries.

The data from the primary survey were stratified to separate large organisations from SMEs. The results showed that most (88%) of large organisations and all the SMEs were involved in product and process innovation between 2019 and 2021. These findings were contrary to the study by Oerlemans et al. (2004) who found that larger organisations in the South African manufacturing and service sectors had higher innovation rates compared to their smaller counterparts. The period investigated by Oerlemans et al. (2004) was 1998 to 2000. The difference in these findings was mainly due to differences in the industries investigated (metals industry versus manufacturing and service sector), different firms that responded to the surveys, and the periods of the investigations. The complete manufacturing sector in South Africa includes organisations in the food and beverage, textile, wood and paper, petroleum, glass, automotive, electronic as well as metals industry as shown in Table 3 of this study. The service sector is broad and includes industries such as entertainment, hospitality, consulting, etc (Bhorat et al., 2018). Therefore, the nature of business is different for organisations in the metals industry compared to those in manufacturing and service sectors. The type of organisations between the metals industry investigated in this study and the sectors investigated by Oerlemans et al. (2004)

also differ in business models and strategic intents. Lastly, the social and economic conditions in South Africa were different between the period (1998-2000) investigate by Oerlemans et al. (2004) and the period of investigated in this study due to economic performance and the impact of COVID-19, among other things. The conclusion in the current study is that organisations in the South African metals industry are involved in product and process innovations, and that more SMEs were involved in innovation activities compared to larger organisations. This is supported by Matekenya and Moyo (2022) who expressed that innovation is crucial for SMEs' development and growth in South Africa. SMEs typically have smaller structures, making them more flexible, and they empower their employees to make more decisions compared to larger organisations which have much larger resources but have more hierarchies that make them more rigid and take longer to make decisions (Fallon-Byrne & Harney, 2017; Sawers et al., 2008).

The novel component of the first research question was identifying who generates more innovative ideas between managers and the workforce (non-managers) in the South African metals industry. The sensing capability that was presented by Teece (2007) involves the ability of individuals and organisations to create and discover new opportunities, and this is related to the idea generation phase in the innovation model presented by Mariello (2007). Therefore, idea generation is an important dynamic capability for innovation that employees (managers and non-managers) need to have in all organisations. This work investigated this idea generation further to understand who generates most of these ideas in the South African metals industry. The findings were that more innovative ideas are generated by the workforce (non-managers) compared to managers in the South African metals industry as confirmed by 86% of the respondents to the primary survey. The workforce spends more time on processes and products, which exposes them to operational challenges. Therefore, they generate these innovative ideas to find alternative solutions in response to these challenges. They are also customer facing which exposes them to newer (or improved) products in the market. The conclusions to the first research question are that more innovation ideas are generated by employees compared to managers in the South African metals industry. This conclusion is novel as no other author had conducted a similar study in this industry. The significance of this finding is that manager in this industry need to create a conducive environment to harness the innovativeness of their employees. Innovation programs and platforms should be developed to encourage non-managerial employees to explore their innovative ideas and to develop these products and process that enhance the sustainability of these organisations. Participation to these innovation programs should not be limited to managers only. This finding could be applicable to other industries but that would need to be explored further.

6.3 Conclusions regarding research question 2 (main research question)

This work proposed that employee education, qualification, tenure, and demographic background attributes are dynamic workforce capabilities that are required for firm level innovation in the South African metals industry. The main innovation focus was on idea generation, though the idea also needed to have been implemented or taken to market in order to fit the definition of innovation given by the Oslo Manual (2018). Correlation and regression statistics were used to determine the relationship between these three employee variables (education qualification, tenure, and demographic background attributes) and firm level innovation.

The findings showed a moderately positive correlation (0.646) between employee education and firm level innovation in the South African metals industry. Børing (2017) also found a positive relationship between education and firm level innovation. However, Børing (2017) saw employee education as the outcome of the organisations training initiatives, while in this work employee education is seen as the tertiary education qualifications that the employee possesses. The workforce with higher levels of education have a better capacity to comprehend, create, and process information swiftly compared to those without education. This education provides these employees with a dynamic capability to generate more feasible innovative ideas. The conclusion is that employee education is important to stimulate new ideas or creativity among employees, which results in improved firm level innovation.

In this work, the R-squared value was 0.417 which indicates that 41.7% of the variation of innovation variable could be explained by the education variable. However, employees without tertiary qualifications should not be ignored as they also contribute to process innovation in the South African metals industry. These employees use their process knowledge, which was typically accumulated through longer tenure, to suggest innovative ideas. It was found in this work that these suggestions are made directly to the technicians and engineers that the unskilled or semi-skilled employees work with and are less likely to be presented to formal business structures and processes by these unskilled or semi-skilled employees. Therefore, the educated employees have an obligation to promote these informal conversations to unearth the innovative idea generation of these employees in organisations. In most instances, the ideas from unskilled or semi-skilled employees would need to be moulded into more feasible ones with the assistance of the skilled and educated workforce. This innovative idea generation capacity of unskilled or semi-skilled employees can also be enhanced by on-the-job training programmes. This finding was also supported by Børing (2017) who found a positive relationship between on the job training and productivity of employees who are less educated. However, the focus by Børing (2017) was on productivity and this work focused on innovative idea generation.

A strong positive correlation (r = 0.888) was observed between the innovation and tenure variables. The tenure variable was developed by combining the variable for the number of years the employee spent in the organisation (job tenure), the variable for number of years the employee spent in the same position in the organisation (position tenure), the variable for total experience of the employee in that field, including experience acquired in other organisations (total work experience) and the variable for level of the employee position in the company structure (position level). Liu et al. (2016) observed a weaker positive effect (r = 0.04) of organisational tenure on employee innovative behaviour. However, Liu et al. (2016) only considered job tenure and did not create a tenure variable based on other aspects, such as job tenure, position tenure, total work experience and position level, that were investigated in this study. In this study, the R-squared value was 0.789 which indicates that 78.9% of the variation of innovation variable could be explained by the tenure variable. The conclusion in this work is that there is a positive relationship between employee tenure and innovation at firm level in the South African metals industry.

The employee demographic background attributes of interest in this work were gender, age, and ethnicity. These attributes were selected since the work by Østergaard et al. (2011) had shown that increasing diversity in terms of gender, age, ethnicity, and education in an organisation leads to an increased knowledge base for that firm, which leads to innovation. However, these variables were not analysed independently but a tenure variable was created which had a good Cronbach's Alpha of 0.755. A strong positive correlation (0.914) between the innovation and employee demographic background attribute variables was observed in this study. The regression statistical analysis resulted in a R-squared value of 0.835 which indicated that 83.5% of the variation of innovation variable could be explained by the tenure variable. Therefore, this work proved that there is a positive relationship between employee demographic background attributes, made up of gender, age, and ethnicity, and innovation at firm level in the South African metals industry.

This work showed that employee education, tenure and demographic background have a positive relationship with firm level innovation, independently. A combined effort of these variables on firm level innovation was also investigated. The correlation coefficients between the three independent variables with innovation were all positive (education: 0.646, tenure: 0.888 and employee demographic background: 0.914). The conclusions were that firm level innovation was positively correlated to the diversity in employee background (0.914), followed by tenure (0.888) and least correlated to the employee education (0.646). A dynamic workforce capability variable was created from the employee education, tenure, and employee demographic background variables, and the Cronbach's Alpha was 0.790 highlighting that the results were reliable and that the different items making up the dynamic workforce capability variable were closely related in this study. An improved correlation coefficient of 0.947 was achieved for the new dynamic workforce capability variable and firm level innovation. Therefore, the conclusions were that there is a positive relationship between employee experience factors (qualification, tenure, and demographic background attributes) that make-up the dynamic workforce capabilities and innovation at firm level innovation in the South African metals industry, which answered the second research question. These findings were also confirmed by the qualitative interview studies and bring novel contribution to the study of dynamic capabilities in the firm level innovation context. All interviewees believed that education, tenure, and demographic background attributes were sufficient capability to measure workforce innovation capacity in the South African metals industry. During the interviews, education was perceived to be the most important, followed by tenure and lastly employee demographic background attributes. A similar order was observed for the team that implements this innovative idea once it has been generated. However, the quantitative studies showed a different order as diversity in employee background had a higher correlation coefficient (0.914), followed by employee tenure (0.888) and lastly employee education (0.646). The sample for the quantitative study was larger (36 organisations) compared to two employees interviewed from three organisations (total of six employees). A positive organisational culture motivates employees to try new things, and management support was identified as key organisational support structured for employees to generate innovative ideas. This culture should also be supported by availability of resources (funds, equipment, and materials), rewards programmes, and general human resource practices that are pro-innovation. At the employee level, motivation, positive attitude, independence (some level of autonomy) and hunger for growth, were also identified as promoters for innovative idea generation by employees within the metals industry in South Africa.

Mohammadi et al. (2017) had also found that workforce diversity in higher education and ethnicity result in superior organisational performance for radical innovation. However, their work was only focused on education and ethnicity and did not consider all variables analysed in the current work. Moreover, the current work showed that the type of innovation that was observed in the South African metals industry was incremental innovation and these findings are not related to the study by Mohammadi et al. (2017). The findings in this work differ from those of Mohammadi et al. (2017) on workforce diversity in terms of both ethnic background and educational disciplinary background, and Hammond et al. (2011)

on employee education and job tenure, as it combined education, tenure, and demographic background attributes as independent variables. This work also defined each independent variable differently as it considered a more holistic approach, for example tenure was not only viewed as job tenure but also considered other aspects that define employee tenure such as job tenure, position tenure, total work experience and position level. The main conclusions of the study are the following:

- There is a positive relationship between employee experience factors (employee qualification, tenure, and demographic background attributes) that make-up the dynamic workforce capabilities and innovation at firm level in the South Africa metals industry.
- The dynamic workforce capabilities, which are influenced by employee experience such as qualification, tenure, and demographic background attributes, should be added to the literature on dynamic capabilities in the context of firm level innovation.
- This work only focused on the sensing high order capability and idea generation innovation phase. Therefore, these findings should be viewed in this context.
- The findings are applicable to the South African metals industry and should be investigated further in other industries and geographic areas.

A summary of the research questions, conclusions and contribution to knowledge is shown in Table 80 below.

Table 80: Consistency matrix: research questions, conclusions and contribution to knowledge

RQ #	State Research Question or Objective	State literature-based proposition or hypothesis	State conclusion or answer based on own research	Highlight key differences between your initial propositions / hypotheses and your findings – this is your contribution to knowledge
1	Who generates more innovation ideas between employees and managers in the South African metals industry?	There is no literature on this	The results from the HSRC data showed that 75.8% of the sampled organisations were involved in product and process innovation between 2014 and 2016, while the results from the primary survey showed an improved percentage of 91.7% for the period of 2019 to 2021. The conclusions are that organisations in the South African metals industry are innovative and generate product and process innovations. The primary survey also showed that non-management employees generate more innovative ideas compared to managers. This was also confirmed by both the managers and non-managers during semi-structured interviews. One of the main reasons was that employees who are non-managers spend more	The novel component of this research was identifying who generates more innovative ideas between managers and the workforce (non-managers) in the South African metals industry. This is also a first attempt in understanding the dynamic workforce capabilities and how these impact firm level innovation in manufacturing organisation. The workforce spends more time on processes and products, which exposes them to operational challenges. Therefore, they generate these innovative ideas to find alternative solutions in response to these challenges. They are also customer facing which exposes them to newer (or improved) products in the market. The conclusions are that more innovation ideas are generated by employees compared to managers in the South African metals industry. The significance of this finding is that managers in this industry need to create a

RQ #	State Research Question or Objective	State literature-based proposition or hypothesis	State conclusion or answer based on own research	Highlight key differences between your initial propositions / hypotheses and your findings – this is your contribution to knowledge
			time working on products and processes, which gives them an edge in generating new and improved ideas.	conducive environment to harness the innovativeness of their employees. Innovation programs and platforms should be developed to encourage non-managerial employees to explore their innovative ideas and to develop these products and processes that enhance the sustainability of these organisations. Participation in these innovation programs should not be limited to managers only. This finding could be applicable to other industries but that would need to be explored further.
2	What is the relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry?	There is no literature on this	This work proposed that employee education, qualification, tenure, and demographic background attributes are dynamic workforce capabilities that are required for firm level innovation in the South African metals industry. The conclusions were that firm level innovation was positively correlated to the diversity in employee background	The key theoretical contribution is that dynamic workforce capabilities exist, and these have an impact on firm level innovation. Further work would need to explore if the same capabilities would be determined if a different population and sample is used. The current quantitative and qualitative work brings a novel contribution to the study of dynamic capabilities in the firm level innovation context. The practical implication is that managers need to encourage employee innovations within their

RQ #	State Research Question or Objective	State literature-based proposition or hypothesis	State conclusion or answer based on own research	Highlight key differences between your initial propositions / hypotheses and your findings – this is your contribution to knowledge
			(0.914), followed by tenure (0.888) and least correlated to the employee education (0.646). This relationship was also confirmed during the interviews with selected employees from three organisations.	organisation. A positive organisational culture motivates employees to try new things, and management support was identified as key organisational support structure for employees to generate innovative ideas. This culture should also be supported by availability of resources (funds, equipment, and materials), rewards programmes, and general human resource practices that are pro-innovation. At the employee level, motivation, positive attitude, independence (some level of autonomy) and hunger for growth, were also identified as promoters for innovative idea generation by employees within the metals industry in South Africa.

6.4 Recommendations

The novel component of this research was identifying who generates more innovative ideas between managers and the workforce (non-managers) in the South African metals industry. The workforce spends more time on processes and products, which exposes them to operational challenges. Therefore, they generate these innovative ideas to find alternative solutions in response to these challenges. They are also customer facing which exposes them to newer (or improved) products in the market. The conclusions are that more innovation ideas are generated by employees compared to managers in the South African metals industry. The significance of this finding is that managers in this industry need to create a conducive environment to harness the innovativeness of their employees. Innovation programs and platforms should be developed to encourage non-managerial employees to explore their innovative ideas and to develop these products and processes that enhance the sustainability of these organisations. Participation in these innovation programs should not be limited to managers only. This finding could be applicable to other industries but that would need to be explored further.

This study has shown that there is product and process innovation in the South African metals industry. These organisations typically use internal resources for innovation with little to no collaboration with external sources such as HEIs, government and research institutes. This is typical of more closed innovation as opposed to open innovation (Chesbrough, 2012). The recommendation for managers and executives is that this type of closed innovation requires employees who have a high level of education since mainly internal resources are used. Therefore, hiring managers in the South African metals industry should keep this in mind when hiring for innovation, and organisations could also use their training budgets to support organisational innovation initiatives. Employee education has a positive correlation to firm level innovation. However, managers should be aware that the diversity in education qualifications and training institutions where these qualifications were obtained is more crucial rather than employing worker with same qualifications obtained from same academic institution. Where having employees with a high level of diversity in education background is not possible, managers should look to increase collaborations with other stakeholders in this industry, such as HEIs, research councils, suppliers, customers, etc. Engineers and technicians should be encouraged to have more frequent informal process and product related conversations with the unskilled or semi-skilled workforce in order to get their innovative ideas and to mould ideas with these employees to a point where they are more feasible.

The key theoretical contribution is that dynamic workforce capabilities exist, and these have an impact on firm level innovation. This work has highlighted that an increase in the dynamic workforce capabilities of employees, by either improving their education, tenure, or demographic background variables, would result in positive firm level innovation for processes and products within the South African metals industry. Therefore, managers can use these findings to inform decisions when approaching innovation. The theoretical significance of this work the contribution to the literature on dynamic capabilities by suggesting that workforce capabilities, which have an impact on firm level innovation, be included. This was shown by using both quantitative and qualitative studies within the South African metals industry. The recommendation for academics is to use this study as a first stab into expanding the literature on the dynamic capabilities framework, which was introduced by Teece and Pisano (1994), by including dynamic workforce capabilities. The focus was on the sensing capability and idea generation innovation phase. However, future work should be conducted to interrogate if these dynamic workforce capabilities are applicable for seizing and reconfigurations. These dynamic workforce capabilities could also be explored in other innovation phases as well as in different industries. Further work would also need to explore if the same capabilities would be determined if a different population and sample is used. The practical implication is that managers need to encourage employee innovations within their organisation. A positive organisational culture motivates employees to try new things, and management support was identified as key organisational support structure for employees to generate innovative ideas. This culture should also be supported by availability of resources (funds, equipment, and materials), rewards programmes, and general human resource practices that are pro-innovation. At the employee level, motivation, positive attitude, independence (some level of autonomy) and hunger for growth, were also identified as promoters for innovative idea generation by employees within the metals industry in South Africa.

6.5 Suggestions for further research

This research focused on the impact of dynamic workforce capabilities on firm level innovation in the South African metals industry. This industry is more mature and relies more on incremental innovation compared to disruptive innovation. Future work can be conducted on different industries that are producing more disruptive innovations. There was no collaboration with other external stakeholders in this industry and it would be interesting to conduct a similar study within an industry that is conducting more open innovation with higher levels of collaborations with external stakeholders such as research councils, HEIs, suppliers, competitors, customers, etc. Some of the organisations involved in this type of open innovation in South Africa are in the agriculture and the information and communications technology (ICT) industries (Krause & Schutte, 2015; Moonsamy, 2017).

The employee experiences that defined the dynamic workforce capabilities were pre-determined by the researcher based on literature. However, a study that looks at different workforce attributes, instead of employee education, tenure, and demographic background attributes, should be conducted. This could lead to more refined variables for dynamic workforce capabilities. A link, if any, should be investigated between these dynamic workforce capabilities and innovative behaviour in manufacturing or other sector firms.

The section on impact of employee education on firm level innovation did not test if this education qualification was acquired prior to joining the organisation or through the use of the organisation's training budgets. Future work to investigate if these two have a different impact on firm level innovation within the metals industry can be explored. Also, the research by Liu et al. (2016) and Gagliardi et al. (2023) showed that employees tenure has a positive influence on firm level innovation and productivity up to a certain level, then it has a negative influence as the employee becomes complacent, less engaged and less motivated.

However, the optimum employee tenure for firm level innovation in the metals industry in South Africa was not investigated in this work. Future work can also explore this as it would provide an indicative optimum tenure for managers when they formulate innovative teams. This optimum tenure would probably be different for educated, semi-skilled and unskilled employees within the South African metals industry. The results from the work by Østergaard et al. (2011) showed that an increase in gender balance (50-60%) had a positive influence for the innovative performance of firms. The percentage gender balance for South African firms tilts more towards males, and it would be interesting to see the optimum percentage gender balance for firm level innovation in this industry in future work.

This work only considered product or process related ideas that have been generated and implemented in the market or within the production processes of the organisation. Other types of innovation, such as business model innovation, were not considered. Future research could also explore these other types of innovations. Future research can also analyse the workforce capabilities for non-commercial entities such as NGOs, social enterprises, government and academic institutes.

The focus of the current work was on idea generation. Further work can explore all three dynamic capabilities (sensing, seizing and reconfiguration) and expand to not only idea generation but implementation of the ideas.

The author acknowledges that the interviewed employees who were managers (two African female, one white female) and non-managers (two white male and one African male) were not representative of the South African demographic. The researcher did not have control over this during this study since the organisations selected the individuals to be interviewed. Future work should also take the demographic representation of South Africa into consideration. Future work that investigates the ‘innovative’ effect of non-technical employees, such as customer-facing ones would also be on management and scholarly interest.

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LIST OF APPENDECES

APPENDIX A: THE COMMUNITY INNOVATION SURVEY 2014

The Community Innovation Survey 2014

THE HARMONISED SURVEY QUESTIONNAIRE, 23 July 2014

The Community Innovation Survey 2014 **Version 13 of 23 July 2014**

This survey collects information on your enterprise's **innovations and innovation activities** during the three years 2012 to 2014 inclusive.

An **innovation** is the introduction of a new or significantly improved product, process, organisational method, or marketing method by your enterprise.

An innovation must have characteristics or intended uses that are new or which provide a significant improvement over what was previously used or sold by your enterprise. However, an innovation can fail or take time to prove itself.

An innovation need only be new or significantly improved for your enterprise. It could have been originally developed or used by other enterprises or organisations.

Innovation activities include the acquisition of machinery, equipment, buildings, software, and licenses; engineering and development work, feasibility studies, design, training, R&D and marketing when they are specifically undertaken to develop and/or implement a product or process innovation. This includes also all types of R&D consisting of research and development activities to create new knowledge or solve scientific or technical problems.

Sections 2 to 7 cover product and process innovations. Organisational and marketing innovations are covered in sections 8 and 9.

Please complete **all** questions, unless otherwise instructed.

Person we should contact if there are any queries regarding the form:

Name: ______________________
Job title: ______________________
Organisation: ______________________
Phone: ______________________
E-mail: ______________________

1. General information about the enterprise

Name of enterprise ______________________________ *ID*
Address[1] ______________________________ *NUTS*
Postal code ____________ **Main activity**[2] ______________________________ *NACE*

1.1 In 2014, was your enterprise part of an enterprise group? (A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group can serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.) *GP*

Yes ☐ In which country is the head office of your group located? [3] _______________ *HO*

No ☐

If your enterprise is part of an enterprise group: Please answer all further questions about your enterprise only for its own activities in [your country]. Exclude all subsidiaries or parent enterprises.

1.2 During the three years 2012 to 2014, did your enterprise:

	Yes *1*	No *0*	
Merge with or take over another enterprise or a part of another enterprise	☐	☐	*ENMRG*
Sell, close or contract out some of the tasks or functions of your enterprise	☐	☐	*ENOUT*

1.3 In which geographic markets did your enterprise sell goods and/or services during the three years 2012 to 2014?

	Yes *1*	No *0*	
A. Local / regional within [your country]	☐	☐	*MARLOC*
B. National (other regions of [your country])	☐	☐	*MARNAT*
C. Other European Union or associated countries* [4]	☐	☐	*MAREUR*
D. All other countries	☐	☐	*MAROTH*

Which of these geographic areas was your largest market in terms of turnover during the three years 2012 to 2014? (Give corresponding letter) _____ *LARMAR*

*: Include the following European Union (EU) and associated countries: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, FYR Macedonia, Malta, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

[1] NUTS 2 code
[2] NACE 4 digit code
[3] Country code according to ISO standard
[4] Each NSO needs to remove their own country from the list of European countries.

2. Product innovation (good or service)

A product innovation is the market introduction of a **new** or **significantly** improved **good or service** with respect to its capabilities, user friendliness, components or sub-systems.

- Product innovations (new or improved) **must be new to your enterprise**, but they **do not need to be new to your market**.
- Product innovations could have been originally developed by your enterprise or by other enterprises or organisations.

A **good** is usually a tangible object such as a smartphone, furniture, or packaged software, but downloadable software, music and film are also goods. A **service** is usually intangible, such as retailing, insurance, educational courses, air travel, consulting, etc.

2.1 During the three years 2012 to 2014, did your enterprise introduce:

	Yes *1*	No *0*	
Goods innovations: New or significantly improved goods (exclude the simple resale of new goods and changes of a solely aesthetic nature)	☐	☐	*INPDGD*
Service innovations: New or significantly improved services	☐	☐	*INPDSV*

If no to all options, go to section 3

Otherwise, go to question 2.2

2.2 Who developed these product innovations?

Tick all that apply

	Goods innovations		Service innovations	
Your enterprise by itself	☐	*INITGD*	☐	*INITSV*
Your enterprise together with other enterprises or organisations*	☐	*INTOGD*	☐	*INTOSV*
Your enterprise by adapting or modifying goods or services originally developed by other enterprises or organisations*	☐	*INADGD*	☐	*INADSV*
Other enterprises or organisations	☐	*INOTHGD*	☐	*INOTHSV*

**: Include independent enterprises plus other parts of your enterprise group (subsidiaries, sister enterprises, head office, etc.). Organisations include universities, research institutes, non-profits, etc.*

2.3 Were any of your product innovations (goods or services) during the three years 2012 to 2014:

		Yes *1*	No *0*	
New to your market?	Your enterprise introduced a new or significantly improved product onto your market before your competitors (it may have already been available in other markets)	☐	☐	*NEWMKT*
Only new to your enterprise?	Your enterprise introduced a new or significantly improved product that was already available from your competitors in your market	☐	☐	*NEWFRM*

Using the definitions above, please give the percent of your total turnover[5] in 2014 from:

New or significantly improved products introduced during the three years 2012 to 2014 that were **new to your market**	*TURNMAR* ☐☐☐ %	
New or significantly improved products introduced during the three years 2012 to 2014 that were **only new to your enterprise**	*TURNIN* ☐☐☐ %	
Products that were **unchanged or only marginally modified** during the three years 2012 to 2014 (include the resale of new products purchased from other enterprises)	*TURNUNG* ☐☐☐ %	
Total turnover in 2014	1 0 0 %	

2.4 To the best of your knowledge, were any of your product innovations during the three years 2012 to 2014:

(Please tick one option in every row)

	Yes *1*	No *0*	Don't know *2*	
A first in [your country]	☐	☐	☐	*INPDFC*
A first in Europe*	☐	☐	☐	*INPDFE*
A world first	☐	☐	☐	*INPDFW*

*: Include the following European Union (EU) and associated countries: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, FYR Macedonia, Malta, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.[6]

If no world-first innovation, go to Section 3,
Otherwise, go to question 2.5

2.5 What percent of your total turnover in 2014 was from world first product innovations introduced between 2012 and 2014? *(This should be a subset of your new-to-market turnover share in question 2.3 above)*

	FWTURN	
0% to less than 1%	☐	*1*
1% to less than 5%	☐	*2*
5% to less than 10%	☐	*3*
10% to less than 25%	☐	*4*
25% or more	☐	*5*
Don't know	☐	*6*

[5] For Credit institutions: Interests receivable and similar income, for insurance services: Gross premiums written
[6] Each NSO needs to remove their own country from the list of European countries.

3. Process innovation

A process innovation is the implementation of a **new** or **significantly** improved production process, distribution method, or supporting activity.

- Process innovations **must be new to your enterprise**, but they **do not need to be new to your market**.
- The innovation could have been originally developed by your enterprise or by other enterprises or organisations.
- Exclude purely organisational innovations – these are covered in section 8.

3.1 During the three years 2012 to 2014, did your enterprise introduce:

	Yes	**No**	
	1	*0*	
New or significantly improved methods of manufacturing for producing goods or services	☐	☐	*INPSPD*
New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services	☐	☐	*INPSLG*
New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing	☐	☐	*INPSSU*

If no to all options, go to section 4

Otherwise, go to question 3.2

3.2 Who developed these process innovations?

	Tick all that apply	
Your enterprise by itself	☐	*INITPS*
Your enterprise together with other enterprises or organisations*	☐	*INTOPS*
Your enterprise by adapting or modifying processes originally developed by other enterprises or organisations*	☐	*INADPS*
Other enterprises or organisations*	☐	*INOTHPS*

**: Include independent enterprises plus other parts of your enterprise group (subsidiaries, sister enterprises, head office, etc). Organisations include universities, research institutes, non-profits, etc.*

3.3 Were any of your process innovations introduced during the three years 2012 to 2014 new to your market?

	INPSNM
Yes	☐ *1*
No	☐ *0*
Don't know	☐ *2*

4. Ongoing or abandoned innovation activities for product or process innovations

Innovation activities include the acquisition of machinery, equipment, buildings, software, and licenses; engineering and development work, feasibility studies, design, training, R&D and marketing when they are specifically undertaken to develop and/or implement a product or process innovation. This includes also all types of R&D consisting of research and development activities to create new knowledge or solve scientific or technical problems. .

4.1 During the three years 2012 to 2014, did your enterprise have any innovation activities that did not result in a product or process innovation because the activities were:

	Yes	No	
	1	*0*	
Abandoned or suspended before completion	☐	☐	*INABA*
Still ongoing at the end of the 2014	☐	☐	*INONG*

If no to all options in questions 2.1, 3.1 and 4.1 go to section 8

Otherwise, go to section 5

5. Activities and expenditures for product and process innovations

5.1 During the three years 2012 to 2014, did your enterprise engage in the following innovation activities:

		Yes	No	
		1	*0*	
In-house R&D	Research and development activities undertaken by your enterprise to create new knowledge or to solve scientific or technical problems (include software development in-house that meets this requirement)	☐	☐	*RRDIN*
	If yes, did your enterprise perform R&D during the three years 2012 to 2014: Continuously (your enterprise had permanent R&D staff in-house) ☐ *1* Occasionally (as needed only) ☐ *2*			*RDENG*
External R&D	Your enterprise contracted-out R&D to other enterprises (include enterprises in your own group) or to public or private research organisations	☐	☐	*RRDEX*
Acquisition of machinery, equipment, software & buildings	Acquisition of advanced machinery, equipment, software and buildings to be used for new or significantly improved products or processes	☐	☐	*RMAC*
Acquisition of existing knowledge from other enterprises or organisations	Acquisition of existing know-how, copyrighted works, patented and non-patented inventions, etc. from other enterprises or organisations for the development of new or significantly improved products and processes	☐	☐	*ROEK*
Training for innovative activities	In-house or contracted out training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes	☐	☐	*RTR*
Market introduction of innovations	In-house or contracted out activities for the market introduction of your new or significantly improved goods or services, including market research and launch advertising	☐	☐	*RMAR*
Design	In-house or contracted out activities to alter the shape, appearance or usability of goods or services	☐	☐	*RDSG*
Other	Other in-house or contracted out activities to implement new or significantly improved products and processes such as feasibility studies, testing, tooling up, industrial engineering, etc.	☐	☐	*RPRE*

5.2 How much did your enterprise spend on each of the following innovation activities in <u>2014</u> only? Innovation activities are defined in question 5.1 above. Include current expenditures (including labour costs, contracted-out activities, and other related costs) as well as capital expenditures on buildings and equipment.[7]

Please fill in '0' if your enterprise had no expenditures for an activity in 2014

Please estimate if you lack precise accounting data

In-house R&D (Include current expenditures including labour costs and capital expenditures on buildings and equipment specifically for R&D)	☐☐☐☐☐☐☐☐	*RRDINX*
External R&D	☐☐☐☐☐☐☐☐	*RRDEXX*
Acquisition of machinery, equipment, software & buildings (Exclude expenditures on these items that are for R&D)	☐☐☐☐☐☐☐☐	*RMACX*
Acquisition of existing knowledge from other enterprises or organisations	☐☐☐☐☐☐☐☐	*ROEKX*
All other innovation activities including design, training, marketing, and other relevant activities	☐☐☐☐☐☐☐☐	*ROTRX*
Total of the above innovation activities	☐☐☐☐☐☐☐☐	*RALLX*

6. Public financial support for innovation activities

6.1 During the three years 2012 to 2014, did your enterprise receive any public financial support for innovation activities from the following levels of government? Include financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees. Exclude R&D and other innovation activities conducted entirely for the public sector* under contract.

	Yes	No	
	1	*0*	
Local or regional authorities	☐	☐	*FUNLOC*
Central government (including central government agencies or ministries)	☐	☐	*FUNGMT*
The European Union (EU)	☐	☐	*FUNEU*
If yes, did your enterprise participate in the EU 7th Framework Programme for Research and Technical Development or in the Horizon 2020 Programme for Research and Innovation?	☐	☐	*FUNRTD*

*The public sector includes government owned organisations such as local, regional and national administrations and agencies, schools, hospitals, and government providers of services such as security, transport, housing, energy, etc.

[7] Give expenditure data in 000's of national currency units to eight digits.

7. Co-operation for product and process innovation activities

7.1 During the three years 2012 to 2014**, did your enterprise co-operate on any of your innovation activities with other enterprises or organisations?** Innovation co-operation is active participation with other enterprises or organisations on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation.

No	☐ *(**Go to section 8**)*	*CO*
Yes	☐ *(Go to question 7.2)*	

7.2 Please indicate the type of innovation co-operation partner by location

(Tick all that apply)

Type of co-operation partner	**[Your country]**	**Other Europe****	**United States**	**China or India**	**All other countries**
A. Other enterprises within your enterprise group	☐ *Co11*	☐ *Co12*	☐ *Co13*	☐ *Co14*	☐ *Co15*
B. Suppliers of equipment, materials, components, or software	☐ *Co21*	☐ *Co22*	☐ *Co23*	☐ *Co24*	☐ *Co25*
C. Clients or customers from the private sector	☐ *Co311*	☐ *Co312*	☐ *Co313*	☐ *Co314*	☐ *Co315*
D. Clients or customers from the public sector*	☐ *Co321*	☐ *Co322*	☐ *Co323*	☐ *Co324*	☐ *Co325*
E. Competitors or other enterprises in your sector	☐ *Co41*	☐ *Co42*	☐ *Co43*	☐ *Co44*	☐ *Co45*
F. Consultants or commercial labs	☐ *Co51*	☐ *Co52*	☐ *Co53*	☐ *Co54*	☐ *Co55*
G. Universities or other higher education institutes	☐ *Co61*	☐ *Co62*	☐ *Co63*	☐ *Co64*	☐ *Co65*
H. Government, public or private research institutes	☐ *Co71*	☐ *Co72*	☐ *Co73*	☐ *Co74*	☐ *Co75*

7.3 Which type of co-operation partner was the most valuable for your enterprise's innovation activities? (Give corresponding letter) _______ *PMOS*

*The public sector includes government owned organisations such as local, regional and national administrations and agencies, schools, hospitals, and government providers of services such as security, transport, housing, energy, etc.

**: Include the following European Union (EU) and associated countries: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, FYR Macedonia, Malta, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

8. Organisational Innovation

An organisational innovation is a new organisational method in your enterprise's business practices (including knowledge management), workplace organisation or external relations that has not been previously used by your enterprise.

- It must be the result of strategic decisions taken by management.
- Exclude mergers or acquisitions, even if for the first time.

8.1 During the three years 2012 to 2014, did your enterprise introduce:

	Yes *1*	**No** *0*	
New **business practices** for organising procedures (i.e. first time use of supply chain management, business re-engineering, knowledge management, lean production, quality management, etc.)	☐	☐	*ORGBUP*
New methods of **organising work responsibilities and decision making** (i.e. first time use of a new system of employee responsibilities, team work, decentralisation, integration or de-integration of departments, education/training systems, etc.)	☐	☐	*ORGWKP*
New methods of **organising external relations** with other enterprises or public organisations (i.e. first time use of alliances, partnerships, outsourcing or sub-contracting, etc.)	☐	☐	*ORGEXR*

9. Marketing innovation

A marketing innovation is the implementation of a new marketing concept or strategy that differs significantly from your enterprise's existing marketing methods and which has not been used before.

- It requires significant changes in product design or packaging, product placement, product promotion or pricing.
- Exclude seasonal, regular and other routine changes in marketing methods.

9.1 During the three years 2012 to 2014, did your enterprise introduce:

	Yes *1*	No *0*	
Significant changes to the aesthetic **design** or **packaging** of a good or service (*exclude changes that alter the product's functional or user characteristics – these are product innovations*)	☐	☐	*MKTDGP*
New media or techniques for **product promotion** (*i.e. first time use of a new advertising media, a new brand image, introduction of loyalty cards, etc.*)	☐	☐	*MKTPDP*
New methods for **product placement** or sales channels (*i.e. first time use of franchising or distribution licenses, direct selling, exclusive retailing, new concepts for product presentation, etc.*)	☐	☐	*MKTPDL*
New methods of **pricing** goods or services (*i.e. first time use of variable pricing by demand, discount systems, etc.*)	☐	☐	*MKTPRI*

10. Public sector contracts and innovation

10.1 During the three years 2012 to 2014, did your enterprise have any contracts to provide goods or services for:

	Yes *1*	No *0*	
Domestic public sector organisations*	☐	☐	*PUBDOM*
Foreign public sector organisations*	☐	☐	*PUBFOR*

*The public sector includes government owned organisations such as local, regional and national administrations and agencies, schools, hospitals, and government providers of services such as security, transport, housing, energy, etc.

If no to both options, go to section 11

Otherwise go to question 10.2

10.2 Did your enterprise undertake any innovation activities as part of a contract to provide goods or services to a public sector organisation? *(Include activities for product, process, organisational and marketing innovations)*

No	☐ (***Go to section 11***)	*0*	*PBINN*
Yes	☐	*1*	

If yes, did one or more of your public sector contracts:

	(If your enterprise had several contracts, tick all that apply)	
Specifically require innovation as part of the contract	☐	*PBINCT*

Not require innovation as part of the contract	☐	*PBNOCT*

11. Intellectual property rights and licensing

11.1 During the three years 2012 to 2014, did your enterprise:

	Yes	No	
	1	*0*	
Apply for a patent	☐	☐	*PROPAT*
Apply for a European utility model	☐	☐	*PROEUM*
Register an industrial design right	☐	☐	*PRODSG*
Register a trademark	☐	☐	*PROTM*

11.2 During the three years 2012 to 2014, did your enterprise:

	Yes	No	
	1	*0*	
License out or sell a patent, industrial design right, copyright or trademark to another enterprise, university or research institute	☐	☐	*PROLEX*
License in* or buy a patent, industrial design right, copyright or trademark owned by another enterprise, university or research institute	☐	☐	*PROLIN*

*Exclude the acquisition of licenses for common software for desktop and laptop computers such as operating systems, word processing, spreadsheets, etc.)

Only answer section 12 if your enterprise did not introduce an innovation and did not have ongoing/abandoned innovation activities during the three years 2012 to 2014 ('no' to all options in questions 2.1, 3.1, 4.1, 8.1 and 9.1).
Otherwise go to section 13.

12. Non-innovators

12.1 Which of the following best describes why your enterprise had no innovation activities during the three years from 2012 to 2014:

	Tick one only		
No compelling reason to innovate	☐	***Go to 12.2***	*HCOMPR*
Considered innovating, but barriers to innovation too large	☐	***Go to 12.3***	*HBARIN*

12.2 How important were the following reasons for your enterprise not to conduct innovation activities during 2012 to 2014?

	Degree of importance				
	High *3*	**Medium** *2*	**Low** *1*	**Not important** *0*	
Low demand for innovations in your market	☐	☐	☐	☐	*HLDEM*
No need to innovate due to previous innovations	☐	☐	☐	☐	*HPRIOR*
No need to innovate due to very little competition in your enterprise's market	☐	☐	☐	☐	*HCOMPL*
Lack of good ideas for innovations	☐	☐	☐	☐	*HIDIN*

Go to question 13.4

12.3 How important to your enterprise were the following barriers to innovation during 2012 to 2014?

	Degree of importance				
	High *3*	**Medium** *2*	**Low** *1*	**Not important** *0*	
Lack of internal finance for innovation	☐	☐	☐	☐	*HFENT*
Lack of credit or private equity	☐	☐	☐	☐	*HCRE*
Lack of skilled employees within your enterprise	☐	☐	☐	☐	*HPER*
Difficulties in obtaining government grants or subsidies for innovation	☐	☐	☐	☐	*HSUBS*
Lack of collaboration partners	☐	☐	☐	☐	*HPAR*
Uncertain market demand for your ideas for innovations	☐	☐	☐	☐	*HDEM*
Too much competition in your market	☐	☐	☐	☐	*HCOMPH*

Go to question 13.4

13. Innovations with environmental benefits

An innovation with environmental benefits is a new or significantly improved product (good or service), process, organisational method or marketing method that creates environmental benefits compared to alternatives.

- The environmental benefits can be the primary objective of the innovation or a by-product of other objectives.
- The environmental benefits of an innovation can occur during the production of a good or service, or during its consumption or use by the end user of a product. The end user can be an individual, another enterprise, the Government, etc.

13.1 During the three years 2012 to 2014, did your enterprise introduce a product (good or service), process, organisational or marketing innovation with any of the following environmental benefits?

	Yes	No	
Environmental benefits obtained <u>within your enterprise</u>	*1*	*0*	
Reduced material or water use per unit of output	☐	☐	*ECOMAT*
Reduced energy use or CO_2 'footprint' (reduce total CO_2 production)	☐	☐	*ECOENO*
Reduced air, water, noise or soil pollution	☐	☐	*ECOPOL*
Replaced a share of materials with less polluting or hazardous substitutes	☐	☐	*ECOSUB*
Replaced a share of fossil energy with renewable energy sources	☐	☐	*ECOREP*
Recycled waste, water, or materials for own use or sale	☐	☐	*ECOREC*
Environmental benefits obtained during the consumption or use of a good or service <u>by the end user</u>			
Reduced energy use or CO_2 'footprint'	☐	☐	*ECOENU*
Reduced air, water, noise or soil pollution	☐	☐	*ECOPOS*
Facilitated recycling of product after use	☐	☐	*ECOREA*
Extended product life through longer-lasting, more durable products	☐	☐	*ECOEXT*

If no to all options, go to question 13.4
Otherwise go to question 13.2

13.2 Were any of these environmental benefits due to the following types of your enterprise's innovations?

	Yes	No	
	1	*0*	
Product (goods or services) innovations	☐	☐	*ECOPRD*
Process innovations	☐	☐	*ECOPRC*
Organisational innovations	☐	☐	*ECORG*
Marketing innovations	☐	☐	*ECOMKT*

13.3 During 2012 to 2014, how important were the following factors in driving your enterprise's decisions to introduce innovations with environmental benefits?

	Degree of importance				
	High	**Medium**	**Low**	**Not relevant**	
	3	*2*	*1*	*0*	
Existing environmental regulations	☐	☐	☐	☐	*ENEREG*
Existing environmental taxes, charges or fees	☐	☐	☐	☐	*ENETX*
Environmental regulations or taxes expected in the future	☐	☐	☐	☐	*ENREGF*
Government grants, subsidies or other financial incentives for environmental innovations	☐	☐	☐	☐	*ENGRA*
Current or expected market demand for environmental innovations	☐	☐	☐	☐	*ENDEM*
Improving your enterprise's reputation	☐	☐	☐	☐	*ENREP*
Voluntary actions or initiatives for environmental good practice within your sector	☐	☐	☐	☐	*ENAGR*
High cost of energy, water or materials	☐	☐	☐	☐	*ENCOST*
Need to meet requirements for public procurement contracts	☐	☐	☐	☐	*ENREQU*

13.4 Does your enterprise have procedures in place to regularly identify and reduce your enterprise's environmental impacts? (For example preparing environmental audits, setting environmental performance goals, ISO 14001 certification, ISO 50001 certification, etc).

No	☐ (***Go to section 14***)	*0*	*ENVID*
Yes	☐	*1*	

If your enterprise had any procedures in place, when were they implemented?

	(Tick all that apply)	
Some procedures were implemented before 2012	☐	*ENVBF*
Some procedures were implemented or significantly changed between 2012 and 2014	☐	*ENVBT*

14. Basic economic information on your enterprise

14.1 What was your enterprise's total turnover for 2012 and 2014?[8] Turnover is defined as the market sales of goods and services (Include all taxes except VAT[9])

	2012	2014
	☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐
	TURN12	*TURN14*

14.2 What was the percent of your total turnover from sales to clients outside your country?

Please insert '0' if your enterprise had no sales outside your country

	2012	2014
	☐☐☐ %	☐☐☐ %
	SLO12	*SLO14*

14.3 14.3 What was your enterprise's average number of employees in 2012 and 2014?[10]

	2012	2014
	☐☐☐☐☐☐	☐☐☐☐☐☐
	EMP12	*EMP14*

14.4 Approximately what percent of your enterprise's employees in 2014 had a tertiary degree?[11]

	EMPUD	
0%	☐	*0*
1% to less than 5%	☐	*1*
5% to less than 10%	☐	*2*
10% to less than 25%	☐	*3*
25% to less than 50%	☐	*4*
50% to less than 75%	☐	*5*
75% or more	☐	*6*

[8] Give turnover in '000 of national currency units. *Leave space for up to nine digits.*
[9] For Credit institutions: Interests receivable and similar income; for Insurance services give gross premiums written.
[10] If administrative data are used and the annual average is not available, give results for the end of each year. Leave space for up to six digits for question 14.3.
[11] ISCED 2011 levels 5 to 8

APPENDIX B: THE COMMUNITY INNOVATION SURVEY 2016 METHODOLOGICAL RECOMMENDATIONS

The Community Innovation Survey 2016
Methodological recommendations

in accordance with section 8§2 of the Annex II to the Commission Regulation (EU) No 995/2012 implementing the production and development of Community statistics on science and technology

December 2016

0. Introduction

The Commission Regulation (EU) No 995/2012, implementing Decision No 1608/2003/EC of the European Parliament and of the Council concerning the production and development of Community statistics on science and technology, puts innovation statistics on a statutory basis and makes the delivery of certain variables compulsory (from thereafter Regulation). This document, which outlines the harmonized methodology to be used for CIS 2016, is related to section 8§2 2 of the Annex II of the Regulation.

1. Target population

The recommended target population of the CIS 2016 is the total population of enterprises in NACE Rev. 2 sections A to N. These sections include most market activities. The survey excludes activities O to U consisting of public administration, education, health and social work, arts, entertainment and recreation; other service activities (professional organisations and personal services), households and extraterritorial bodies. [1]

Annex 1 provides guidance in cases in which the target population may change or cause difficulty.

<u>1.1 Classification of Economic Activities, NACE</u>

CIS 2016 uses the NACE Rev. 2 classification of economic activities.

- Core coverage

It is **mandatory** to include the following NACE Rev.2 sections and divisions in the core target population of the CIS 2016:

- mining and quarrying (NACE B: 05-09)
- manufacturing (NACE C: 10-33)
- electricity, gas steam and air conditioning supply (NACE D: 35)

[1] The target population for CIS 2014 does not include several NACE Rev. 2 divisions where there can be a mix of public and market services, including education (NACE 85), health (NACE 86-88), and arts (NACE 90-93), nor other services (NACE 94-96).

1

- water supply; sewerage, waste management and remediation activities (NACE E: 36-39)
- wholesale trade, except of motor vehicles and motorcycles (NACE 46)
- transportation and storage (NACE H: 49-53)
- information and communication (NACE J: 58-63)
- financial and insurance activities (NACE K: 64-66)
- architectural and engineering activities; technical testing and analysis (NACE 71)
- scientific research and development (NACE 72)
- a dvertising and market research (NACE 73)

Section 6§1 of the Annex II to the Regulation indicates the requested breakdowns by economic activity and size classes.

- *Additional coverage*

On a **voluntary basis** also the following NACE Rev. 2 divisions can be covered (in order of descending priority):

- construction (NACE 41-43)
- wholesale and retail trade and repair of motor vehicles and motorcycles (NACE 45)
- retail trade, except of motor vehicles and motorcycles (NACE 47)
- legal and accounting activities (NACE 69)
- activities of head offices; management consultancy activities (NACE 70)
- other professional, scientific and technical activities (NACE 74)
- employment activities (NACE 78)
- security and investigation activities (NACE 80)
- services to buildings and landscape activities (NACE 81)
- real estate activities (NACE 68)
- accommodation and food service activities (NACE 55-56)
- rental and leasing activities (NACE 77)
- agriculture, forestry and fishing (NACE 01-03)
- travel agency, tour operator and other reservation services and related activities (NACE 79)
- office administrative, office support and other business support activities (NACE 82)
- veterinary activities (NACE 75)

These economic activities should be regarded as "non-core" and do not necessarily have to meet the same quality requirements as for the core coverage e.g. for item and unit non- response (i.e. a non-response survey does not have to be carried out in respect of these NACE activities) or the required level of precision.

1.2 Size-classes

It is recommended that all enterprises be included in the target population. However, the mandatory coverage consists of the enterprises with 10 employees or more.

1.3 Statistical units

According to the section 1 of the Annex II to the Regulation the statistical unit for the CIS 2016 shall be the enterprise, as defined in the Council Regulation 696/1993 on statistical units. EU Regulation 2186/1993 requires that Member States set up and maintain a register of enterprises, (as well as associated legal units and local units).

In the Council Regulation 696/1993[2], the enterprise is defined as "the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision making, especially for the allocation of its current resources. It may carry out one or more activities at one or more locations and it may be a combination of legal units, one legal unit or part of a legal unit."

Of note, the voluntary activities under NACE Rev. 2 include NACE 70, which covers the managerial, strategic and organisational functions of head offices in addition to management consultancy activities. To prevent double counting, particularly interval level results for the head offices of enterprise groups, such as for R&D or innovation expenditures should be reported separately from the results for enterprises.

1.4 The reference period

The reference period to be covered by the survey shall be 2014-2016 inclusive i.e. the three-year period from January 1st 2014 to December 31st 2016. However, few questions refer only to one year.

2. Survey methodology

2.1 Sampling frame

The official, up-to-date, statistical business register[3] of the country should be used.

2.2 Census or sample survey

Data should be collected through a census, sample survey or a combination of both.

2.3 Stratification

The target population should be broken down into similar structured subgroups or strata which should be as homogeneous as possible and form mutually exclusive groups. Appropriate stratification will normally give results with smaller sampling errors than a non-stratified sample of the same size and will make it possible to ensure that there are enough units in the respective domains[4] to produce results of acceptable quality.

The stratification variables to be used for the CIS 2016, i.e. the characteristics used to break down the sample into similarly structured groups, should be:

[2] Council Regulation (EEC) N° 696/1993 of 15 March 1993, OJ N° L76 of the 3 March on the statistical units for the observation and analysis of the production system in the Community.
[3] Council Regulation (EEC) N° 2186/1993 of 22 July 1993.
[4] Domains are defined as strata or combinations or strata, for which results will be published.

- *The economic activities*[5].

Stratification by NACE shall be done at least in accordance with the NACE categorization presented in the section 6§1 of the Annex II to the Regulation.

- *Enterprise size according to the number of employees*[6].

The size-classes used should at least be the following:

- 0-9 employees (voluntary, but recommended if surveyed)
- 10-49 employees
- 50-249 employees
- 250+ employees.

More detailed breakdown by economic activity and size class may also be used, but, whatever activity levels / size-classes are chosen, they should fit into the categories presented in the section 6§1 of the Annex II to the Regulation.

- *Regional sampling*.

In accordance with section 8§2 of the Annex II of the Regulation, the survey methodology could also include the NUTS 2 region as the sampling criteria. The sample at the regional level should be large enough to provide NUTS 2 results for SME size category (between 10 and 249 employees).

2.4 Sample size

There is no minimum sample size defined needed, as long as the sample size chosen will meet the precision levels required (see section 4.7). However, if a particular stratum has less than six enterprises, then all the enterprises in this stratum should be selected for the survey.

The expected response rate should be borne in mind i.e. the sample size should take into account the non-response rates experienced in CIS 2014 and compensate accordingly. Finally, there should be no replacement of deleted or not-relevant units. The sample size should be large enough to compensate for any of these types of units.

2.5 Sample selection and allocation

The selection of the sample should be based on random sampling techniques, with known selection probabilities, applied to strata. It is recommended to use simple random sampling without replacement within each stratum.

Different allocation schemes can be used, depending on the structure of the population. It is recommended to use optimum allocation, taking into account the need to "compromise" the allocation, in order to obtain the required levels of precision for all indicators and domains.

The variance in each stratum to be used for sample selection can be based on previous CIS 2014 results, if there is reliable information available. If not, one can either use the CIS 2014 national average or assume that a problem stratum will be close to a stratum for which reliable results are available. If new sectors of the economy are added for the CIS 2016, one can either use the

[5] The NACE code to use for stratification should be that of the enterprise at the end of the reference period 2016.
[6] The enterprise size to use for stratification should be the number of employees at the end of the reference period 2014.

national average for the CIS 2014 or assume that the new sector will be close to a sector that has been sampled previously.

Member States are free to use whatever sampling methods they prefer, as long as the quality thresholds for the results are achieved. However, in accordance with section 8§3 of the Annex II of the Regulation, Eurostat should be informed of the method of sampling and allocation scheme being used.

Annex 2 provides further information on calculating sample size and allocating samples.

3. Collecting and processing of data

3.1 Survey questionnaire

The CIS 2016 uses the harmonised survey questionnaire developed by the CIS 2016 Task Force and adopted by all Member States[7]. The questionnaire covers the main themes listed in the Oslo Manual 3rd edition. This harmonised questionnaire shall be used in national innovation surveys. The CIS 2016 includes several new questions compared to CIS 2014, specific methodological recommendations for these new questions are provided in Annex 3.

3.2 Data collection

The CIS 2016 should be mainly based on online or mailed surveys. Online versions should match the mailed questionnaire (harmonized survey questionnaire) as closely as possible and follow the recommendations developed as part of the work for CIS 2014.

Member States may use other data collection methods, as long as this does not result in significant differences in responses compared to a mailed survey. Telephone CATI surveys should be used cautiously, particularly when combined with either a mail or online survey.

3.3 Combining the CIS with other surveys

Member States may combine the CIS 2016 questionnaire with other surveys, as long as this does not negatively affect the quality or the comparability of the output of the CIS 2016.

A combined survey can produce very different results compared to an innovation-only survey as shown for example by two Norwegian studies on the results of CIS 2010 and CIS 2012. The studies showed that the share of innovators in the innovation-only survey is significantly higher compared to the CIS results which are based on a combined R&D and CIS survey.

One of the possible explanations given is that by removing the R&D module, the perception of the survey is shifted away from a technology and knowledge driven viewpoint. This might influence the threshold among respondents for reporting an activity as innovative. It is recommended that combining surveys should be avoided, where possible, until more information is available on the effect of combined surveys on CIS results. Further information on the effect of combining surveys is provided in Annex 4 of the Methodological Recommendations for CIS 2014.

[7] The Community Innovation Survey 2016 - The harmonized survey questionnaire, 12 September 2016 (V11)

3.4 Data editing

Throughout the processing cycle, there should be a systematic and sustained follow up with the responding enterprises to make sure that the data provided is of good quality and passes all edit checks. Data quality checks have to be done at the micro- and macro-level by Member States before the results are finally processed and sent to Eurostat.

Further information on data editing is provided in Annex 4.

4. Data quality

4.1. Response rates

The units that do not respond to the CIS 2016 survey questionnaire may have different characteristics than those that do respond. Therefore, all efforts shall be made to minimise unit (and item) non-response.

The recommended technique to elicit response is to send at least two reminder letters to the sampled enterprise. These should be sent out within an acceptable period after the sending of the original questionnaire. Timely telephone follow-up after the mailed reminders can also improve unit response rates. Annex 5 gives an example of how to maximize response rates.

4.2 Unit non-response and non-response survey

If non-respondents, as an un-weighted percentage of all relevant enterprises in the sampling frame, exceed 30%, then a simple random sample of **at least** 10% of the non-respondents (excluding non-relevant enterprises) should be selected. The questions to be included in the non-response survey are specified in Annex 6. The purpose is to determine if the non-respondent is an innovator or not, using three mutually exclusive definitions of different types of innovative activities:

1. The enterprise is a product/process (PP) innovative enterprise. It introduced a product or process innovation, but did **not** perform R&D for PP innovation.
2. The enterprise performs R&D for PP innovation activities.
3. The enterprise is **only** a non-technological innovator: it introduced an organisational or marketing innovation, but is not engaged in PP activities.

As a final check, the non-response analysis should determine if there is a statistically significant difference in the broad definition of innovation, defined as a firm that has introduced either a product, process, organisational, or marketing innovation or which reports performing R&D.

If non-response is not equally distributed across strata, Member States may use a stratified non-response sample. The non-response survey should have a very high response rate. This non-response survey should be carried out for at least the core target NACE population. A telephone non-response survey is first recommended because this is likely to provide the highest possible response rates. In countries where telephone surveys provide unreliable data, a written or face-to-face non-response survey can be conducted, as long as a very high response rate is obtained.

If the results from the non-response analysis indicate that there is a statistically significant difference between respondents and non-respondents in a given strata for one or more of the three types of innovative activities (see Annex 7), this information should be used when calculating the weighting factors (see section 4.6). Member States shall describe how the information from the non-response survey has been used to reduce eventual bias in the estimates.

4.3 Item non response

Item non-response should be kept at a minimum by asking the enterprises for the additional information needed. Item non-response for general variables on the enterprises should not exist, as this information should be available in the business register or from other sources. Some respondents may return questionnaires that have some items filled in, but these cases should only be counted as respondents if they are usable in the processing stage.

Before carrying out automatic imputation, Member States should, as far as possible, make use of administrative, historical (e.g. the CIS 2014 or other past surveys) or other available data sources such as R&D surveys.

4.4 Quality checks for interval level data

Current best practice is to check interval level data (question 2.3 on innovation sales shares and question 5.2 on innovation expenditures) either against alternative data sources (as for R&D expenditures) or for outliers or other unexpected values. In the latter case, the enterprise should be contacted to confirm or correct the reported value. These methods are particularly important for large enterprises that account for a high share of total reported R&D and innovation expenditures.

4.5 Imputation

After every attempt is made to get the information from the enterprises concerned imputations shall be done to correct for remaining item non-response. Imputed values should be flagged as this enables proper non-response analysis to be done.

Editing may be used to impute metric (or measurement) variables separately from ordinal (or ranking) variables.

(1) Metric variables

A weighted mean of each metric variable, by NACE and size class, is calculated and applied as a ratio to the enterprises with the missing values, within the stratum concerned.

(2) Ordinal, nominal and percentage variables

This imputation shall be done after the metric estimation. The technique used is nearest-neighbour hot decking using entropy[8]. This technique will use data from clean records (a donor with a record not violating any error check), in order to copy the missing data. The donors are chosen in such a way that the distance between the donor and recipient be minimised[9].

Annex 8 provides further information on imputation procedures. Member States may also use other reliable methods of imputation, as long as the quality of results is at least identical.

[8] Cold deck imputation, on the other hand, makes use of a fixed set of values, which covers all of the data items. These values can be constructed with the use of historical data, subject-matter expertise, etc. A 'perfect' questionnaire is created in order to answer complete or partial imputation requirements.

[9] Nearest neighbour imputation: In this case a criteria is developed to determine which responding unit is 'most like' the unit with the missing value in accordance with the predetermined characteristics. The closest unit to the missing value is then used as the donor.

4.6 Weighting and calibration

The survey results should be weighted in order to adjust for the sampling design and for unit non-response to produce valid results for the target population. In the case of non-response, the weightings should adjust for statistically significant differences in the proportion of each of the three mutually exclusive types of innovative firms, as defined in section 4.2 above. Additional auxiliary information should also be incorporated, if it is considered that this will enhance the accuracy of the estimates.

The basic method for adjusting for different probabilities of selection used in the sampling process is to use the inverse of the sampling fraction i.e. using the number of enterprises or employees. This would be based on the figure N_h/n_h where N_h is the total number of enterprises/employees in stratum h of the population and n_h is the number of enterprises/employees in the **realised** sample in stratum h of the population, assuming that each unit in the stratum had the same inclusion probability. This will automatically adjust the sample weights of the respondents to compensate for unit non-response.

However, if a non-response analysis is carried out (and the results indicate that there is a difference between respondents and non-respondents), then the results of the non-response analysis should also be used when calculating the final weighting factors. One approach is to divide each stratum into a number of response homogeneity groups with (assumed) equal response probabilities within groups. A second approach could be to use auxiliary information at the estimation stage for reducing the non-response bias.

If the frame contains auxiliary information about the sampling units i.e. variables that are correlated with at least some of the measurement variables of interest, this information should be used to improve the estimation further[10]. In general, the variables to use for calibration are turnover and the number of enterprises, both by NACE and size classes but others can also be used.

Various software packages are available to do the calculations needed to derive calibrated weights. These include:

- CLAN. This was developed by Statistics Sweden and it is a suite of SAS-macro commands.
- CALMAR (Calibration on Margins). This is another SAS macro developed by INSEE in France.
- CALJACK. This is also a SAS macro developed by Statistics Canada.

Several different sets of weights may be produced, depending on the variables of interest. In practice however, there will probably be only up to three different weights produced.

Member States are free to use whatever calibration technique they prefer but in accordance with section 8§3 of the Annex II of the Regulation, Eurostat should be informed on the calibration methods used.

[10] It can be done for balancing purposes (in the sense that after calibration, "the sample looks like the population") or for improved consistency of estimates (in production systems, each sampled unit is given a unique final weight as part of the calibration process; as a result, estimates are consistent in the sense that the parts add up to the totals).

4.7 Precision of results

The CIS 2016 should be carried out in order to achieve a certain level of precision for the total population concerning the following indicators:

1. Percentage of innovation active enterprises.
2. Percentage of innovators that introduced new or improved products new to their market.
3. Turnover from new or improved products, as a percentage of total turnover.
4. Percentage of enterprises involved in innovation cooperation (in the total of product and/or process innovative enterprises.

In addition, the CIS 2016 should also achieve a certain level of precision for the total population with regard to the following indicator:

5. Total turnover per employee.

According to the Article 6 of the Regulation Member States shall take all necessary measures to ensure the quality of the data provided.

After processing the data, the 95% confidence intervals[11] for the first three indicators should be $\hat{\theta} \pm 0.05$, for indicator 4 the 95% confidence interval should be $\hat{\theta} \pm 0.10$, and for indicator 5 the confidence interval should be ± 10% of the estimate $\hat{\theta}$.

5. Transmission of data

5.1 Data to be transmitted

Article 5 of the Regulation lays down two types of data to be transmitted to Eurostat. The first set refers to aggregated statistics that will be transmitted on a mandatory basis while the second refers to individual data records that may be transmitted on a voluntary basis.

Mandatory variables are listed in section 2 of the Annex II of the Regulation. The section 2 says furthermore that, beyond the statistics listed Member States may compile additional statistics which will be incorporated in the harmonised survey questionnaire (voluntary questions or variables).

Eurostat will provide the tabulation scheme as well as the transmission format to be used for transmitting both data sets (the tabulated data set and the microdata).

Aggregated statistics shall be treated in accordance with the standard confidentiality rules at national level. Data sets will be flagged with primary and secondary confidentiality by the Member States for the transmission to Eurostat. Transmission includes also confidential data.

In accordance with Article 6 and the Annex III of the Regulation, Member States shall transmit the standard predefined Quality Reports to Eurostat. These will be complemented (or include)

[11] The confidence interval for the parameter, $\hat{\theta}$, with approximate confidence level of 95%, is given by:

$$\hat{\theta} \pm 1.96 \cdot \sqrt{Variance\ (\hat{\theta})}$$

with the information concerning the national methodology used (section 8§3 of the Annex II of the Regulation).

The individual data records will used for the compilation of SAFE Centre research file (secure-use files) and anonymized microdata set (scientific-use files) and be made available for further scientific research, according to the procedures laid down in Commission Regulation (EU) No 557/2013.

5.2 Output tabulation

In accordance with section 6§1 of the Annex II to the Regulation results will be broken down by economic activity and employment size classes.

The output tabulation for CIS 2016 which will be produced in accordance with Annex II of the Regulation on innovation statistics will be based on the tabulation used for the CIS 2016 taking into account the changed survey elements (e.g. extended/modified coverage and breakdowns, new and modified questions including the new module of the survey).

With regard to regional innovation data, the tabulation scheme will also contain certain variables on optional basis the core coverage results broken down by:

- NUTS 2 level by industry (NACE Rev. 2 sections B-C-D-E) and services (NACE Rev. 2 sections H-J-K and divisions 46-71-72-73);
- NUTS 2 level by size classes (as listed in section 2.3).

Obtaining NUTS 2 data for large enterprises with multiple establishments is difficult, due to the problem of how to assign enterprise activities to a single region. This problem is likely to be less important for SMEs, the majority of which will be single establishment enterprises. Therefore, regional results should be provided for all SMEs with between 10 and 249 employees combined. This may also be necessary if sample sizes are not adequate for a detailed regional breakdown for all size classes listed in section 2.3.

5.3 Transmission tool

CIS 2014 tabulated data and as well the microdata shall be transmitted to Eurostat via eDAMIS (electronic Data files Administration and Management Information System) under the following consignment: CIS_CIS_2. Safe and secure eDAMIS procedure guarantees also a method of tracking the transmissions.

5.4 Deadlines

The deadlines for mandatory data and Quality Report transmission indicated in the Annex II and Annex III of the Regulation shall be respected.

As agreed at the Working Group Meeting, Eurostat will ask for an earlier transmission of tabulated data of at most 10 key indicators (final tabular data). The transmission of the rest of all indicators will happen according to the Regulation.

Annex 1: Target population changes

The following are situations where the target population may change or cause difficulty during the survey:

- Subsidiaries of multinationals requesting contact with the parent organization. While the subsidiaries may get the information from abroad, the information should only relate to the particular national subsidiary. There is a general difficulty with getting multi-national organizations to report information at national level but they will have to make every effort to delineate their data for national units at least. Only domestic units of multi-national corporations should be included in the survey.

- Companies under liquidation or that were liquidated during the observation period (2014-2016 inclusive). Companies that were liquidated before the period should not be considered as part of the target population. Companies that were liquidated during the period should also be deleted from the sample and target population, unless it is decided that their liquidation was so late in the survey period that they should be included in the target population.

- New companies created during the observation period. These should be added to the population.

- Enterprises changing NACE section. These should be recoded accordingly and considered as part of the new NACE section rather than the old one.

- Two or more enterprises combine to form one enterprise. If this happened before or at the beginning of the survey period (and one or more of the units is in the sample) then the new unit should respond with a single form for both (or more) enterprises. Additionally the population should be changed to delete the two (or more) individual units and to include the new unit only. If neither unit was in the sample then the population should simply be amended to reflect the changes.

  If the merger happened late in the survey period, then the original units can be treated as they are, i.e. separately, and ignore the merger. Care will have to be taken however that neither unit returns information for more than its' original elements and they do not send in responses covering the other merged elements as well.

- Enterprises that split to form new units. If this happened early in the survey period then the target population should be amended to reflect the new units. Any such enterprise that is part of the sample should return forms for each new unit separately. If the split happens late in the survey period or if the enterprise cannot supply information on each new element separately, keep the unit as it was before the split.

- Enterprises that are outside the target population, i.e. in NACE sections not covered by CIS 2016. These should be excluded from all processing if they are in the sample. In addition, the target population should be adjusted before the calculation of weights, in order to exclude these and other types of non-relevant enterprises.

Annex 2: Sample size calculation and allocation[12]

Generally, the factors that affect precision of the results are:

- Size of the population
- Variability of characteristics in the population
- Sample plan and estimators
- Non- response
- Cost and time
- Operational constraints (like training of staff etc.)

I. Estimation of parameters

Consider a set of variables $y_1,\ldots,y_a,\ldots,y_A$ and let $y_a(k)$ be the value of variable y_a for unit k in the finite population U. Also, consider a partitioning of U into D possibly overlapping domains $U_1 \ldots U_2 \ldots U_D$. For each one of the $A^x D$ possible combinations of variables and domains, a number of parameters θ of interest can be defined for the whole population or for different domains.

II. Sample design

The sample is drawn as stratified sample with simple random sampling without replacement within strata. The stratification is according to section 2.3, taking into account the study-domains for the output tabulation in section 5.2.

III. Sample size in domains of study

Each domain is considered as a population, which is divided into one or more strata. The sample size, n_D , in domain D is calculated as:

$$n_D = \frac{\left(\sum_{h=1}^{H} W_h \cdot S_h \right)^2}{V(\hat{\theta}_D) + \frac{1}{N_D} \sum_{h=1}^{H} W_h \cdot S_h^2} \qquad (2.1)$$

where $V(\hat{\theta}_D)$ is the variance for the estimated parameter; H is number of strata in domain D; $W_h = N_h / N_D$, where N_h is the number of enterprises in stratum h; N_D is the number of enterprises in domain D; and S_h^2 is the stratum variance for the variable, y_a.

[12] For general information on sampling, see Cochran W. G. (1977) Sampling Techniques, third edition, John Wiley.

$$S_h^2 = \frac{1}{N_h - 1} \sum_{k \in a_h} \left(y_a(k) - \frac{1}{N_h} \sum_{k \in a_h} y_a(k) \right)^2 \qquad (2.2)$$

The expression in (2.1) is obtained by considering the cost to be equal for all strata, e.g. $c_h = c$ for all h, as in formulae (5.25) in section 5.5 in Cochran[13].

IV. Precision

The confidence interval for the parameter, θ, with approximate confidence level of 95%, is given by:

$$\hat{\theta}_D \pm 1.96 \cdot \sqrt{V(\hat{\theta}_D)} \qquad (2.3)$$

The precision, α_D, in terms of the length of the confidence interval:

$$\alpha_D = 1.96 \cdot \sqrt{V(\hat{\theta}_D)} \qquad (2.4)$$

From (2.4) the variance, $V(\hat{\theta}_D)$, can be expressed as:

$$V(\hat{\theta}_D) = \left(\frac{\alpha_D}{1.96} \right)^2 \qquad (2.5)$$

By combining (2.1) and (2.5), the sample size in domain D is given by:

$$n_D = \frac{\left(\sum_{h=1}^{H} W_h \cdot S_h \right)^2}{\left(\frac{\alpha_D}{1.96} \right)^2 + \frac{1}{N_D} \sum_{h=1}^{H} W_h \cdot S_h^2} \qquad (2.6)$$

Note

1. To calculate n_D, the true variances in each stratum, S_h^2, is needed and the precision, α_D.
2. In practice, the standard deviations for each stratum, S_h, are not known. Therefore, the CIS 4 or other sources might have to be used, but these estimates might be rather unreliable.

[13] Cochran W. G. (1977), Sampling Techniques, third edition, John Wiley; section 5.5 (Optimum Allocation)

3. The above-described sample size calculation will ensure that the sampling error of a specific variable does not exceed the predetermined value. However, in section 4.6 there are 5 indicators for which a certain level of precision should be attained. The sample size thus needs to be calculated for each indicator and the largest sample size should be used.

II. Allocation

If the cost per unit is the same in all strata, then the *Neymann allocation* can be used. The total sample size in the domain, D, is distributed among strata, e.g. the sample size in stratum h, n_h, is given by:

$$n_h = n_D \cdot \frac{N_h \cdot S_h}{\sum_{h=1}^{H} N_h \cdot S_h}. \qquad (2.7)$$

<u>Note</u>

1. The determination of an optimum allocation is often an iterative process. The first step may yield, in some strata, a sample size larger than the number of enterprises in the population. The usual procedure is to take all enterprises in those strata as part of the sample and subsequently reduce the total sample size and recalculate n_h again for the remaining strata.

2. The above-described allocation is optimal for a specific variable. It might not be the case when allocating the sample for other variables and "compromise" allocation schemes are needed. For the CIS 2014 the sample has to be allocated in order to meet the precision criteria for the 5 indicators for which a certain level of precision of results is required (see section 4.6).
3. Several different such schemes can be used. A simple procedure for multivariate allocation is to compute the average sample sizes for each stratum but methods that are more sophisticated may also be used.

Annex 3: Methodological recommendations for new CIS 2016 questions

The changes to the CIS 2016 compared to CIS 2014 were driven by four main factors:

1) the introduction of a new question on business strategies to be used for profiling and policy use;
2) the introduction of a new question on the expected change in innovation expenditures in one and two years ahead (i.e. T+1 and T+2) for making the data more timely and policy relevant;
3) a new set of questions on legislation and regulations and,
4) a module on innovations in logistics.

This section follows the structure of the Harmonised CIS 2016. Question numbering may vary with national surveys.

Question 1.4 - Business strategies

a) Respondents can tick one box per row but this is assumed to be clear as similar instructions (or the lack thereof) are provided in similar question types in the CIS (for instance Q7.1, Q10.1 Q12.2, Q12.3 and Q14.3). NSIs are free to add the instruction "*Please tick one option in every row*" for these question types but this is not considered necessary.

Question 5.3 – Expected innovation expenditures

a) A clear distinction should be made between 2017 compared to 2016 and 2018 compared to 2017. For the later, cognitive testing showed it was more difficult to answer for T+2, hence no percentage changes should be asked for 2018 compared to 2017.
b) The question should follow Q5.2 on innovation expenditures, as it asks for the expected change of the total innovation expenditures answered in Q5.2.

Question 11 – Effect of legislation or regulations on innovation activities

a) When translating, the question should emphasize to assess the effect on the innovation activities of an enterprise and not their activities in general.
b) Respondents can tick all boxes. On the one hand a particular innovation activity could have been stimulated by a particular regulation while on the other hand the same regulation could have created major problems for another innovation activity.
c) If respondents tick both the Not relevant and any other box in the same row, the Not relevant response should be ignored.
d) Q11.2. No specifications

Ad-hoc module on innovations in logistics – chapter 14 of CIS 2016

a) Q14.1 might lead to consistency problems with Q3.1 Process innovation. Answers to Q14.1 should not lead to corrections for answers to Q3.1. For instance, should a respondent answer yes to any of the items under questions 14.1, then no corrections should be made in their answer(s) for Q3.1. Preferably these enterprises should be contacted to inquiry why they have not answered yes in Q3.1.

b) Q14.2, the term operating expenses and what expenses it includes might differ across countries. The instructions after the question should therefore be carefully translated see also the guidelines/translations provided by DG MOVE.

c) Q14.4, answers for Q14.4 should not lead to corrections for answers to Q5.2 total innovation expenditures. If respondents provide an answer that is not consistent with Q5.2 total innovation expenditures, NSIs should preferable contact the respondents to inquiry.

Annex 4: Data editing

The types of checks being done in the SAS programmes are:

- Completeness checks. This is where the questionnaire is not fully completed. Contact should be made with the reporting unit to get the information as soon as possible after receipt of the incomplete form.
- Out of scope units. These are units which do not belong to the target population i.e. wrong NACE, wrong size etc. If this is the case, i.e. if the units are not part of the target population, then they will be dropped from further data processing.
- Data validation checks. This tests whether answers are permissible i.e. the answer is within the range of answers allowed. If a validation error occurs then the answer must be amended (by getting further information from the enterprise for example) to bring it into line with the range allowed.
- Relational checks. This checks that the relationship between two variables is within specific bounds i.e. innovation expenditure should equal the total given. These errors may be "hard" (a violation of the rule indicates that something is incorrect) or "soft" (just a warning that something might be wrong). The hard errors will have to be corrected while the soft errors should be confirmed with the enterprise (and corrected if the information is actually wrong).
- Routing errors. This tests whether all questions that should have been answered have been answered, i.e. innovators answered questions on effects of innovation. An error here indicates that the respondent did not understand the sequencing of questions. They should be contacted to correct the information.

Annex 5: Total Design Method for Improving Response Rates

The Total Design Method (Dillman, D. (1978): The Total Design Method, Wiley) consists of a combination of actions (or moments) that have proven effective in reducing non-response when using mail questionnaires.

The theory underlying the TDM is social exchange, which suggests that the likelihood that individuals will respondent to a survey questionnaire is a function of how much effort is required to respond, and what they feel they are likely to get in exchange for completing the questionnaire.

The TDM was originally developed for individual and household surveys. An adaptation for the business environment is described in Tailored Design Method (Dillman, 2000) and Moore & Baxter (Moore, D. and Baxter, R. 1993) in "Increasing Mail Questionnaire Completion for Business Populations: The Effects of Personalization and a Telephone Follow-up Procedure as Elements of the Total Design Method".

Five main actions that can be used to improve response rates in business surveys are:

Have a respondent-friendly questionnaire. This should be easy and clear to understand, have a relevant question order and a comprehensible, "user-friendly" layout.

There should be up to five contacts with the potential respondent. A pre-notice letter (sent to respondents a few days prior to the questionnaire), the questionnaire (sent a few days to a week after the pre-notice letter, a thank you/reminder postcard (sent about one week after the questionnaire). If necessary, there should also be a replacement questionnaire (sent to non-respondents between 2-4 weeks after questionnaire was mailed) and a final contact (made a week after the replacement questionnaire was sent out.

In all cases where mail response is requested, the use of a real stamp on return envelopes can increase the response rates (It represents something of value and is something the respondent is less likely to throw away).

Personalised correspondence could be used by using real stationery, real names and real signatures.

Finally, a small token or financial incentive can significantly improve response rates. However, incentives can have modest and, in some cases, no effect at all.

Other references that can be consulted for more information are:

Paxson, M.C.; Dillman, D.A.; Tarnai, J.: Improving Response to Business Mail surveys.

Dillman, D.A.: Mail & Internet Surveys: The Tailored Design Method. Wiley, 2000

Annex 6: Non respondent survey questionnaire

The non-respondent questionnaire should include the following questions on technical and non-technical innovation, plus the spoken preamble. The questionnaire is designed to be completed within approximately 5 minutes.

Read out: An innovation is the introduction of a new or significantly improved product, process, organisational method, or marketing method by your enterprise.

An innovation must have characteristics or intended uses that are new or which provide a significant improvement over what was previously used or sold by your enterprise. However, an innovation can fail or take time to prove itself.

An innovation need only be new or significantly improved for your enterprise. It could have been originally developed or used by other enterprises or organisations.

1. During the three years 2014 to 2016, did your enterprise introduce any of the following types of innovations? Please answer yes or no.

		Yes	No
1.	New or significantly improved **goods or services**	☐	☐
2.	New or significantly improved methods of manufacturing or producing goods or services	☐	☐
3.	New or significantly improved **logistics, delivery or distribution methods** for your inputs, goods or services.	☐	☐
4.	New or significantly improved **supporting activities for your processes,** such as maintenance systems or operations for purchasing, accounting or computing.	☐	☐
5.	New or significantly improved **organisational methods**. These involve changes to your enterprise's business practices, organisation of work responsibilities, or external relations with other enterprises or public institutions.	☐	☐
6.	New or significantly improved **marketing methods**. These involve the implementation of new marketing concepts or strategies that differ significantly from your enterprise's existing marketing methods and which have not been used before.	☐	☐

2. At some time during the three years 2014 to 2016, did your enterprise perform R&D to develop or improve goods, services, or processes?

Yes ☐
No ☐

[Only ask the next question if there are one or more positive responses to questions 1.1 or 1.2]

3. During the three years 2014 to 2016, did your enterprise **acquire advanced machinery, equipment or software** in order to produce new or significantly improved goods or services or as part of new or improved processes?

Yes ☐
No ☐

Annex 7: Testing the non-response survey

The aim of this analysis is to sample a selection of non-respondents and find out if they have a different behaviour than that of the original respondents. If a non-response survey has been carried out (as it should be if the non-response rate is above 30%, i.e. 30% or more of relevant enterprises did not respond to the survey), a statistical test has to be carried out to check whether the population of non-respondents is significantly different from the populations of respondents.

Test for the equality of two proportions:

H_0: $P_R = P_{NR}$ or $P_R - P_{NR} = 0$ where $\mathbf{P_R}$ is the weighted percentage of innovators in the respondent population and $\mathbf{P_{NR}}$ is the weighted percentage of innovators in the non-respondent population.

H_1: $P_R \neq P_{NR}$

Test statistic:
$$Z = \frac{(\hat{P}_R - \hat{P}_{NR})}{\sqrt{S^2(\hat{P}_R) + S^2(\hat{P}_{NR})}}$$

$S^2(\hat{P}_R)$ is the estimated variance of the proportion of innovators in the original, realised sample, calculated after weighting for sampling fractions while $S^2(\hat{P}_{NR})$ is the estimated variance of the proportion of innovators in the non-response sample.

If a simple random sample or a stratified sample of the non-respondents is drawn then the variance , $S^2(\hat{P}_{NR})$, would be calculated as:

$$S^2(\hat{P}_{NR}) = \sum \left(\frac{N_h(1-r_h)}{N(1-r)} \right)^2 \left(\frac{\hat{P}_{NRh}(1-\hat{P}_{NRh})}{n_{NRh}} \right) \left(1 - \frac{n_{NRh}}{N_h(1-r_{h)}} \right)$$

Where $\left(\frac{N_h(1-r_h)}{N(1-r)} \right)$ is the weight of stratum h.

$\hat{P}_{NRh}$ is the percentage of innovators in the non-response sample in stratum h

N_h is the total number of units in the frame population in stratum h

n_{NRh} is the number of units in the non-response sample in stratum h

r_h is the response rate of the original sample in stratum h

With large enough sample sizes, the Z-statistics will be approximately normally distributed. Therefore, if the test statistic is in the critical region (usually defined as greater than 1.96 or less than -1.96, for a 95% confidence interval) then H_0 can be rejected i.e. there is a statistically significant difference between the two proportions[14].

[14]For further information, see Wonnacott, H., and Wonnacott, J. R., Introductory Statistics, 5th Edition, John Wiley, 1990, chapter 9.

A brief description of the potential process of imputation is given here.

Metric imputation

Metric imputation shall take the "clean" data set, estimate the missing items and create a complete metric data set.

The steps involved are:

- Detect and exclude outliers from calculations of the mean.
- Impute the weighted ratio mean, taking into account the amount of missing values within each stratum.

The key factors affecting metric imputation are:

- Values of the three parameters (factor1, factor2 and remout) which control the process
- Amount of item non-response

Factor1 is the outlier value used to remove extreme values from the dataset (of responses for that variable) before imputation. By default, this is 1.5 (or 1.5 times of the inter-quartile range). In a skewed distribution, this might lead to too many records being rejected. This criterion is checked by the value of the Remout variable. By default this is 30, i.e. do not use factor1 where its use leads to the rejection of 30% or more of the records. If the remout value is exceeded, then the imputation procedure moves onto factor2. By default this is set at 3.0 i.e. use all records within 3.0 times of the inter-quartile range.

The three variables controlling the imputation procedure can be amended within the SAS program but, for comparability purposes, it is important that the values used should be as close to the default values as possible. Therefore, the first step to improve item non-response should be to improve response rates. It is very important that item non-response should be kept to a minimum.

After this has been done, if the variables controlling imputation have to be changed (because records are still not being imputed), start off by increasing the remout value little by little until the imputation procedure improves (for example reduce from 30% to 25% to 20%). If this does not work increase factor2 and remout (from its original value) until the imputation procedure produces acceptable results.

If item non-response within a stratum is higher than 50% then the stratum is merged with a neighbouring size class in the same NACE class. If the proportion of non-missing values is still lower than 50% for all size groups within the NACE class the imputation is implemented within subsections of NACE or ultimately by using the whole population. Where strata have non-response rates higher than 50%, every effort should be made to improve the results for these critical strata.

Ordinal and nominal imputation

After the metric estimation comes the Ordinal estimation. The objective of this process step is to estimate nominal and ordinal variables (and in some cases metric variables). As for the metric estimation, it is the amount and structure of the item non-response that is the main factor influencing the outcome of the imputation process.

The basic method is:

- Metric variables are broken down into classes. Respondents are partitioned into classes such that the elements in the same class are considered similar. The variables used here are NACE and size class.
- Metric and ordinal variables are used to estimate nominal variables.

The key factors affecting the ordinal imputation are:

- Values of one parameter (classl) which controls the process
- Amount of item non-response

ClassL determines how much data to include for each variable in the imputation process. If ClassL=2 then only one class is created around the median, excluding large proportions of the data (outliers). ClassL=5 includes more data and creates 4 classes etc.

If there is still item non-response after ordinal estimation, there might be several reasons for this:

- Item response is very low, too low for some strata. This should be addressed by trying to improve response rates in these critical strata at least.
- The setting of ClassL is too strict, reducing the critical mass of data for the estimation procedure. Therefore, increase ClassL to include more data.

However, as for metric estimation, it is important that the final setting is as close to the benchmark (set for each variable in the SAS programs) as possible, in order to maintain comparability of data.

APPENDIX C: SOUTH AFRICAN BUSINESS INNOVATION SURVEY 2014-2016

SOUTH AFRICAN BUSINESS INNOVATION SURVEY 2014 – 2016

INDUSTRY AND SERVICES

This survey collects information on your enterprise's innovations and innovation activities between 2014 and 2016 inclusive.

Please note: In order to compare enterprises with and without innovation activities, we request **ALL enterprises** regardless of sector or size, to respond to **ALL questions, unless otherwise instructed.**

ADDRESS *If your address has changed, please update here.*

Name (with title)	
Designation	
Company	
Address 1	
Address 2	
Address 3	
Postal code	

science & technology — Department: Science and Technology, REPUBLIC OF SOUTH AFRICA
HSRC Human Sciences Research Council
STATS SA STATISTICS SOUTH AFRICA

VITAL SURVEY INFORMATION

What is this survey about?
This survey collects information about innovations and innovation activities in the business sector during the three-year period 2014 to 2016 inclusive. The survey is meant to produce statistical information for understanding the business sector innovation performance, its determinants and impacts. Among other uses, the statistics will inform the government in developing policies to stimulate innovation, productivity and competitiveness.

What is an innovation?
An **innovation** is the introduction of a new or significantly improved product, process, organisational method, or marketing method by your enterprise. The innovation must be new to your enterprise, although it could have been originally developed by other enterprises.

Sections 2 to 7 of this questionnaire cover product, process, organisational and marketing innovations.

What is the scope of this survey?
The statistical unit for the survey is the **enterprise** as defined by Statistics South Africa: an enterprise is "a legal unit or a combination of legal units that includes and directly controls all functions necessary to carry out its production activities". It refers to a business, company or firm that is capable in its own right to own assets, incur liabilities and conduct economic activities. Enterprises can range from a very small concern with only one or two employees to a much larger and more formal business or firm.

Who is the authority of this survey?
The Department of Science and Technology (DST), as a partner within the National Statistics System, mandated the Centre for Science, Technology and Innovation Indicators of the Human Sciences Research Council (HSRC) to perform this survey.

What about the confidentiality of my company's information?
All information gathered by this survey will be held in strictest confidence. The data may be used for statistical purposes to complement research and analysis of innovation indicators. Under no circumstances will the HSRC, DST or Statistics South Africa publish, release or disclose any information on or identifiable with, individual firms or business units.

Who should complete this questionnaire?
This questionnaire should be completed by the CEO, Managing Director, or a senior manager who has adequate knowledge of the strategy and innovation matters of the enterprise.

What if I need assistance?
If you have any problems in completing this questionnaire and/or meeting the due date, please do not hesitate to contact any of the staff listed below for assistance:

Name of staff member	Sector of responsibility	Telephone	Email address
Cheryl Moses Loyiso Maciko	Manufacturing	021 466 7843 021 466 7869	cmoses@hsrc.ac.za lmaciko@hsrc.ac.za
Hlamulo Makelane Yasser Buchana	Mining and Quarrying Financial Intermediation Engineering Transport, Storage and Communication	021 466 7833 021 466 7840	hrmakelane@hsrc.ac.za ybuchana@hsrc.ac.za
Firdous Khan Ndiyakholwa Ngqulu	Wholesale Trade and Retail Trade	021 466 7810 021 466 7848	fkhan@hsrc.ac.za nngqulu@hsrc.ac.za

KEY: **Definition** **Instruction**

DETAILS OF PERSON COMPLETING THE QUESTIONNAIRE:

Name (with title)	
Job Title	
Telephone	
Email	
Signature/ Electronic Initials	

2

1 General information about the enterprise

In this section we ask for basic information about your enterprise

1. Please provide a short description of your main business activity.

1.1 Is your enterprise part of an enterprise group?
A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group may serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.

Yes ☐ No ☐

In which country is the head office of your group located?

1.2 Does your enterprise have a subsidiary(ies) outside South Africa?

Yes ☐ No ☐

If your enterprise is part of an enterprise group, please answer **ALL** questions about **YOUR ENTERPRISE ONLY**, for its own activities in South Africa. Exclude all subsidiaries or parent enterprises.

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1.3 Please provide the year in which your enterprise was established. Y Y Y Y

1.4 During the three years 2014 to 2016, did your enterprise:

	Yes	No
→ Merge with or take over another enterprise	☐	☐
→ Sell, close or outsource parts of your enterprise	☐	☐
→ Establish new subsidiaries in other African countries	☐	☐
→ Establish new subsidiaries outside Africa	☐	☐

1.5 In which geographic markets did your enterprise sell goods or services during the three years 2014 to 2016?

- South Africa (national) ☐
- South Africa (only some provinces) ☐
- Rest of Africa ☐
- Europe ☐
- United States ☐
- Asia ☐
- Other countries, please specify:

1.5.1 Please indicate which of these markets were the largest in terms of turnover?

1.6 What was your enterprise's total number of employees in 2014 and 2016?
Annual average number of employees, both full-time and part-time. If not available, give the number of employees at the end of each year.

2014
2016

1.6.1 Approximately, what percentage of your total employees had a university degree or diploma in 2016? %

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1.7 What was your enterprise's approximate total turnover for 2014 and 2016?

Turnover is defined as the total amount received for goods sold and services rendered for the financial year (including amounts received for work done, services rendered, rent and or lease payments received for land and buildings, rent, leasing and hiring received for machinery, vehicles and other equipment; but excluding value added tax (VAT), net profit or loss on sales or revaluation of fixed assets (including profit or loss on foreign exchange), export freight charges, interest received). Please give exact turnover e.g. One million Rand should be entered as 1 000 000.

2014 R ☐☐☐☐☐☐☐☐☐☐☐☐

2016 R ☐☐☐☐☐☐☐☐☐☐☐☐

The following sections (2, 3, 4, 5 and 6) request information regarding product, process, organisational and marketing innovation.

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2 Product (goods or services) innovation

In this section you are asked questions about your enterprise's product innovations

A product innovation is the introduction to market of a **new** or **significantly** improved good or service with respect to its capabilities, such as improved user-friendliness, components, software or sub-systems. The innovation **must be new to your enterprise, but it does not need to be new to your industry sector or market**. It does not matter if the innovation was originally developed by your enterprise or by other enterprises. A **good** is usually a tangible object such as a smart phone, furniture, or packaged software, but downloadable software, music and film are also goods. A **service** is usually intangible, such as retailing, insurance, educational courses, air travel, consulting, etc.

Please note: The latest terminology classifies "**products**" as consisting of both "**goods**" **and** "**services**". For example a firm in the financial services sector may report a "new financial product". The provision of innovative services is of increasing importance in competitive economies and the survey covers both manufacturing and services orientated firms.

2.1 During the three years 2014 to 2016, did your enterprise introduce:

	Yes	No
→ **Entirely New goods** *Exclude the simple resale of new goods purchased from other enterprises and minor changes that only alter the appearance of the product*	☐	☐
→ **Significantly improved goods** *An existing product whose performance has been significantly enhanced or upgraded*	☐	☐
→ **Entirely New services**	☐	☐
→ **Significantly improved services**	☐	☐

If no to all, please go to section **3.1**

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2.2 By whom were these **product (goods and services)** innovations developed?

Select the single most appropriate option only

- → Mainly your enterprise ☐
- → Other enterprises in your enterprise group ☐
- → Your enterprise together with other enterprises or institutions ☐
- → Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions ☐
- → Mainly other enterprises or institutions ☐

2.2.1 Did these innovations originate mainly in South Africa or abroad? South Africa ☐ Abroad ☐

2.3 Were any of your product innovations (goods and services) during the three years 2014 to 2016 new to your market or new to your firm?

	Yes	No
→ **New to your market?** *Your enterprise introduced a new or significantly improved good or service onto your market before your competitors (it may have already been available in other markets).*	☐	☐
→ **Only new to your firm?** *Your enterprise introduced a new or significantly improved good or service that was already available from your competitors in your market.*	☐	☐

2.4 To the best of your knowledge, were any of your product innovations during the three years 2014 to 2016:

	Yes	No	Don't know
→ **New to the world?** *Your enterprise introduced a good or service that is entirely new to the world*	☐	☐	☐
→ **A first in South Africa but not the world?**	☐	☐	☐
→ **A first in your industry within South Africa but not new to South Africa or to the world?**	☐	☐	☐

2.5 Using the definitions in question 2.3 and 2.4, please estimate **the percentage** of your **total turnover** in 2016 from:

	2016 % turnover distribution
→ Goods and service innovations introduced during 2014 to 2016 that were **new to the world**	☐☐☐ %
→ Goods and service innovations introduced during 2014 to 2016 that were **new to your market**	☐☐☐ %
→ Goods and service innovations introduced during 2014 to 2016 that were only **new to your firm**	☐☐☐ %
→ Goods and services that were **unchanged or only marginally modified** during 2014 to 2016 *Include the resale of new goods or services purchased from other enterprises.*	☐☐☐ %
Total turnover in 2016 = 100%	1 0 0 %

2.6 If your answer to question 2.4 was yes then please give short descriptions of these innovations and the approximate period of time it took to develop these innovations (or attach separate pages or promotional brochures).

3 Process innovation

In this section you are asked questions about your enterprise's process innovations

Process innovation is the use of **new** or **significantly improved** methods for the production or supply of goods and services. The innovation (new or improved) **must be new to your enterprise, but it does not need to be new to your industry sector or market.** It does not matter if the innovation was originally developed by your enterprise or by other enterprises. Exclude purely organisational innovations such as changes in firm structure or management practice – these are covered in question 4.

3.1 During the three years 2014 to 2016, did your enterprise introduce any:

	Yes	No
→ New or significantly improved methods of manufacturing or producing goods or services?	☐	☐
→ New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services?	☐	☐
→ New or significantly improved supporting activities for your processes, such as maintenance and operating systems for purchasing, accounting or computing?	☐	☐

If no to **all** questions, please go to section **4**

3.2 By whom were these process innovations developed?

- → Mainly your enterprise ☐
- → Other enterprises in your enterprise group ☐
- → Your enterprise together with other enterprises or institutions ☐
- → Your enterprise by adapting or modifying processes originally developed by other enterprises or institutions ☐
- → Mainly other enterprises or institutions ☐

Select the most appropriate option only

3.2.1 Did these innovations originate mainly in South Africa or abroad? South Africa ☐ Abroad ☐

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4 Organisational and marketing innovations

In this section you are asked questions about your enterprise's organisational and marketing innovations

An organisational innovation is the implementation of new or significant changes in firm structure, business practice or management methods that are intended to improve your firm's use of knowledge, the quality of your goods and services, or the efficiency of work flows. Exclude mergers or acquisitions, even if for the first time.

A marketing innovation is the implementation of new or significantly improved marketing or sales methods to increase the appeal of your goods and services or to enter new markets. Examples include changes in product design or packaging, product placement, product promotion or pricing BUT excludes seasonal, regular and other routine changes in marketing methods.

4.1 During the three years 2014 to 2016, did your enterprise introduce:
Organisational innovations

	Yes	No
→ New or significantly improved business practice (i.e. knowledge management, systems to better use or exchange information, knowledge and skills within your enterprise, first time use of supply chain management, business re-engineering, lean production, quality management, etc.)? *Exclude routine upgrades.*	☐	☐
→ Major changes to the organisation of work within your enterprise, such as changes in the management structure or integrating different departments or activities?	☐	☐
→ New or significant changes in your external relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or sub-contracting?	☐	☐

If no to all the above, move to question **4.3**

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4.2 If your enterprise introduced an organisational innovation during the three years 2014 to 2016, how important were each of the following results?

	Importance of results			
	High	Medium	Low	Not relevant
→ Improved market share	☐	☐	☐	☐
→ Reduced time to respond to customer or supplier needs	☐	☐	☐	☐
→ Improved quality of your goods or services	☐	☐	☐	☐
→ Reduced costs per unit output	☐	☐	☐	☐
→ Improved employee satisfaction and/or reduced rates of employee turnover	☐	☐	☐	☐

4.3 During the three years 2014 to 2016 did your enterprise introduce:
Marketing innovations

	Yes	No
→ Significant changes to the design or packaging of a good or service? *(Exclude routine/seasonal changes).*	☐	☐
→ New or significantly changed sales or distribution methods, such as internet sales, franchising, direct sales or distribution licenses?	☐	☐
→ New media or techniques for **good or service promotion** (i.e. the first time use of a new advertising media, a new brand image, introduction of loyalty cards, etc.)?	☐	☐
→ New methods for **good or service placement** or sales channels (i.e. first time use of franchising or distribution licenses, direct selling, exclusive retailing, new concepts for good or service presentation, etc.)?	☐	☐
→ New methods of **pricing goods or services** (i.e. first time use of variable pricing by demand, discount systems, etc.)?	☐	☐

5 Ongoing or abandoned innovation activities

In this section you are asked questions about any of your enterprise's innovation activities that were abandoned or still ongoing at the end of 2016

Innovation activities include the acquisition of machinery, equipment, software, licenses, engineering and development work, training, marketing and research and experimental development (R&D) when they are specifically undertaken to develop and/or implement a product or process innovation.

5.1 During the three years 2014 to 2016:

→ Did your enterprise have any innovation activities that did not result in a product, process, marketing or organisational innovation because the activities were abandoned or still ongoing at the end of 2016?

	Abandoned		Still ongoing at the end of 2016	
	Yes	No	Yes	No
Product innovation	☐	☐	☐	☐
Process innovation	☐	☐	☐	☐
Organisational innovation	☐	☐	☐	☐
Marketing innovation	☐	☐	☐	☐

If you answered 'No' to to all options in questions 2.1, 3.1, 4.1, 4.3 and 5.1, please go to question 9.2, otherwise continue to question 6.1.

6 Innovation activities and expenditures

This section asks for information about your enterprise's expenditure on product and process innovation activities

6.1 During the three years 2014 to 2016, did your enterprise engage in the following innovation activities?

		Yes	No
A	Intramural (in-house) Research and Experimental Development (R&D) *Creative work undertaken on a systematic basis within your enterprise to increase the stock of knowledge and its use to devise new and improved products and processes (including software development).*	☐	☐
	If yes, did your enterprise perform R&D during 2014 to 2016: Continuously ☐ Occasionally ☐		
B	Extramural or outsourced R&D *Same activities as above, but performed by other companies (including other enterprises within your group) or by public or private research organisations and purchased by your enterprise.*	☐	☐
C	Acquisition of machinery and equipment *Acquisition of advanced machinery and equipment to produce new or significantly improved products and processes.*	☐	☐
D	Acquisition of buildings *Acquisition of new buildings to be used for new or significantly improved products and processes.*	☐	☐
E	Acquisition of other external knowledge *Acquisition of existing know-how, copyrighted works, patented and non-patented inventions, etc. from other enterprises or organisations for the development of new or significantly improved products and processes.*	☐	☐
F	Training *Internal or external training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes.*	☐	☐
G	Market introduction of innovations *Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising.*	☐	☐

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		Yes	No
H	Other activities *Other in-house or contracted out activities to implement new or significantly improved products or processes such as feasibility studies, testing, tooling up, etc.*	☐	☐
I	Lease or rental of machinery, equipment and other capital goods	☐	☐
J	Acquisition of computer hardware	☐	☐
K	Acquisition of computer software	☐	☐
L	Design *In-house or contracted out activities to alter the shape, appearance or usability of goods or services.*	☐	☐
M	Engineering activities	☐	☐

6.2 Please estimate the amount of expenditure in 2016 only for the innovation activities listed below. Include personnel and related costs.
Please provide exact expenditure e.g. Five hundred thousand Rand should be entered as 500 000,00 in the box provided.
Please put zero (0) in the category box if your enterprise had no expenditure in 2016.

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Please report for 2016 only

A	Intramural (in-house) R&D *Include labour costs, capital expenditures on buildings and equipment specifically for R&D.*	R ☐☐☐☐☐☐☐☐,☐☐
B	Purchase / or acquisition of extramural or outsourced R&D	R ☐☐☐☐☐☐☐☐,☐☐
C	Acquisition of machinery *Exclude expenditures on equipment for R&D.*	R ☐☐☐☐☐☐☐☐,☐☐
D	Acquisition of buildings	R ☐☐☐☐☐☐☐☐,☐☐
E	Acquisition of other external knowledge	R ☐☐☐☐☐☐☐☐,☐☐
F	Training	R ☐☐☐☐☐☐☐☐,☐☐

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G	Marketing expenditure	R ☐☐☐☐☐☐☐☐,☐☐
H	Acquisition of computer software	R ☐☐☐☐☐☐☐☐,☐☐
I	Acquisition of computer hardware	R ☐☐☐☐☐☐☐☐,☐☐
J	All other innovation activities including design, and other relevant activities	R ☐☐☐☐☐☐☐☐,☐☐
	Total of the above innovation activities	**R** ☐☐☐☐☐☐☐☐,☐☐

6.3. Please provide the approximate number of employees involved in the Innovation activities accounted for in 6.2 above

Male	Female	Total

7 Sources of information and co-operation for innovation activities

In this section you are asked about your enterprise's sources of information and co-operation for its product and process innovation activities

7.1 During the three years 2014 to 2016, how important to your enterprise's innovation activities were each of the following information sources?
Include information sources that provided information for new innovation projects or contributed to the completion of existing projects.

Information source		**Importance of results**			
		High	Medium	Low	Not used
Internal sources	Sources within your enterprise or enterprise group	☐	☐	☐	☐
Market resources	Suppliers of equipment, materials, components or software	☐	☐	☐	☐
	Clients or customers	☐	☐	☐	☐
	Competitors or other enterprises in your sector	☐	☐	☐	☐
	Consultants, commercial laboratories	☐	☐	☐	☐
Education & research	Universities / higher education institutions	☐	☐	☐	☐
	Government or public research institutes	☐	☐	☐	☐
	Private research institutes	☐	☐	☐	☐
Other sources	Conferences, trade fairs, exhibitions	☐	☐	☐	☐
	Scientific journals and trade/technical publications	☐	☐	☐	☐
	Professional and industry associations	☐	☐	☐	☐

7.2 During the three years 2014 to 2016, did your enterprise co-operate on any of your innovation activities with other enterprises or institutions?
Innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to benefit commercially. Exclude pure contracting out of work with no active co-operation.

	Yes	No
	☐	☐

If **no**, please go to question **8.1**

If yes, please check which of the following reasons were important in determining the involvement of your business unit in co-operative arrangements to develop or commercialize new or significantly improved products (goods or services) and/or processes.

→ Sharing the cost of developing innovations	☐	☐
→ Accessing research and development (R&D)	☐	☐
→ Accessing information	☐	☐
→ Accessing critical expertise/skills	☐	☐
→ Prototype development	☐	☐
→ Scaling up production processes	☐	☐
Commercialisation of Innovation		
→ Accessing new markets	☐	☐
→ Accessing new distribution channels	☐	☐

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7.3 Please indicate the type of co-operation partner and their location.

Tick all that apply.

	Type of co-operation partner	South Africa	Rest of Africa	Europe	USA	Asia	Other countries
A	Other enterprises within your enterprise group	☐	☐	☐	☐	☐	☐
B	Suppliers of equipment, materials, components or software	☐	☐	☐	☐	☐	☐
C	Clients or customers	☐	☐	☐	☐	☐	☐
D	Competitors or other enterprises in your sector	☐	☐	☐	☐	☐	☐
E	Consultants and commercial labs	☐	☐	☐	☐	☐	☐
F	Universities / higher education institutions	☐	☐	☐	☐	☐	☐
G	Government or public research institutes (e.g. CSIR)	☐	☐	☐	☐	☐	☐
H	Private research institutions	☐	☐	☐	☐	☐	☐

7.4 Which type of co-operation partner was the most valuable for your enterprise's innovation activities?
Give corresponding letter from 7.3. For example, if you selected Clients or customers, write 'C'.

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8 Effects of innovation during 2014 – 2016

In this section you are asked to rate the success of your product and process innovation outcomes

8.1 How successful were each of the following types of outcomes for your product (goods or services) and process innovations introduced during the three years 2014 to 2016?
Tick 'Not relevant' if there were no innovation outcomes.

Innovation outcomes		Level of success of outcomes: High	Medium	Low	Not relevant
Product outcomes	Increased range of goods or services	☐	☐	☐	☐
	Improved quality of goods or services	☐	☐	☐	☐
Strategic/marketing outcomes	Entered new local markets or increased local market share	☐	☐	☐	☐
	Entered new export markets or increased export market share	☐	☐	☐	☐
	Increased the Intellectual Property portfolio	☐	☐	☐	☐
Process outcomes	Improved flexibility of production or service provision	☐	☐	☐	☐
	Increased capacity of production or service provision	☐	☐	☐	☐
	Reduced labour costs per unit output	☐	☐	☐	☐
	Reduced materials and energy per unit output	☐	☐	☐	☐
	Reduced lead times	☐	☐	☐	☐
Financial outcomes	Increased revenue	☐	☐	☐	☐
	Improved profitability	☐	☐	☐	☐
	Reduced unit production costs	☐	☐	☐	☐
	Increased IP revenue	☐	☐	☐	☐
Other outcomes	Reduced environmental impacts	☐	☐	☐	☐
	Improved health and safety	☐	☐	☐	☐
	Met governmental regulatory requirements	☐	☐	☐	☐

9 Public sector procurement and innovation

In this section you are asked for information about your enterprise's public procurement and innovation

***The public sector includes government owned organisations such as local, regional and national administrations and agencies, schools, hospitals, and government providers of services such as security, transport, housing, energy, etc.**

9.1 During the three years 2014 to 2016, did your enterprise have any procurement contracts to provide goods or services for:

	Yes	No
→ South African public sector organisations*	☐	☐
→ Foreign/International public sector organisations*	☐	☐

If **no** to both questions go to question **10.1**

9.2 Did your enterprise undertake any innovation activities as part of a procurement contract to provide goods or services to a public sector organisation?
If your enterprise had several procurement contracts, tick all that apply.

→ Yes and innovation required as part of the contract ☐
→ Yes, but innovation not required as part of the contract ☐
→ No, innovation not performed and not required ☐

10 Funding for Innovation

In this section you are asked to provide information about your enterprise's funding sources for its innovation activities

10.1 During the three years 2014 to 2016, were your innovation activities funded through any of the sources listed below?

		Yes	No
A	Own Funds	☐	☐
B	Funds from related companies (subsidiary or associated companies)	☐	☐
C	Funds from other (non-financial) enterprises	☐	☐
D	Funds from South African government*	☐	☐
E	Foreign funds (EU, etc.)	☐	☐
F	Other sources	☐	☐

**If your answer to this question is 'Yes' please skip question 10.2.*

Questions 10.2 to 13 to be ANSWERED BY ALL ENTERPRISES

	Yes	No
10.2 Are you aware that the South African government offers financial support for innovation?	☐	☐

10.2.1 During the three years 2014 to 2016, did your enterprise receive any form of financial or non-financial support for innovation activities from the South African government?
The support can be from the Department of Science and Technology, Department of Trade and Industry or any national or provincial government department or their agencies such as the Technology Innovation Agency, National Research Foundation, Industrial Development Corporation, Medical Research Council, etc.

Type of support		**Applied/ requested for support**		**Accessed/ Obtained the support**	
		Yes	No	Yes	No
Financial support	Incentive grants	☐	☐	☐	☐
	Loans or guarantees	☐	☐	☐	☐
	Equity financing or venture capital	☐	☐	☐	☐
	Tax incentive for R&D	☐	☐	☐	☐
Non-financial support	Training support or internships	☐	☐	☐	☐
	Access to research equipment or laboratory facilities	☐	☐	☐	☐
	Access to ICT infrastructure	☐	☐	☐	☐
	Export support	☐	☐	☐	☐
	Incubation or mentoring	☐	☐	☐	☐
	Other, please specify	☐	☐	☐	☐

10.2.2 If you have not accessed government funds for innovation activities please indicate the reasons for not doing so:

- → Process too complicated ☐
- → Risk of exposure of confidential information ☐
- → Time Constraints ☐
- → Other: Please specify

11 Factors hampering innovation activities

In this section you are asked to rate the importance of the barriers that your enterprise encountered during its innovation processes

11.1 During the three years 2014 to 2016, how important were the following factors in hampering your innovation activities or projects or influencing a decision not to innovate?

		Degree of importance			
		High	Medium	Low	Factor not experienced
Cost factors	Lack of funds within your enterprise or group	☐	☐	☐	☐
	Lack of finance from sources outside your enterprise	☐	☐	☐	☐
	Innovation costs too high	☐	☐	☐	☐
	Lack of credit or private equity	☐	☐	☐	☐
	Difficulty in obtaining government grants or subsidies for innovation	☐	☐	☐	☐
Knowledge factors	Lack of managerial skills	☐	☐	☐	☐
	Lack of engineering skills	☐	☐	☐	☐
	Lack of technicians	☐	☐	☐	☐
	Lack of information on technology	☐	☐	☐	☐
	Lack of information on markets	☐	☐	☐	☐
	Difficulty in finding co-operation partners for innovation	☐	☐	☐	☐
Market factors	Market dominated by established enterprises	☐	☐	☐	☐
	Uncertain demand for innovative goods or services	☐	☐	☐	☐
	Lack of demand from customers	☐	☐	☐	☐
	Too much competition in your market	☐	☐	☐	☐
Institutional factors	Lack of infrastructure	☐	☐	☐	☐
	Weakness of Intellectual Property (IP) rights	☐	☐	☐	☐
	Legislation, regulations, standards, taxation	☐	☐	☐	☐
Reasons not to innovate	No need due to prior innovations	☐	☐	☐	☐
	No need because of no demand for innovations	☐	☐	☐	☐

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12 Intellectual property rights

In this section you are asked whether your enterprise employed any form of protection methods for its intellectual property

12.1 During the three years 2014 to 2016, did your enterprise use any of the following methods to protect its intellectual property:

	Yes	No
Formal methods of protection		
→ Secure a patent in South Africa?	☐	☐
→ Apply for a patent outside of South Africa?	☐	☐
→ Register an industrial design?	☐	☐
→ Register a trade mark?	☐	☐
→ Claim copyright?	☐	☐
→ Obtain plant breeders rights?	☐	☐
→ Use trade secrets or confidentiality agreements?	☐	☐
IP Transactions		
→ Grant a licence on any intellectual property rights resulting from innovation?	☐	☐

24

13 Business capabilities for innovation

In this section you are asked to provide information regarding your enterprise's business capabilities for innovation

13.1 During the three years 2014 to 2016, did your enterprise develop or use any of the following advanced technologies?

	Yes	No
→ Material handling, supply chain and logistics technologies	☐	☐
→ Computerised design and engineering	☐	☐
→ Business intelligence technologies	☐	☐
→ Green technologies	☐	☐
→ Advanced information control technologies	☐	☐
→ Advanced processing and fabrication technologies	☐	☐
→ Geomatics or geospatial technologies	☐	☐
→ Nanotechnology	☐	☐
→ Biotechnologies/bioproducts	☐	☐
→ Other types of advanced technologies, please specify ______		

Dear Respondent,

You've come to the end of the questionnaire. Thanks for taking the time to respond to our questions, and for interacting with us in the process.

We're planning to deliver results to your business and the rest of South Africa at the end of 2018.

What next? Please place the completed questionnaire in the paid-for reply envelope included in your survey pack, and drop it into your nearest SA Post Office letter box. We're old fashioned that way.

Your participation matters.

The Business Innovation Survey 2014-2016 Team

Centre for Science, Technology
and Innovation Indicators
Human Sciences Research Council
PO Box 15200
Vlaeberg
8018

Keen to stay in touch?

We're blogging about innovation data

https://sabizinnovationsurvey.blog/

And tweeting, too

@BizInnovationSA

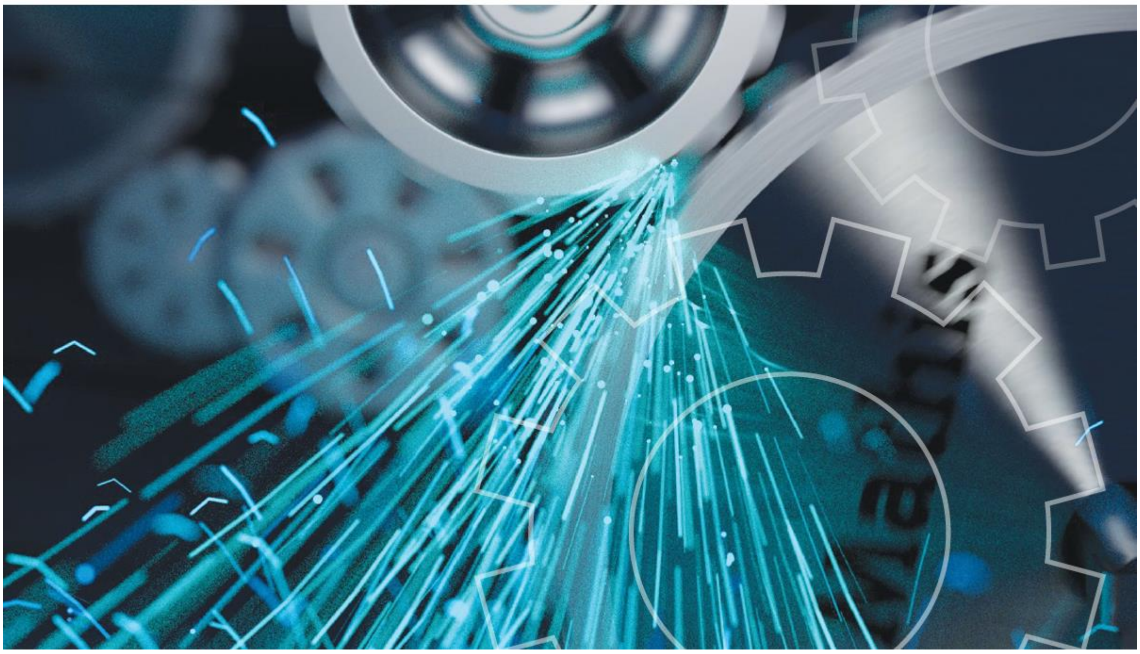
You can also sign up for regular Friends of the Business Innovation Survey email

http://eepu[illegible]om/cZYI0n

Submit Questionnaire

BUSINESS INNOVATION SURVEY 2014 - 2016

FOR A MORE INNOVATIVE SOUTH AFRICA



APPENDIX D: PARTICIPANT INFORMATION SHEET FOR A SURVEY

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Participant Information Sheet for a survey

Dear Sir / Madam,

My name is Luyolo Mabhali and I am a PhD student in the Graduate School of Business Administration (better known as Wits Business School), at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the effect of dynamic workforce capabilities on firm level innovation in the South African metals industry, under the supervision of Associate Professor Mjumo Mzyece. The aim of this research project is to expand the dynamic capability theory by showing a relationship between employee experience factors, which make-up the dynamic workforce capabilities, and firm level innovation in the South African metals industry.

As part of this project, I would like to invite you to take part in answering an online questionnaire. This activity will involve answering an online questionnaire and will take around 30 minutes. The data will be deleted after 5 years.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The questionnaire will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely in a password protected computer and will not be disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report. Please note that by completing and submitting the survey, it means that consent to participate has been received.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. The data will also be used for conferences and publications. If you wish to receive a summary of this report/conference/ journal publications, I will be happy to send it to you. The data collected from this research project will be stored in a password protected computer and will be kept for 5 years. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

Luyolo Mabhali

Researcher: Luyolo Andrew Baxolise Mabhali

0420076T@students.wits.ac.za

+27 78 202 9776

Supervisor: Associate Professor Mjumo Mzyece

mjumo.mzyece@wits.ac.za

+27 11 717 3649

Link to the survey:

https://wits.eu.qualtrics.com/jfe/form/SV_6mvr2Hq2ExkNMbA

APPENDIX E: RESEARCH QUESTIONNAIRE

Effect of dynamic workforce capabilities on firm level innovation in the South African metals industry

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Start of Block: Default Question Block

Q34 Do you give consent to participate in this study?

○ No (21)

○ Yes (22)

Skip To: End of Survey If Do you give consent to participate in this study? = No

Q1 What was the annual turnover of your organization in:

	Click to write Scale Point 1 (1)
2019 (1)	
2020 (2)	
2021 (3)	

Q2 What was the total number of employees in your firm in:

	Click to write Scale Point 1 (1)
2019 (1)	
2020 (2)	
2021 (3)	

Q3 In which province is your organization located (if multiple, pick location of headquarters only)?

▼ Eastern Cape (1) ... Western Cape (9)

Q4 Does your organization have subsidiaries or branches?

○ Yes (1)

○ No (2)

Q5 How old is your organization (in years)?

____

Q8 What is the percentage of employees in your organization with a tertiary qualification (degree or diploma)?

____

Q6 What is the main business activities of your organization?

○ Manufacturing or processing metals (e.g. steel, gold, etc.) (1)

○ Manufacturing or processing of non metallic materials (e.g. plastics, ceramics, etc.) (2)

○ Manufacturing (other) (3)

○ Services (4)

○ Other (5)

Q7 Please provide a short description of your main business activity

____

Q9 Was your organization involved any product or process innovation activities between 2019 and 2021?

○ No (1)

○ Yes (2)

Display This Question:

If Was your organization involved any product or process innovation activities between 2019 and 2021? = Yes

Q10 By whom was this innovation developed?

- ◯ By the firm on its own (1)
- ◯ by collaborating with other firms (2)
- ◯ by modifying products/processes from other firms (3)

---

*

Q11 What is the total number of employees in your organization that are involved in research and development or innovation activities

____

---

*

Q12 What is the percentage of employees, involved in research and development or innovation activities, with tertiary qualification (degree or diploma)?

____

Q13 What is your organization's innovation or R&D budget as a percentage of turnover?

____

Q14 Does your organization have a training budget?

○ No (1)

○ Yes (2)

Display This Question:

If Does your organization have a training budget? = Yes

Q15 What is your organization's training budget as a percentage of turnover?

____

Q16 Did your organization invest in new equipment between 2019 and 2021?

- ○ No (1)
- ○ Yes (2)

Q17 Does your organization have strategic alliances with Higher Education Institutes or Research Councils?

- ○ No (1)
- ○ Yes (2)

Q18 Did your organization introduce new or improved products or processes into the market (or inside the organization's operations) between 2019 and 2021?

- ○ No (1)
- ○ Yes (2)

Q19 What was the percentage increase in turnover that the organization benefitted due to this new or improved process or product?

- 0-10% (1)
- 10-20% (2)
- 20-30% (3)
- 30-50% (4)
- More than 50% (5)

Q20 Does your organization have an intentional innovation strategy?

- No (1)
- Yes (2)

Q21 Please answer the following questions about the innovation that was implemented in your organization between 2019 and 2021

	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Product idea came from workforce (excludes management with direct reports) (1)	○	○	○	○	○
Product idea came from management (with direct reports) (2)	○	○	○	○	○
Process idea came from workforce (excludes management with direct reports) (3)	○	○	○	○	○

Process idea came from management (with direct reports) (4)	○	○	○	○	○
Product idea came as joint effort from workforce and management (5)	○	○	○	○	○
Process idea came as joint effort from workforce and management (6)	○	○	○	○	○

Q24 For the innovation ideas implemented in your organization between 2019 and 2021, please rate the influence of the following statements to innovative idea generation by the employees

	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Education qualification of the employee (1)	○	○	○	○	○
Number of years the employee spent in the organization (tenure) (2)	○	○	○	○	○
Number of years the employee spent in the same position in the organization (position tenure) (3)	○	○	○	○	○

Total experience of the employee in that field (including experience acquired in other organizations) (4)	○	○	○	○	○
Level of the employee position in the company structure (5)	○	○	○	○	○
Gender of the employee (6)	○	○	○	○	○
Age of the employee (7)	○	○	○	○	○
Ethnic background of the employee (8)	○	○	○	○	○

Q25 For the innovation ideas implemented in your organization between 2019 and 2021, please rate the influence of the following statements about the team on successful implemented the innovative idea

	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Diversity of the team (1)	○	○	○	○	○
Education qualifications of the team (2)	○	○	○	○	○
Average tenure of the team in the organization (3)	○	○	○	○	○
Tenure of the innovation lead in the organization (4)	○	○	○	○	○

Number of years in the same position for the innovation lead (5)	○	○	○	○	○
Position level of the innovation lead in the organization (6)	○	○	○	○	○
Team gender balance (7)	○	○	○	○	○
Team age mix/balance (8)	○	○	○	○	○
Team ethnic mix (9)	○	○	○	○	○

Q22 Please rate the following statements, using your own experiences (not restricted to the innovation in your company)

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
More product innovation ideas come from workforce compared to manager (1)	○	○	○	○	○
More product innovation ideas come from managers compared to employees who are not managers (2)	○	○	○	○	○

More product innovation ideas come from joint efforts of managers and employees (3)	○	○	○	○	○
More process innovation ideas come from workforce compared to manager (4)	○	○	○	○	○

More process innovation ideas come from managers compared to employees who are not managers (5)	○	○	○	○	○
More process innovation ideas come from joint efforts of managers and employees (6)	○	○	○	○	○

Q23 Please rate the impact of the following items on innovation, using your own experience (not restricted by the innovation on your own company).

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Education qualification of the employee (1)	○	○	○	○	○
Number of years the employee spent in the organization (tenure) (2)	○	○	○	○	○
Number of years the employee spent in the same position in the organization (position tenure) (3)	○	○	○	○	○

Total experience of the employee in that field (including experience acquired in other organizations) (4)	○	○	○	○	○
Level of the employee position in the company structure (5)	○	○	○	○	○
Gender of the employee (6)	○	○	○	○	○
Age of the employee (7)	○	○	○	○	○
Ethnic background of the employee (8)	○	○	○	○	○

Q26 Please rate the impact of the following team related items on successful implementation of innovation, using your own experience (not restricted by the innovation on your own company).

	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Diversity of the team (1)	○	○	○	○	○
Education qualifications of the team (2)	○	○	○	○	○
Average tenure of the team in the organization (3)	○	○	○	○	○
Tenure of the innovation lead in the organization (4)	○	○	○	○	○

Number of years in the same position for the innovation lead (5)	○	○	○	○	○
Position level of the innovation lead in the organization (6)	○	○	○	○	○
Team gender balance (7)	○	○	○	○	○
Team age mix/balance (8)	○	○	○	○	○
Team ethnic mix (9)	○	○	○	○	○

Q27 Please rate the following statements

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Workforce creates the most innovative ideas in the South African metals industry compared to managers (1)	○	○	○	○	○

Managers creates the most innovative ideas in the South African metals industry compared to workforce (2)	○	○	○	○	○

Q28 Are you aware of the dynamic capabilities framework for innovation?

○ Yes (1)

○ No (2)

Q29 Please rate the following statements on dynamic capabilities

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Dynamic capabilities are a requirement for innovation (1)	○	○	○	○	○
Workforce capabilities have an impact on innovation (2)	○	○	○	○	○

Workforce capabilities have a greater impact on firm level innovation compared to managerial capabilities (3)	○	○	○	○	○
Employee who are not manager (these include specialists) introduce more innovative ideas compare to managers (4)	○	○	○	○	○

Managers introduce more innovative ideas compare to employee who are not managers (including specialists) (5)	○	○	○	○	○

Q30 Please rate the following statements about workforce capabilities and their impact on innovation

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Education is an important workforce capability for innovation (1)	○	○	○	○	○
Ethnic background is an important workforce capability for innovation (2)	○	○	○	○	○

Employee's demographic background attributes play an important workforce capability for innovation (3)	○	○	○	○	○
Employee tenure in the organization is an important workforce capability for innovation (4)	○	○	○	○	○
Employee position tenure in the organization is an important workforce capability for innovation (5)	○	○	○	○	○

More innovation ideas are generated by employees compared to managers in the South African metals industry (6)	○	○	○	○	○
Qualification, tenure and demographic background attributes all have a positive relationship with firm level innovation in the South African metals industry (7)	○	○	○	○	○

Q31 Please state any other employee related factors that you feel influence firm level innovation?

____

Q33 Please state any further comments you might have on firm level innovation in the South African metals industry

____

Q32 Please state any further comments that might have influence the responses in the above survey. These could be on recent events that have an impacts on innovation in your organization

____

End of Block: Default Question Block

APPENDIX F: SUMMARY OF THE RESEARCH QUESTIONNAIRE

Sample stratification

	Action
Annual turnover	Select from list
Number of employees in firm	select from list

Control Variables

Variables	**Action**
Annual turnover	Select from list
Total number of full time employees in firm	Select from list
Province where firm operates (headquarters)	select from list
Does the firm have subsidiaries or branches	Yes/No - if yes, state where
Is the firm a subsidiary of an international firm	Yes/No - if yes, state Nationality of the international firm
Age of the firm	Respondent to complete answer
Main business type	Select from list, Other -respondent types

Survey to test for firm-level innovation (the Community Innovation Survey (CIS) survey can also be used for this)

Variable	**Action**
Is the firm involved in R&D activities (formal and informal)	Yes/No, elaborate
If yes above, is the innovation done by the firm on its own; with other enterprises; or by modifying products/processes from other enterprises	Select from list
What is the innovation / R&D budget as percentage of turnover	Select from list
What is the further training budget as percentage of turnover	Select from list
Has the firm invested in new equipment in past 5 years	Yes/No, elaborate
Strategic alliances with HEIs and Research Councils	Yes/No, elaborate
New (or improved) product brought to market in past 5 years (exclude the simple resale of new goods and changes of a solely aesthetic nature)	Yes/No, elaborate
% increase in turnover due to new / improved product	Select from list
New (or improved) process used in operations in past 5 years	
% increase in turnover due to new / improved process	Select from list
Does the firm have an intentional innovation strategy	Yes/No, elaborate

Survey to test for innovation by workforce

Variable	**Action**
Product idea came from workforce (excluding management level)	Yes/No, elaborate
Product idea came from management	Yes/No, elaborate
Process idea came from workforce (excluding management level)	Yes/No, elaborate
Process idea came from management	Yes/No, elaborate
Product idea came as joint efforts from workforce and management	Yes/No, elaborate
Process idea came as joint efforts from workforce and management	Yes/No, elaborate

Survey to test for dynamic workforce capabilities

Employee Innovation Variables	**Actions**
Education qualification	Select from list
Number of years in organisation	Select from list
Number of years in position (same organisation)	Select from list
Number of years in position add similar experience from other organisations)	Select from list
Position / level in the organisation	Select from list
Employee gender	Select from list
Employee age	Select from list
Employee ethnic group	Select from list
Team Innovation Variables	**Actions**
Team type	Select from list
Average team qualification	Select from list
Average years in organisation	Select from list
Innovation lead - number of years in organisation	Select from list
Innovation lead - number of years in position	Select from list
Innovation lead - position level in organisation	Select from list
Team gender balance	Select from list
Team age balance	Select from list
Team ethnic composition (by birth)	Supply numbers in block for each ethnic group

APPENDIX G: ANONYMISED COPY OF THE PERMISSION TO CONDUCT RESEARCH AT A COMPANY

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

University of the Witwatersrand,
Graduate School of Business Administration
2 St David's Place,
Parktown, Johannesburg
2050

Name of Representative at Company A
Address: Company A

June 2021

Dear Sir/Madam,

Re: Permission to conduct research at Company A

My name is Luyolo Mabhali and I am studying for a doctorate degree in the Graduate School of Business Administration at the University of the Witwatersrand, Johannesburg. I am seeking permission to do research at Company A.

I am conducting research on the effect of dynamic workforce capabilities on firm level innovation in the South African metals industry, under the supervision of Associate Professor Mjumo Mzyece. The aim of this research project is to expand the dynamic capability theory by showing a relationship between employee experience factors, which make-up the dynamic workforce capabilities, and firm level innovation in the South African metals industry. The proposed employee experience factors that will be considered in this work are qualification, tenure and demographic background attributes.

There is some work that has been done in terms of dynamic managerial capabilities, but less on the employee capability side. Also, the influence of the workforce on innovation was also studied by Rothaermel and Hess (2007) but the focus was on highly skilled employees such as scientists with advanced degrees.

However, the majority of employees in the manufacturing sector in the Republic of South Africa do not fall under this category (Makgetla, 2014). This work aims to address this gap by proposing an expanded dynamic capabilities model that includes workforce capabilities. Your organisation is chosen as one of the innovative organisations within the metals industry in South Africa.

I would like to invite two individuals from your organisation to participate in this study. These individuals should be a manager (with direct reports) who has developed process or product innovation (new/improved) in the past five years and an employee (with no direct reports) who has developed process or product innovation (new/improved) in the past five years. The focus will be on product and process innovation that has been successfully implemented within the organisation’s operation or in the market. If these individuals agree, they will be interviewed and requested to answer questions about firm level innovation in South Africa. This will take approximately one hour and the interviews will be conducted online using MS Teams. Their responses will be audio recorded using a digital device. This recording will be stored in a password protected computer and only the researcher will have access to it. The data will be deleted after five years.

Participants will be asked to give their written consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous in the final thesis and all publications. Individual privacy will be maintained in all published and written data resulting from the study.

The results will be part of the doctorate thesis and will also be used for conference and other publications. If you wish to receive a summary of this thesis/conference/ journal publications, I will be happy to send it to you.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

All research data will be stored in a password protected computer and will be kept for five years, after which it will be destroyed.

I therefore request permission in writing to conduct my research at your organisation. The permission letter should be on your organisation’s headed paper, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,
Luyolo Mabhali

Researcher:
Luyolo Andrew Baxolise Mabhali
0420076T@students.wits.ac.za
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Supervisor:
Associate Professor Mjumo Mzyece
mjumo.mzyece@wits.ac.za
+27 11 717 3649

APPENDIX H: CONSENT FORM FOR INTERVIEWS

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Consent Form for interviews

Title of project: Effect of dynamic workforce capabilities on firm level innovation in the South African metals industry

Name of researcher: Luyolo Andrew Baxolise Mabhali

I, ……………………………………….., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview may be audio recorded	YES	NO

…………………………………… (signature)
…………………………………… (name of participant)
…………………………………… (date)

…………………………………… (signature)
…………………………………… (name of person seeking consent)
…………………………………… (date)

APPENDIX I: COPY OF ETHICS CLEARANCE

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Mabhali

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H21/05/21**
PROJECT TITLE	Effect of dynamic workforce capabilities on firm-level innovation in the South African metals industry
INVESTIGATOR(S)	Dr L Mabhali
SCHOOL/DEPARTMENT	Wits Business School/
DATE CONSIDERED	21 May 2021
DECISION OF THE COMMITTEE	Approved Risk Level: Minimal
EXPIRY DATE	5 July 2024
DATE 06 July 2021	**CHAIRPERSON** J. Knight (Professor J Knight)

cc: Supervisor : Professor M Mzyece

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

____________________ ______/______/______
Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

APPENDIX J: SET OF QUESTIONS USED FOR THE SEMI-STRUCTURED INTERVIEWS

Interview questions: These questions are about idea creating AND implementation

R 1a: Is there product/process innovation in the South African metals industry?

Hyp 1a: Process / product innovation exists at firm level for organisations in the South African metals industry.

Questions:

1. *What product/process innovation was implemented in your organization between 2019 and 2021?*
2. *Post this period, was there innovation ideas that were successfully implemented in your organization? Give examples if possible. Were they done internally or adopted from other industries (or abroad)?*
3. *Do you think the South African metals industry is innovative and why?*
4. *How long have you been working within the metals industry in South Africa?*
5. *What type of innovation (new or improved products/new or improved processes) do you think is more prevalent in the South African metals industry?*
6. *Do you think innovation is done intentionally as part of the strategy in the SA metals industry or it just happens? Why do you think this? Do you have examples to show?*
7. *Do you think South African organizations have an R&D budget? What about the training budget? Does this play a role in form-level innovation? Give example about your organisation or experience in this?*
8. *What about innovation that happens outside the formal innovation budget? Do you think this is key? Is this captured in your organisation (recorded as part of innovation or R&D budget?*
9. *Elaborate on what innovation streams exist in your organisation? Are these formalised? Should they be formalised? Are the incentivised? Should they be incentivized?*
10. *Explain your training budget, does it results in innovation? In what sense and how do you track this? Is it possible to track it? How can the impact of training be measured (specifically for innovation purposes)?*
11. *Do you think South African organizations in the metals industry invest in new equipment? Do they buy this equipment locally or abroad? What about modification or repurposing of equipment, do you think this is big in SA?*
12. *What do you think about strategic alliances between HEIs and Research councils within the SA metals industry? What is hindering this? What would incentivise this relationship? Any other ideas around this topic?*
13. *Is the government playing a role to support firms in the metals industry to be innovative? Does it encourage partnerships between these firms and HEIs/Research Councils?*

R 1b: Who generates more innovative ideas between employees and managers in the South African metals industry?

Hyp1b: More innovative ideas are generated by employees compared to managers in the South African metals industry.

<u>Questions: These questions are about idea creating not implementation</u>

1. *Do you think employees who are not managers generate more innovative ideas compared to managers in your organization? Why do you think this is the case?*
2. *What prevents managers from creating ideas? What is their role in firm level innovation?*
3. *Do you think employees who are not managers generate more innovative ideas compared to the manager in general?*
4. *Does this also apply to the metals industry in South Africa?*
5. *What helps the employees to generate more innovative ideas compared to managers?*
6. *Do you think this is a global trend?*
7. *Do you think there is a special capability that innovative employees who are not managers poses that managers don't have?*

R 2: What is the relationship between employee experience factors (qualification, tenure, and demographic background attributes) that make up the dynamic workforce capabilities and innovation at the firm level?

Hyp 2a: There is a positive relationship between employee education level and innovation at the firm level.

<u>Questions: These questions are about idea creating not implementation</u>

1. *What do you think are the important determinants for firm level innovation in the South African metals industry? What are important employee-related factors that influence firm level innovation?*
2. *What types of innovation (product/process/business model) are important for firms in the South African metals industry? Is the implementation of*

process or product innovation good (sufficient) variables to measure if firm level innovation exists in the South African metals industry? Elaborate?

3. *Do you think education is important for innovation in the SA metals industry? Why? How is the current situation in your organisation? What do you mean by education, does this mean tertiary qualification or postgraduate qualifications?*
4. *In your organization, do you think having a tertiary education qualification help employees become innovative? Why do you say that? What about employees who learnt from experience "school of hard knocks"?*
5. *Are employees without a tertiary education qualification less innovative in general? Why do you say that?*
6. *If tertiary education qualification is important for innovativeness, why did the metals industry in South Africa survive when it had fewer employees (as a percentage of total staff complement) with tertiary education?*

Hyp 2b: There is a positive relationship between employee tenure and innovation at firm level

Questions: These questions are about idea creating not implementation

1. *In your perspective are critical employee turnover variables (why do people change jobs)?*
2. *In your perspective are critical employee turnover variables that have an impact on firm level innovation (which variable that cause people to leave that would have an impact on the company they are leaving becoming innovative or not)?*
3. *Is the number of years in the position important and why?*
4. *Is the number of years the employee spent in the same position in the organization (position tenure) important for firm level innovation and why?*
5. *Is the total experience of the employee in that field (including experience acquired in other organizations) important for firm level innovation and why?*
6. *Is there level of the employee position in the company structure important for firm level innovation and why?*
7. *Rank these statements according to their importance in their influence on firm level innovation in the South African metals industry:*
    a. *Number of years in the position*
    b. *Number of years the employee spent in the same position in the organization (position tenure)*
    c. *Total experience of the employee in that field (including experience acquired in other organizations)*
    d. *Level of the employee position in the company structure*
8. *Are employers with newer employees (with less tenure) less likely to come up with an innovative process or product innovations compared to*

employees who have been in the organization longer? Why is that the case?

9. *Is there anything else, that has to do with employee tenure, that you feel is critical to firm level innovation in the South African metals industry?*

Hyp 2c: There is a positive relationship between employee demographic background attributes and innovation at firm level

<u>Questions: These questions are about idea creating not implementation</u>

1. *What do you understand as employee demographic background attributes?*
2. *In your perspective are critical employee demographic background attributes variables?*
3. *In your perspective are critical employee demographic background attributes variables that have an impact on firm level innovation in the South African metals industry?*
4. *Is the gender of the employee important and why?*
5. *Is the age of the employee important for firm level innovation and why?*
6. *Is the ethnic background of the employee important for firm level innovation and why?*
7. *In a diverse country like South Africa, is ethnic background important for innovation?*
8. *Why would that be the case? Is it influenced by upbringing? Is it influenced by culture?*
9. *Rank these statements according to their importance in their influence on firm level innovation in the South African metals industry:*
    a. *Gender of the employee*
    b. *Age of the employee*
    c. *Ethnic background of the employee*
10. *Is there anything else, that has to do with employee demographic background, that you feel is critical to firm level innovation in the South African metals industry?*

Hyp 2d: There is a positive relationship between the dynamic workforce capabilities and firm level innovation in the South African metals industry

<u>Questions: These questions are about idea creating AND implementation</u>

1. *Are you aware of dynamic capabilities? What does this mean, in your perspective?*

2. *In your perspective are dynamic workforce (or employee) capabilities?*
3. *In your perspective what are the employee's capabilities that make them innovative in the South African metals industry?*
4. *Are these different in other industries? Why and give example?*
5. *Are the dynamic capabilities required for managers different from those required of employees and why?*
6. *Which is more important for firm level innovation between education, employee tenure and employee background? Why did you make such choice? Is education the most important factor or not as important in the South African metals industry (in your perspective)?*

Implementing team – all the following questions are about implementation of innovation

1. What are the characteristics of a team that implemented innovation in your organization?
    a. *What are some of the important team characteristics that made the implementation of the innovative idea successful?*
    b. *Is the diversity of the team important and why?*
    c. *Is Education qualifications of the team and why?*
    d. *Is the average tenure of the team in the organization important and why?*
    e. *Is the tenure of the innovation lead in the organization important and why?*
    f. *Is the number of years in the same position for the innovation lead important and why?*
    g. *Is the position level of the innovation lead in the organization important and why?*
    h. *Is the team gender balance important and why?*
    i. *Is the team age mix/balance important and why?*
    j. *Is the team ethnic mix important and why?*

2. What would be the ideal characteristics for a team that would successfully implement innovation in the South African metals industry?
    a. *What are some of the ideal team characteristics required to successfully implement innovation?*
    b. *Is the diversity of the team important and why?*
    c. *Is Education qualifications of the team important and why?*
    d. *Is the average tenure of the team in the organization important and why?*
    e. *Is the tenure of the innovation lead in the organization important and why?*
    f. *Is the number of years in the same position for the innovation lead important and why?*

g. *Is the position level of the innovation lead in the organization important and why?*
h. *Is the team gender balance important and why?*
i. *Is the team age mix/balance important and why?*
j. *Is the team ethnic mix important and why?*

<u>Dynamic capability:</u>

1. *What do you think are the capabilities that allow employees to be innovative in your organization?*
2. *Do you think these capabilities are applicable to the entire South African metals industry?*
3. *What do you think are critical and unique employee skills and capabilities that enable them to be innovative in the South African metals industry?*

<u>Other:</u>

1. *Did COVID-19 affect turnover and headcount in your organisation between 2019 and 2021?*
2. *Why do you think there was a change or not change in headcount? Could it be due to operational requirements?*
3. *What sheltered the organisation financially between 2019 and 2021?*

APPENDIX K: DATA RECEIVED FROM HSRC

Respondent #	# Employeed 2016	Diploma/ Degree	Turnover 2016	Innov New Goods	Innov Improved Goods	Innov New Serv	Innov Improved Serv	New or Improved Product	Origin of Inn Prod	New to Market	New to Company	New to world	New in SA	New to industry	New or Improved Process	Origin of Inn Proc	Prod or Proc Inn	Origin of Prod/Proc Inn
1	116	5	321 900 000	Yes	Yes	No	No	Yes	RSA	No	Yes	No	No	No	Yes	RSA	Yes	RSA
2	441	2	530 775 000	No	Yes	No	No	Yes	Abroad	No	Yes	No	No	No	No	N/A	Yes	Abroad
3	345	50	471 533 333	Yes	Yes	Yes	Yes	Yes	RSA	Yes	No	Don't Know	Don't Know	Don't Know	Yes	RSA	Yes	RSA
4	131	30	597 000 000	Yes	Yes	Yes	Yes	Yes	Abroad	No	Yes	No	No	No	No	N/A	Yes	Abroad
5	68	15	272 000 000	No	No	No	Yes	Yes	RSA	Yes	No	Yes	Don't Know	Don't Know	Yes	RSA	Yes	RSA
6	77	40	266 300 000	No	No	No	Yes	Yes	Abroad	No	No	No	No	No	Yes	Abroad	Yes	Abroad
7	215	29	1 292 000 000	Yes	Yes	Yes	Yes	Yes	RSA	Yes	Yes	No	Yes	Don't Know	Yes	RSA	Yes	RSA
8	900	3	890 000 000	Yes	Yes	No	No	Yes	RSA	Yes	No	Yes	No	No	No	N/A	Yes	RSA
9	995	13	2 214 000 000	Yes	Yes	Yes	Yes	Yes	Abroad	No	Yes	No	No	No	Yes	RSA	Yes	RSA
10	935	30	4 909 000 000	Yes	Yes	No	Yes	Yes	Abroad	Yes	No	Yes	No	No	Yes	Abroad	Yes	Abroad
11	885	8	4 565 000 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
12	245	50	255 700 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
13	2 099	4	1 790 000 000	No	Yes	No	Yes	Yes	RSA	Yes	Yes	Don't Know	Yes	Yes	Yes	RSA	Yes	RSA
14	410	2	485 000 000	Yes	Yes	No	Yes	Yes	Abroad	Yes	Yes	No	Yes	No	Yes	Abroad	Yes	Abroad
15	1 865	10	2 376 000 000	Yes	Yes	No	Yes	Yes	RSA	Yes	Yes	Yes	Yes	Yes	Yes	RSA	Yes	RSA
16	62	5	245 000 000	Yes	Yes	No	No	Yes	RSA	Yes	Yes	Yes	Yes	Yes	Yes	Abroad	Yes	RSA
17	351	2	420 000 000	No	No	Yes	Yes	Yes	RSA	Yes	No	No	Yes	Yes	No	N/A	Yes	RSA
18	170	10	290 000 000	No	Yes	No	No	Yes	Abroad	Yes	No	Yes	No	No	Yes	Abroad	Yes	Abroad
19	1 547	30	11 770 000 000	Yes	No	No	No	Yes	RSA	No	Yes	No	Yes	Yes	Yes	RSA	Yes	RSA
20	665	3	754 600 000	Yes	Yes	No	No	Yes	Abroad	Yes	Yes	Yes	No	No	No	N/A	Yes	Abroad
21	568	5	1 444 000 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
22	243	3	114 800 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
23	240	20	127 000 000	No	Yes	No	Yes	Yes	RSA	Yes	Yes	Don't Know	No	No	No	N/A	Yes	RSA
24	150	1	102 400 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
25	60	11	36 027 663	Yes	Yes	No	No	Yes	RSA	No	Yes	Don't Know	Don't Know	Don't Know	No	N/A	Yes	RSA
26	73	0	36 000 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	Yes	RSA	Yes	RSA
27	19	0	22 000 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
28	10	10	705 800 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
29	11	9	6 900 000	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	No	N/A
30	36	35	36 453 806	No	Yes	No	Yes	Yes	RSA	Yes	No	No	Don't Know	Don't Know	No	N/A	Yes	RSA
31	269	65	347 600 000	Yes	Yes	No	Yes	Yes	RSA	Yes	No	Yes	Don't Know	Don't Know	No	N/A	Yes	RSA
32	535	17	463 500 000	Yes	No	No	No	Yes	RSA	Yes	Yes	No	No	Yes	Yes	RSA	Yes	RSA
33	33	10	70 000 000	No	Yes	No	Yes	Yes	RSA	No	Yes	No	Don't Know	No	Yes	Abroad	Yes	RSA

Keys: Respondent # = Respondent number; # Employed 2016 = total number of employees in 2016; Diploma/Degree = percentage of your total employees had a university degree or diploma in 2016; Turnover 2016 = turnover in 2016; Innov New Goods = introduction of new good between 2014 and 2016; Innov Improved Goods = introduction of improved good between 2014 and 2016; Innov New Serv = introduction of new services between 2014 and 2016; Innov Improved Serv = introduction of improved services between 2014 and 2016; New or Improved Product = introduction of new or improved product (goods/service) between 2014 and 2016; Orig of Inn Prod = origin of the innovation product (SA or Abroad); New to Market = Product was new to market; New to Company = Product was new to company only; New to world = Product was new to the world; New in SA= Product was new in South Africa; New to Industry = Product was new to the metals industry; New or Improved Process = company developed a new or significantly improved methods of manufacturing or producing goods or services; Orig Inn Proc = origins of the new or improved process innovation (SA or Abroad); Prod or Proc Inn = Organisations with product or process innovation during the period between 2014 and 2016; Origin of Prod/Proc Inn = Origins of the product or process innovation.

APPENDIX L: FILTERED DATA FROM THE HSRC WITH NUMBERS ASSIGNED TO THE CATEGORICAL VARIABLES

Respondent #	# Employeed 2016	Diploma/ Degree	Turnover 2016	Innov New Goods	Innov Improved Goods	Innov New Serv	Innov Improved Serv	New or Improved Product	Origin of Inn Prod	New to Market	New to Company	New to world	New in SA	New to industry	New or Improved Process	Origin of Inn Proc	Prod or Proc Inn	Origin of Prod/Proc Inn
1	116	5	321 900 000	1	1	2	2	1	1	2	1	2	2	2	1	1	1	1
2	441	2	530 775 000	2	1	2	2	1	2	2	1	2	2	2	2	3	1	2
3	345	50	471 533 333	1	1	1	1	1	1	1	2	4	4	4	1	1	1	1
4	131	30	597 000 000	1	1	1	1	1	2	2	1	2	2	2	2	3	1	2
5	68	15	272 000 000	2	2	2	1	1	1	1	2	1	4	4	1	1	1	1
6	77	40	266 300 000	2	2	2	1	1	2	2	2	2	2	2	1	2	1	2
7	215	29	1 292 000 000	1	1	1	1	1	1	1	1	2	1	4	1	1	1	1
8	900	3	890 000 000	1	1	2	2	1	1	1	2	1	2	2	2	3	1	1
9	995	13	2 214 000 000	1	1	1	1	1	2	2	1	2	2	2	1	1	1	1
10	935	30	4 909 000 000	1	1	2	1	1	2	1	2	1	2	2	1	2	1	2
11	885	8	4 565 000 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
12	245	50	255 700 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
13	2 099	4	1 790 000 000	2	1	2	1	1	1	1	1	4	1	1	1	1	1	1
14	410	2	485 000 000	1	1	2	1	1	2	1	1	2	1	2	1	2	1	2
15	1 865	10	2 376 000 000	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
16	62	5	245 000 000	1	1	2	2	1	1	1	1	1	1	1	1	2	1	1
17	351	2	420 000 000	2	2	1	1	1	1	1	2	2	1	1	2	3	1	1
18	170	10	290 000 000	2	1	2	2	1	2	1	2	1	2	2	1	2	1	2
19	1 547	30	11 770 000 000	1	2	2	2	1	1	2	1	2	1	1	1	1	1	1
20	665	3	754 600 000	1	1	2	2	1	2	1	1	1	2	2	2	3	1	2
21	568	5	1 444 000 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
22	243	3	114 800 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
23	240	20	127 000 000	2	1	2	1	1	1	1	1	4	2	2	2	3	1	1
24	150	1	102 400 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
25	60	11	36 027 663	1	1	2	2	1	1	2	1	4	4	4	2	3	1	1
26	73	0	36 000 000	2	2	2	2	2	3	3	3	3	3	3	1	1	1	1
27	19	0	22 000 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
28	10	10	705 800 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
29	11	9	6 900 000	2	2	2	2	2	3	3	3	3	3	3	2	3	2	3
30	36	35	36 453 806	2	1	2	1	1	1	1	2	2	4	4	2	3	1	1
31	269	65	347 600 000	1	1	2	1	1	1	1	2	1	4	4	2	3	1	1
32	535	17	463 500 000	1	2	2	2	1	1	1	1	2	2	1	1	1	1	1
33	33	10	70 000 000	2	1	2	1	1	1	2	1	2	4	2	1	2	1	1

APPENDIX M: RESULTS ON TURNOVER AND HEADCOUNT PER ORGANISATION RECEIVED FROM THE PRIMARY SURVEY

Company	Turnover_2019	Turnover_2020	Turnover_2021	Average_Turnover	Median_Turnover	Headcount_2019	Headcount_2020	Headcount_2021	Average_Headcount	Median_Headcount
1	R2 747 000 000	R 2 569 000 000	R2 658 000 000	R 2 658 000 000	R 2 658 000 000	2104	2143	2165	2137	1402
2	R 200 000 000	R 150 000 000	R 180 000 000	R 176 666 667	R 180 000 000	700	620	650	657	560
3	R 767 929 000	R 828 664 500	R 886 671 051	R 827 754 850	R 828 664 500	500	450	400	450	425
4	R 40 000 000	R 38 000 000	R 35 000 000	R 37 666 667	R 38 000 000	500	320	400	407	270
5	R 80 000 000	R 60 000 000	R 60 000 000	R 66 666 667	R 60 000 000	220	220	220	220	327
6	R 200 000 000	R 150 000 000	R 120 000 000	R 156 666 667	R 150 000 000	468	461	433	454	344
7	R 192 000 000	R 200 000 000	R 215 000 000	R 202 333 333	R 200 000 000	254	254	213	240	397
8	R 700 000 000	R 650 000 000	R 600 000 000	R 650 000 000	R 650 000 000	678	564	540	594	276
9	R 5 000 000	R 3 000 000	R 3 000 000	R 3 666 667	R 3 000 000	12	12	12	12	24
10	R 30 000 000	R 26 000 000	R 2 300 000	R 19 433 333	R 26 000 000	50	48	36	45	60
11	R 16 000 000	R 15 000 000	R 14 000 000	R 15 000 000	R 15 000 000	70	69	70	70	110
12	R 20 000 000	R 60 000 000	R 20 000 000	R 33 333 333	R 20 000 000	150	150	150	150	170
13	R 50 000 000	R 40 000 000	R 43 000 000	R 44 333 333	R 43 000 000	190	190	190	190	194
14	R 280 000 000	R 150 000 000	R 220 000 000	R 216 666 667	R 220 000 000	220	198	200	206	285
15	R6 000 000 000	R 4 500 000 000	R7 000 000 000	R 5 833 333 333	R 6 000 000 000	500	350	440	430	470
16	R 400 000 000	R 1 000 000 000	R1 000 000 000	R 800 000 000	R 1 000 000 000	700	700	400	600	350
17	R 380 000 000	R 370 000 000	R 300 000 000	R 350 000 000	R 370 000 000	300	264	250	271	161
18	R2 000 000 000	R 3 000 000 000	R3 500 000 000	R 2 833 333 333	R 3 000 000 000	72	72	72	72	45
19	R 33 000 000	R 21 000 000	R 25 000 000	R 26 333 333	R 25 000 000	18	12	18	16	207
20	R 480 000 000	R 450 000 000	R 430 000 000	R 453 333 333	R 450 000 000	403	395	400	399	402
21	R 600 000 000	R 400 000 000	R 450 000 000	R 483 333 333	R 450 000 000	1000	350	450	600	181
22	R 8 000 000	R 5 000 000	R 5 000 000	R 6 000 000	R 5 000 000	12	12	10	11	1606
23	R 800 000 000	R 480 000 000	R 320 000 000	R 533 333 333	R 480 000 000	5000	4800	3200	4333	1912
24	R 341 000 000	R 562 000 000	R 554 000 000	R 485 666 667	R 554 000 000	502	624	507	544	566
25	R 380 000 000	R 860 000 000	R 870 000 000	R 703 333 333	R 860 000 000	700	700	370	590	288
26	R 90 000 000	R 60 000 000	R 70 000 000	R 73 333 333	R 70 000 000	205	205	205	205	303
27	R 100 000 000	R 100 000 000	R 250 000 000	R 150 000 000	R 100 000 000	500	450	400	450	2150
28	R8 000 000 000	R10 000 000 000	R5 000 000 000	R 7 666 666 667	R 8 000 000 000	4600	3800	3800	4067	2260
29	R 508 564 105	R 407 844 964	R 600 564 105	R 505 657 725	R 508 564 105	720	470	490	560	410
30	R 488 000 000	R 540 000 000	R 520 000 000	R 516 000 000	R 520 000 000	350	350	340	347	203
31	R 20 000 000	R 20 000 000	R 18 000 000	R 19 333 333	R 20 000 000	65	65	65	65	137
32	R 180 000 000	R 120 000 000	R 150 000 000	R 150 000 000	R 150 000 000	209	209	209	209	112
33	R 7 000 000	R 6 000 000	R 4 000 000	R 5 666 667	R 6 000 000	15	12	12	13	228
34	R 800 000 000	R 820 000 000	R 750 000 000	R 790 000 000	R 800 000 000	450	450	440	447	451
35	R 800 000 000	R 850 000 000	R1 200 000 000	R 950 000 000	R 850 000 000	462	452	453	456	232
36	R 6 000 000	R 5 000 000	R 5 000 000	R 5 333 333	R 5 000 000	12	10	11	11	11