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**2023**
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Ramadeen, Jeeth. (2023). The influence of a complementary system of industry 4.0 capabilities on the performance of South African financial services firmss [Master's dissertation, University of the Witwatersrand, Johannesburg]. WireDSpace. https://hdl.handle.net/10539/38730

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# THE INFLUENCE OF A COMPLEMENTARY SYSTEM OF INDUSTRY 4.0 CAPABILITIES ON THE PERFORMANCE OF SOUTH AFRICAN FINANCIAL SERVICES FIRMS




Research report
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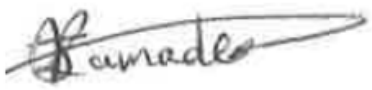
**Candidate's Signature:** _ ____  __ **Date:** 28/03/2023

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# ABSTRACT

In this study, the relationships between Industry 4.0 (I4.0) complementary capability and performance outcomes were examined by utilising the resource-based view (RBV) of the firm. To achieve this, a conceptual framework was developed and tested, with a focus on eight specific I4.0 capabilities: Digitalisation, Integration, Decentralisation, Virtualisation, Real-time capability, Modularity, Service Orientation, and Human Resources. A relational cross-sectional survey examined how I4.0 complementary capability affects firm performance outcomes. The study employed a positivist perspective and utilised deductive reasoning to measure these effects. Data was gathered via structured questionnaire from 73 business and IT decision-makers within South Africa. The study employed correlation and multiple regression techniques to analyse the statistical relationship between I4.0 complementary capability and performance outcomes. The study's results indicate that adopting I4.0 complementary capability has a positive effect on firm performance. This suggests that businesses that implement I4.0 complementary capability are more likely to experience improved performance outcomes. The study found that digitalisation is a consistent and significant contributor to firm performance and that when combined with virtualisation, it has a positive and significant effect. However, there was no statistically significant relationship between I4.0 complementary capability and Innovation Capability. Nevertheless, digitalisation alone showed a strong positive and statistically significant relationship with innovation capability. Lastly, the study found no statistical significance in the relationship between I4.0 complementary capability and Value Outcomes. Digitalisation, on the other hand, was found to be a consistent and significant contributor to value outcomes, and when combined with virtualisation, it also had a positive and significant effect. The research study provides a unique contribution by utilizing the resource-based view of the firm to establish a connection between I4.0 complementary capabilities and performance outcomes within Financial Services. The study's results offer valuable insights for researchers and organisations seeking to understand which I4.0 capabilities are most significant and how they can enhance a firm ability to achieve performance outcomes. The financial services industry is showing a strong interest in understanding the potential benefits of I4.0. This research provides insight into the relationship between an I4.0 complementary capability and firm performance outcomes, which can help practitioners prioritize their efforts to develop such a capability and determine the most important underlying I4.0 capabilities. By identifying the most critical I4.0 capabilities and their impact on firm performance, practitioners can focus their resources on implementing effective interventions that can improve their overall performance outcomes.

# CHAPTER 1: INTRODUCTION

## 1.1 Background

The technology landscape is rapidly evolving with emerging technologies and a range of applications shaping life as we know it. Organisations find themselves in constant need to stay relevant and remain competitive in existing and developing markets (Piccarozzi, Aquilani, and Gatti, 2018). As we stand on the threshold of the Fourth Industrial Revolution, the last decade has witnessed its remarkable emergence, also recognized as 4IR or Industry 4.0 (I4.0) or the Digital Revolution. This transformative era has undeniably taken centre stage in both academic and practical domains. (Mehdiabadi *et al.*, 2020). Aligning with the expectations of I4.0, organisations have displayed a significant amount of interest in understanding the implications, and various advantages of this concept and its potential to enhance their competitiveness. (Gökalp, Şener, and Eren, 2017; Horváth and Szabó, 2019).

The three previous revolutions that inspired I4.0 are, the First Industrial revolution introduced steam power and mass production; the Second Industrial Revolution led to the transition into the transformative force of twentieth-century electric power; the Third Industrial revolution centred on the era of computing and information age (Piccarozzi, Aquilani and Gatti, 2018). I4.0, still within the infancy stages, can be regarded as the new industrial age that encompasses advanced technologies and capabilities that are fundamentally based on the digitalisation of physical assets and the principles of integration and interconnectedness (Mehdiabadi *et al.*, 2020). The greater part of the literature accentuates I4.0 as being relevant to the manufacturing sector (Piccarozzi, Aquilani and Gatti, 2018). Although plausible, we tend to argue that I4.0 has major relevance within financial services (Bilan *et al.*, 2019). There's an abundance of definitions available, however, the academic and practitioner discussions on I4.0 within financial services deserve more attention. There is a need for a consistent I4.0 definition across organisations (Piccarozzi, Aquilani and Gatti, 2018). In doing so the essence of I4.0 can be encapsulated offering a better understanding to the various audiences. Although the definitions of I4.0 vary depending on the literature (Piccarozzi, Aquilani and Gatti, 2018), they often have a consistent view of benefits and competitive advantage that are typically conceptualised as an organisation's or firm performance.

Within financial services, I4.0 can be argued to have a strong focus on digitalisation in creating digital ecosystems through the use of digital technologies (Centre of Excellence in Financial Services, 2017; Bilan *et al.*, 2019; Niemand *et al.*, 2020). Further literature suggests I4.0 within the financial services sector centres on digitalisation infused with design principles, that Integration, Decentralisation, Virtualisation, Real-time capability, Service Orientation, and Modularity (Centre of Excellence in Financial Services, 2017; Bilan *et al.*, 2019; Manser Payne,

Dahl and Peltier, 2021). These principles are part of I4.0's framework, which aims to help financial services organisations become better positioned to compete in today's environment (Ohene-Afoakwa and Nyanhongo, 2017). According to the research, the driving forces behind I4.0 are related to the expected benefits. Lu (2017) argues that increased operational efficiency and productivity are the goals of I4.0 within the manufacturing sector. However, the most prominent factor is a competitive advantage. Horváth and Szabó (2019) propose that investment in I4.0 technologies can result in a comparative and decisive advantage over competitors increasing the overall business value. Some of the primary benefits that financial services can draw on are increased process efficiencies, reduced costs, increased product or service quality, real-time interaction with consumers and business partners, innovation capabilities, personalisation of products and services, and lastly, increasing market share (Bilan *et al.*, 2019; Horváth and Szabó, 2019). Unfortunately, there is currently limited scientific evidence supporting the various performance factors that are related to the development and implementation of I4.0 in the financial services industry.

The paper focuses on conceptualising I4.0 as a complementary capability based on the underpinning I4.0 capabilities. These principles are identified as, Collaboration, Digitalisation, Integration, Decentralisation, Real-time capability, Service orientation, and Digitalisation and Human Resources (Centre of Excellence in Financial Services, 2017; Havle and Üçler, 2018; Bilan *et al.*, 2019; Manser Payne, Dahl and Peltier, 2021) within the financial services sector in South Africa to better understand the implications on Firm Performance. South Africa is renowned for its mature financial sector that operates within the confines of a developing economy (Financial Sector Conduct Authority and Genesis Analytics, 2022). Although South Africa's economy is characterised by various factors such as high unemployment, income inequality, and lack of infrastructure development, the financial services sectors contribute significantly to the country's total gross domestic product (Centre of Excellence in Financial Services, 2017) therefore it is suited and relevant for this study. South Africa provides a lot of opportunities for discussion about how I4.0 can benefit the country's financial sector and the overall economy.

## 1.2 Financial Institutions in South Africa

South Africa's financial sector is one of the most developed and sophisticated in Africa. The sector has undergone significant changes since the latter 90’s with the government introducing policies aimed at creating a more inclusive and competitive financial system. As a result, South Africa's financial sector is now dominated by five major banks which collectively account for more than 90% of the sector's assets. South Africa has 36 registered banking entities overseen by both the Financial Sector Conduct Authority (FSCA) and the Prudential Authority (PA). (International Monetary Fund. Monetary and Capital Markets Department, 2022). The competitive environment for banks is evolving rapidly due to the emergence of new players such as tech startups, newly established banks, and retailers offering financial

services. Over the past four years, three innovative newcomers have entered the market, each offering unique value propositions for customers. In addition to the traditional banking sector, South Africa has a well-developed insurance industry, which has grown rapidly in recent years. The country is institutions, asset management firms, and stock exchanges. The investment and asset management industry in South Africa has experienced steady growth in recent years, serving millions of consumers. As of September 30, 2021, the industry held an estimated ZAR4.26 trillion in total assets under management, demonstrating the significant size and importance of the industry. South Africa's retirement industry is also a significant contributor to the country's economy, with assets totalling more than ZAR4.6 trillion. This places the industry's assets to Gross Domestic Product (GDP) ratio among the highest in the world, indicating the industry's significant scale and importance to the country's financial landscape. Within the financial advisory and intermediaries' industry, non-discretionary financial service providers (FSPs) represent the largest category of Financial Advisory and Intermediary Services (FAIS). As a result, this industry is the largest sector within the financial services landscape. This highlights the significant role that FSPs play in providing financial advice and guidance to clients and underscores their importance in the broader financial ecosystem (Financial Sector Conduct Authority and Genesis Analytics, 2022)

## 1.3 Research Problem

The concept of I4.0 encapsulates how technology has expanded into all areas of society, including production, finance, transportation, communications, and services (Mehdiabadi *et al.*, 2020). Although still in its infancy, I4.0 plays a significant role in shaping the future of financial services and requires a set of capabilities to be successful. A significant barrier to the adoption of I4.0 by organisations is a lack of foundational understanding of its concepts, benefits, and advantages (Dikhanbayeva *et al.*, 2020). A study revealed that up to 85% of organisations fail to sustain initiatives (Sousa-Zomer, Neely, and Martinez, 2020). Thus, there is a need to understand what constitutes I4.0 capabilities in financial services.

Secondly, organisations are constantly seeking new ways to remain competitive. The ultimate goal of I4.0 is to deliver a competitive advantage and provide added value. As these are the driving forces for implementation, organisations are turning to I4.0 capabilities as a business opportunity and tool for future challenges (Dikhanbayeva *et al.*, 2021). However, not all capabilities may guarantee a competitive advantage or added value. Although there is increasing importance of I4.0 capabilities, their impact on the development of competitive advantage and value creation is yet to be empirically confirmed. Thus, there is a significant lack of empirical evidence within financial services to determine the extent to which I4.0 influences Firm Performance factors if any. It is important that organisations thoroughly understand the various factors that affect the development of their competitive advantage and in deciding how to allocate resources to ensure value.

## 1.4 Purpose and Research Questions

The purpose of this research study is to understand and determine the relationship between I4.0 complementary capabilities and Firm Performance outcomes in financial services. Secondly, the research examines the extent to which I4.0 capabilities influence Firm Performance outcomes. To address the purpose, there is a need to empirically design and then test a model to measure Firm Performance outcomes. By applying the Resource-based view framework, this research provides a comprehensive empirical study. In doing so, the study contributes to the continuous growth of academic and practitioner interest in I4.0 by imparting a deeper understanding of its capabilities and its potential to produce profitable outcomes. Thus, the following research questions have been formulated:

**RQ1 - What is the relationship between industry 4.0 capabilities and Firm Performance outcomes?**

**RQ2 - To what extent do Industry 4.0 capabilities influence Firm Performance outcomes**

### 1.4.1 Relevance to Academic Research

Literature indicates most studies primarily focus on the industrial sector with one empirical study in financial services focusing on Digitalisation and Servitisation thus empirical studies on I4.0 complementary capabilities affecting Firm Performance are lacking. This study applies the Resource-based view (RBV) framework as a theoretical lens to determine the impact of an I4.0 complementary capability on Firm Performance within financial services. Therefore, fills an information systems (IS) literature gap by applying the Resource-based view framework to explore I4.0's impact on Firm Performance in financial services. For instance, Salam (2019) performed a study to determine I4.0 and Firm Performance relationships from a supplier perspective using RBV in manufacturing. A study conducted by Serumaga-Zake and Poll (2021), focuses on South African SMEs in manufacturing and Firm Performance also using the theoretical approach of the Resource-based view (RBV), similarly, Chauhan, Singh, and Luthra (2021) present a study that explores the various barriers that prevent organisations from fully adopting I4.0 and how these barriers affect their firm performance. These studies focused on specific capabilities. The RBV framework has been adopted by many studies on various IS domains however, none of the study's focus provides a comprehensive view of I4.0 in financial services. The primary motivation for carrying out an RBV-based approach is that it provides a compelling framework that allows researchers to integrate multiple dissimilar resources to study the varying effects on performance. The resource-based view posits that Firm Performance is influenced by an organisation’s resources and capabilities (Wade and

Hulland, 2004). The RBV framework, though widely used, shows varying effects of capabilities on Firm Performance based on technologies and contexts**.**

### 1.4.2 Importance to Practice

This study's research will contribute practically by identifying relevant I4.0 capabilities in Financial Services. Some of the capabilities highlighted involve digitalisation, design principles, and the human resources that create the foundation for I4.0 enablement. Despite being aware of the importance of I4.0, financial services organisations are unable to capitalise on capabilities yielding benefits and returns. Building on academic literature, this study will make a significant contribution by exploring the relationship between I4.0 and Firm Performance, including other organisational benefits. Performing this research develops a case for the appropriate implementation of I4.0 within financial services. The surge in tech start-ups referred to as fintech which involves leveraging technology to provide financial services continues to pose a challenge to traditional banks as it erodes their profitability (Mackenzie, 2015). By understanding and implementing I4.0 as a complementary capability, traditional financial services organisations are enabled to keep up with non-traditional competitors gaining significant competitive advantage and, in some cases, forming alliances with them. Amongst the many other benefits, financial services can harness I4.0 from a more service-orientated business model integrating an end-to-end value chain and leveraging digital channels (Omni channels) to enhance flexibility, response times, and delivering customer-centric solutions that may lead to overall business value and reduced costs. Finally, this study's findings offer financial services valuable insights and lessons on successful I4.0 implementation drawing from other organizations' experiences with positive results.

## 1.5 Delimitations and Assumptions

Delimitations set research boundaries and scope, outlining the extent and limitations of the study's focus. The below are noted

- The study specifically targeted organisations located in South Africa and the research was conducted solely within this geographic region
- The research study targeted both small to medium-sized enterprises (SMEs) and large organisations within the financial services sector.
- The research study focused on business and IT decision-makers within their respective firms, as these individuals are likely to have the most knowledge and understanding of I4.0 and related technologies.
- This study is conducted at the organisational level and, as such, concentrates on organisational units rather than individual adoption within the organisation or adoption by their customers.

- RBV is used to assess financial services in South Africa. It can be supplemented with contingency and organizational theories, but it has limitations in understanding individual-level factors.

## 1.6 Report Structure

This chapter introduces the research background on I4.0 in financial services. The research problem was divided into two research questions, which aimed to investigate the correlation between the I4.0 complementary capability and Firm Performance, as well as to determine the degree to which these capabilities affect Firm Performance. Additionally, the research contributions were highlighted. The subsequent chapters of the research report follow a structured format.

**Chapter 2: Literature Review -** The literature review serves to evaluate the existing understanding of the topic under investigation and pinpoint any areas of knowledge that need further exploration. In this chapter, the I4.0 capabilities presented in financial services are outlined, followed by a comprehensive systematic literature review that seeks to address RQ1.

**Chapter 3: Theoretical Background and Research Hypotheses** - This chapter commences by introducing the theoretical basis of Resource-Based View (RBV), which is followed by the formulation of a research model that will serve as the backbone of the study. The factors and constructs that will be employed in the investigation are subsequently analysed to construct hypotheses that aim to address RQ2.

**Chapter 4: Research Methodology -** This chapter outlines the quantitative research design used to address RQ2.

**Chapter 5: Data Analysis** – provides detailed results of the data analysis. The research instrument is subjected to a rigorous reliability and validity evaluation. Using regression and correlation analyses, the hypothesis is tested, and the findings are concisely explicated.

**Chapter 6: Research Findings**- A comprehensive discussion is presented on the inferences derived from the data analysis stage. The ultimate interpretations are presented to conclude the research question and its corresponding hypotheses.

**Chapter 7: Conclusion -** The final chapter addresses study findings, implications for academia and practice, and future research recommendations.

# CHAPTER 2: LITERATURE REVIEW

There is a need to contextualize the I4.0 phenomenon hence the chapter begins by providing a brief review of the previous Industrial Revolutions. This is followed by assessing and defining I4.0 within financial services. A systematic literature review (SLR) is then followed to determine the relationship between I4.0 capabilities and Firm Performance outcomes (RQ1). The SLR strategy is defined, and the journals and databases used are listed.

## 2.1 History of Industry 4.0

Over the past few centuries, society has borne witness to disruptive innovations and developments that have fundamentally transformed life as we know it. It is an ongoing transition that is triggered by either evolutionary or revolutionary inventions. Today, more than 200 years later after the first industrial revolution, we are arguably into the Fourth Industrial Revolution. Although contentious, the understanding of all three past industrial revolutions is necessary for context.

### 2.1.1 First Industrial revolution (1760-1850)

Originating in Great Britain, the first industrial revolution introduced novel thinking and concepts that can be described as the transition from manual productivity and methods being replaced by mechanical production facilities powered by water and steam plants (Sutherland, 2020). The First Industrial revolution shifted economies from rural to urban mechanised production and saw a shift in the construction industry from wood to metal (Sutherland, 2020). Primarily people lived in rural-orientated communities whereby manual labour was performed in homes using basic tools and machinery. It was during this period that resources such as iron, and steel coal were considered in the advent of the steam engine resulting in steam-powered production lines and introduced railways. This triggered the invention of new machines that increased productivity and transitioned from working independently to people gathering and working under one roof resulting in the first factories with mass production (Schlötzer, 2015; Sutherland, 2020).

### 2.1.2 Second Industrial revolution (1870-1970)

The United States of America was primarily responsible for the Second Industrial Revolution which saw a shift in mass production, distribution, and communication (Sutherland, 2020). This led to the harnessing of electricity within lighting, motors, and communications resulting in the new information age. Construction evolved into urban water and sewage systems, highways, and high-rise buildings. Air and road transportation was fuelled by combustion engines (Sutherland, 2020). There was also a shift to scientific thinking and approaches

resulting in the increased feedback loop from technology to science. New technologies created better instruments and equipment to support the scientific world including plastics and antibiotics (Schlötzer, 2015).

### 2.1.3 Third Industrial Revolution (the 1960s onwards)

The United States of America once again stood at the forefront of the Third Industrial Revolution, which ushered in the introduction of electronics and information technology, contributing to higher levels of production automation including significant advances in computing and networks ( Lu, 2017; Sutherland, 2020). Leading innovations included the Internet, electronic documentation, email, and faxes. Automatic teller machines (ATMs) and mobile telecommunications were also invented during this period. Major benefits included rapid improvement in quality and price reductions (Sutherland, 2020).

### 2.1.4 Fourth Industrial revolution

Also referred to as I4.0, I4.0, 4IR, or digital revolution was officially established in Germany in 2011 during the Hannover Fair. It's part of the country's High-Tech Strategy 2020 program to keep its manufacturing industry at the forefront. Even though they have different names, several other countries that are part of the I4.0 group have the same goal: increasing their industrial competitiveness in the face of a dynamic global market (Ramdani Murdiana, 2020). The primary influence focused on the industrial sector specifically manufacturing since it introduces technological advancements relating to smart factories (Pereira and Romero, 2017). It is based on the principles of Integration, decentralisation, service orientation, and interconnectedness that are central to I4.0, which focuses on the end-to-end digital transformation of physical assets and the integration into digital ecosystems within the broader value chain (Reinhard, Vedso and Schrauf, 2015; Horváth and Szabó, 2019). Due to the rapid emergence of digital technology in various fields, many industries are expected to benefit from I4.0. Schwab (2016) provides a well-rounded view encapsulating the heart of 4IR by describing it as, a “fusion of technologies that is blurring the lines between the physical, digital and biological spheres” (Schwab, 2016, p. 7). The below figure summarises the previous industrial revolutions transitioning into the 4th Industrial revolution.

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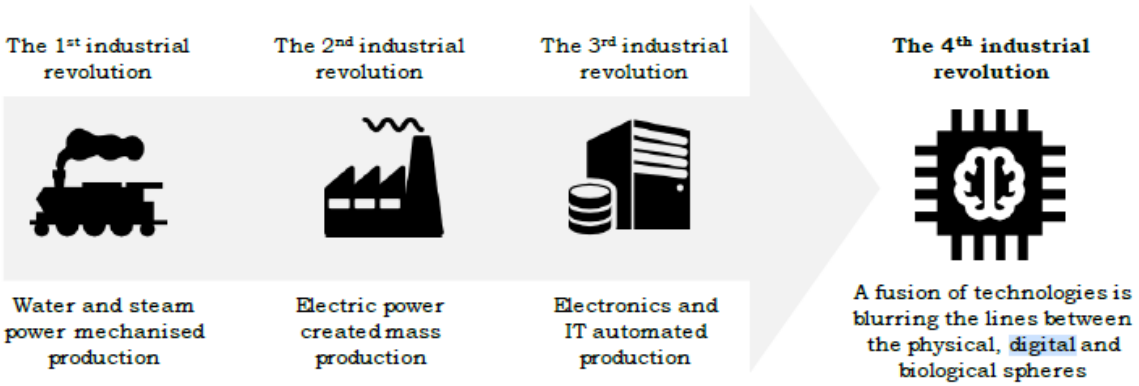


Figure 1. The Fourth Industrial Revolution, What it Means and How to Respond, Foreign Affairs (Source: Brits, 2017, p. 1)

## 2.2 Industry 4.0 and Financial Services

There is no consistent definition for I4.0 since the literature implicates various views that are debatable. Despite the importance of implementing I4.0 in various organisations, a standard definition of the term does not exist. Most definitions offer a flavour of manufacturing or technology perspectives (Piccarozzi, Aquilani and Gatti, 2018). These are often related to the technical aspects of the sector. Some of the research provide an SME's and management view with little to no definition in financial services. Therefore, this section considers various existing definitions and attempts to synthesize a definition that is consistent within financial services.

The definitions are split into the below categories:

*Table 1: Industry 4.0 Definitions per category*

| Category | Definition |
|---|---|
| **Manufacturing** | "Industry 4.0 represents nothing less than the fourth industrial revolution, comprising 3D printing, Big data, Internet of Things, and Internet of Services, all the ingredients needed to facilitate smart manufacturing and logistics processes" (Prause and Atari, 2017, p. 423)<br><br>"Industry 4.0, which is internationally also known as the Industrial Internet of Things, refers to the integration of Internet of Things technologies into industrial value creation enabling manufacturers to harness entirely digitized, connected, smart, and decentralized value chains" (Piccarozzi, Aquilani and Gatti, 2018, p. 13)<br><br>"Industry 4.0 is "An integrated, adapted, optimized, service-orientated, and interoperable manufacturing process which is correlated with algorithms, big data, and high technologies" (King and Grobbelaar, 2020, p. 4)<br><br>"The new technological developments that the Internet and support technologies form the backbone of integrating physical objects, human players, intelligent machines, |

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| | production lines, and processes across organisational boundaries." (Havle and Üçler, 2018, p. 2) |
| **Technical** | "the essence of Industry 4.0 conception is the introduction of network-linked intelligent systems, which realize self-regulating production: people, machines, equipment, and products will communicate to one another" (Kovács and Kot, 2016, p. 122)"<br><br>"The new technological developments that the Internet and support technologies form the backbone of integrating physical objects, human players, intelligent machines, production lines and processes across organisational boundaries" (Schumacher, Erol and Sihn, 2016, p. 162)<br><br>"Industry 4.0 is the fourth industrial revolution applying the principles of cyber-physical systems (CPS), internet and future-oriented technologies and smart systems with enhanced human-machine interaction paradigms" (Sanders, Elangeswaran and Wulfsberg, 2016, p. 816)<br><br>"Industry 4.0 goes with intelligent networks of Cyberphysical Systems and Human Resources communicating over the Internet of Things and the Internet of Services" (Longo, Nicoletti and Padovano, 2017, p. 1)<br><br>"Industry 4.0 is a term reputedly first used to describe a high-technology strategy proposed by the German government, and is now commonly used to refer to the development of cyber-physical systems and dynamic data processes that use massive amounts of data to drive smart machines" (Strange and Zucchella, 2017, p. 174) |
| **Competitiveness** | "Industry 4.0 is a necessary tool to maintain the competitiveness of organisations; they seem to suggest that Industry 4.0 is a must, just to maintain competitiveness" (Piccarozzi, Aquilani and Gatti, 2018, p. 12)<br><br>"Industry 4.0 an innovative tool to generate business competitiveness, pointing to its value as a critical success factor for the development and strength of organisations as a whole" (Piccarozzi, Aquilani and Gatti, 2018, p. 12).<br><br>"Industry 4.0 allows for safeguarding the competitiveness of organisations in the long term" (Piccarozzi, Aquilani and Gatti, 2018, p. 12) |
| **Value** | "Industry 4.0 will deliver greater flexibility and robustness and Industry 4.0-related value chains will be built of flexible and adaptable business structures, possess the permanent ability for internal evolutionary developments to cope with a changing business environment" (Prause, 2015, p. 161)<br><br>"A new value chain organisation and management throughout the product's life cycle" (Havle and Üçler, 2018, p. 2).<br><br>"A collective term for technologies and concepts of value chain organisation." (Hermann, Pentek and Otto, 2016, p. 11) |

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| | Industry 4.0 is the new buzzword. “It comprises the entire value chain process in manufacturing goods and providing services”<br>“4th industrial revolution is to connect all elements of the value chain process into one single system” (Kinzel, 2017, p. 81) |
| **Digitalisation** | “In this paper Industry 4.0 shall be defined as the embedding of smart products into digital and physical processes. Digital and physical processes interact with each other and cross geographical and organisational borders” (Schmidt *et al.*, 2015, p. 2)<br><br>“The term Industry 4.0 comprises a variety of technologies to enable the development of a digital and automated manufacturing environment as well as the digitisation of the value chain.” (Oesterreich and Teuteberg, 2016, p. 122)<br><br>“Industry 4.0 is the vision of smart components and machines which are integrated into a common digital network based on the well well-proven internet standards.” (Kolberg, Knobloch and Zühlke, 2017, p. 284)<br><br>" It is the fusion of these technologies and their interaction across the physical, digital and biological domains." (Schwab, 2016, p. 12)<br><br>“A simple definition is given by is advances in digitalisation and automation” (King and Grobbelaar, 2020, p. 4)<br><br>“Industry 4.0, focuses on the digitalisation of all physical assets and the massive integration of value chain participants“ (Mehdiabadi *et al.*, 2020, p. 4)<br><br>“The concept of Industry 4.0 is based on the creation of value through the close interaction of all economic agents through digitalisation. Each physical asset involved in the process of creating value is digitized and embedded into a single ecosystem of Industry 4.0” (Bilan *et al.*, 2019, p. 70)<br><br>"Industry 4.0 describes the growing digitisation and automation of the production environment, as well as the creation of digital value chains to enable communication between products, the environment, and business partners.” (Ślusarczyk and Ul Haque, 2019, p. 58)<br><br>“Industry 4.0 as an umbrella term used to describe a group of connected technological advances that provide a foundation for increased digitisation of the business” (Burritt and Christ, 2016, p. 27) |

The financial sector is a highly competitive and dynamic industry that has undergone significant transformation due to digitalisation (Mehdiabadi *et al.*, 2020; Molloy *et al.*, 2021). The concept of I4.0 is a strategic approach toward digital transformation that aims to maximise profitability in financial services. To achieve this, financial organisations require a comprehensive digital infrastructure and end-to-end transformation to create an organisational ecosystem that's based on strategic future thinking (Bilan *et al.*, 2019; Machkour and Abriane, 2020). This transition requires considering the concept of the digital

customer and aligned offerings through the value chain process, from production to consumption. The concept of the value chain can be described as a collection of activities that are involved in bringing a product or service to life. These include the various phases of production, such as the initial concept stage, the development of the product, and the delivery to consumers (Piccarozzi, Aquilani and Gatti, 2018). The essence of I4.0 can be summarised as the use of digital technology to satisfy unique needs through new products and processes and secondly permits mass customisation through process innovation. Banks in particular are constantly striving to stay ahead by seeking new ways to transform and ensure sustainable growth to outperform competitors ( Machkour and Abriane, 2020). Key themes identified in financial services include digitalisation, value creation, customer focus, innovation, and competitive advantage (Piccarozzi, Aquilani and Gatti, 2018). This is further supported by several authors, however, Mehdiabadi et al.(2020) present a customer perspective suggesting a redesign of the business model supported through the integration of systems, processes, and architectures. He emphasizes that the focus of I4.0 within financial services is argued to be customer-centric in that it provides personalised individual service, integrated and customised experience, and revolutionizes how the organisation interacts with its customers. Business models within I4.0 require a comprehensive rethinking of existing products and services supported by the open, flexible, and integrated architecture. Integration of systems will help facilitate the automation of banking processes resulting in the improvement of mobile applications (Mehdiabadi *et al.*, 2020). Digital transformation is central as there is an emphasis on the digitisation of organisation assets, digital transacting, and customizing offers to existing and new markets within financial services. Digital transacting improves the service experience, supports mobility increases transaction speeds, and efficiency for customers. As a result, there are higher levels of operational effectiveness, productivity, the development of innovative products and services, seamless and speedy transactions, and real-time information systems (Mehdiabadi *et al.*, 2020). In addition, Bilan et al (2019) support the notion of digitalisation by stressing the value creation process and integration. The objective of I4.0 in financial services is based on creating value through the use of Digitalisation. Physical assets used within processes to drive value are digitised and embedded in a single ecosystem. Through the interaction between physical and digital assets, value creation is achieved. I4.0 and digital transformation are used interchangeably across various industries, which includes the horizontal integration of various cost-creating chains and the creation of new business models (Bilan *et al.*, 2019). Finally, from an organisational implementation perspective, Dikhanbayeva et al (2021) state that I4.0 and digitalisation are synonymous. We, therefore, define I4.0 in this study as:

The integration of disruptive innovations, technologies, and people into the value creation processes of organisations, to enable and harness an entirely interconnected, intelligent, automated, digitised, and decentralised value chain that will drive flexible business structures, enhancing organisational agility in responding and adapting to dynamic business

environments and enabling the organisation to be competitive within industries (Piccarozzi, Menon and Shah, 2020).

## 2.3 Industry 4.0 Capabilities and Firm Performance

According to research, the technology component of I4.0 is a critical enabler for financial services organisations to achieve digital transformation. This study is not technology specific but rather looks into the various capabilities that are required to implement I4.0 within the industry. The study identifies the fundamental I4.0 pillars and provides a clear understanding of these as capabilities for implementing I4.0 in financial services.

A literature review was performed to determine the various enablers of I4.0. Results of the study were summarised using a systematic literature review (SLR) approach. The SLR is a rigorous and comprehensive process guiding the examination of a specific phenomenon to offer valuable insights. The ability to replicate the findings is also a key component of the SLR methodology. This study adapted the method used by Okoli and Schabram (2010) and adapted to the six steps prescribed. Below are the steps performed:

*Table 2. SLR Steps*

| Steps | Purpose | Details |
|---|---|---|
| 1. Purpose of the review | Identify and synthesize all the available evidence on a specific research question or topic. | What is the relationship between I4.0 complementary capabilities and Firm Performance outcomes? |
| 2. Determine data sources | Identifying electronic academic databases with top-ranked information systems journal papers and studies. | The below database sources were considered:<br>• Proquest<br>• Science Direct<br>• IEEE Explore<br>• Emerald<br>• Web of Science |
| 3. Searching for literature | The literature review process involves a comprehensive search that includes information on the databases searched and keywords used per database | a) Unit of analysis:<br><br>"Financial services" OR<br>"Financial Sector"<br>OR "Financial institution"<br>OR "Financial industry"<br>OR (Banking AND (organisation OR Organisation)<br><br>b) IT Artefact:<br>"Industry 4.0" OR "Fourth industrial revolution" OR "4IR" OR "4th industrial revolution" OR Digitalisation |

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| | | c) The phenomenon of Interest:(Capabilities OR Principles OR Enablers OR Performance OR "Competitive advantage" OR Benefits<br>Search used:<br><br>• ("Industry 4.0" OR "Fourth industrial revolution" OR "4IR" OR "4th industrial revolution" OR Digitalisation OR Digitalisation) AND ("Financial services" OR (Banking AND (organisation OR Organisation)) OR "Financial Sector" OR "Financial institution" OR "Financial industry" OR "banking 4.0") AND (Capabilities OR Principles OR Enablers OR Performance OR benefits OR "Competitive advantage" OR Resource-based view OR RBV)<br>• Excluded the below to get better results to search on some databases. (Capabilities OR Principles OR Enablers OR Performance OR benefits OR "Competitive advantage" OR Resource-based view OR RBV) |
| 4. Quality appraisal | Review articles diligently to ensure adequate quality and selection criteria. | Inclusion criteria:<br>• Organisational-level study<br>• Peer reviewed<br>• Research that is done by practitioners<br>• Conference and journal research papers<br>• Papers in English<br><br>Exclusion criteria:<br>• Studies on individual levels<br>• A paper which lacks I.40 research.<br>• Papers including technology-specific topics e.g., Blockchain |
| 5. Collection of data and synthesis | After completing the steps for identifying relevant studies, the research process involves extracting and analysing key information from these studies | • An initial search was performed with the phenomenon of interest being Capabilities OR Principles OR Enablers. Due to the lack of results, the search criterion was then broadened by removing the phenomenon of interest and the unit of analysis.<br>• The evaluation of the literature collected through the utilisation of the guidelines and practitioner papers provided a sufficient number of references to identify I4.0 capabilities. |
| 6. Writing the review | The SLR must be adequately documented to enable reproducibility | The below-detailed process was used in identifying the key papers across the databases to ensure replicability |

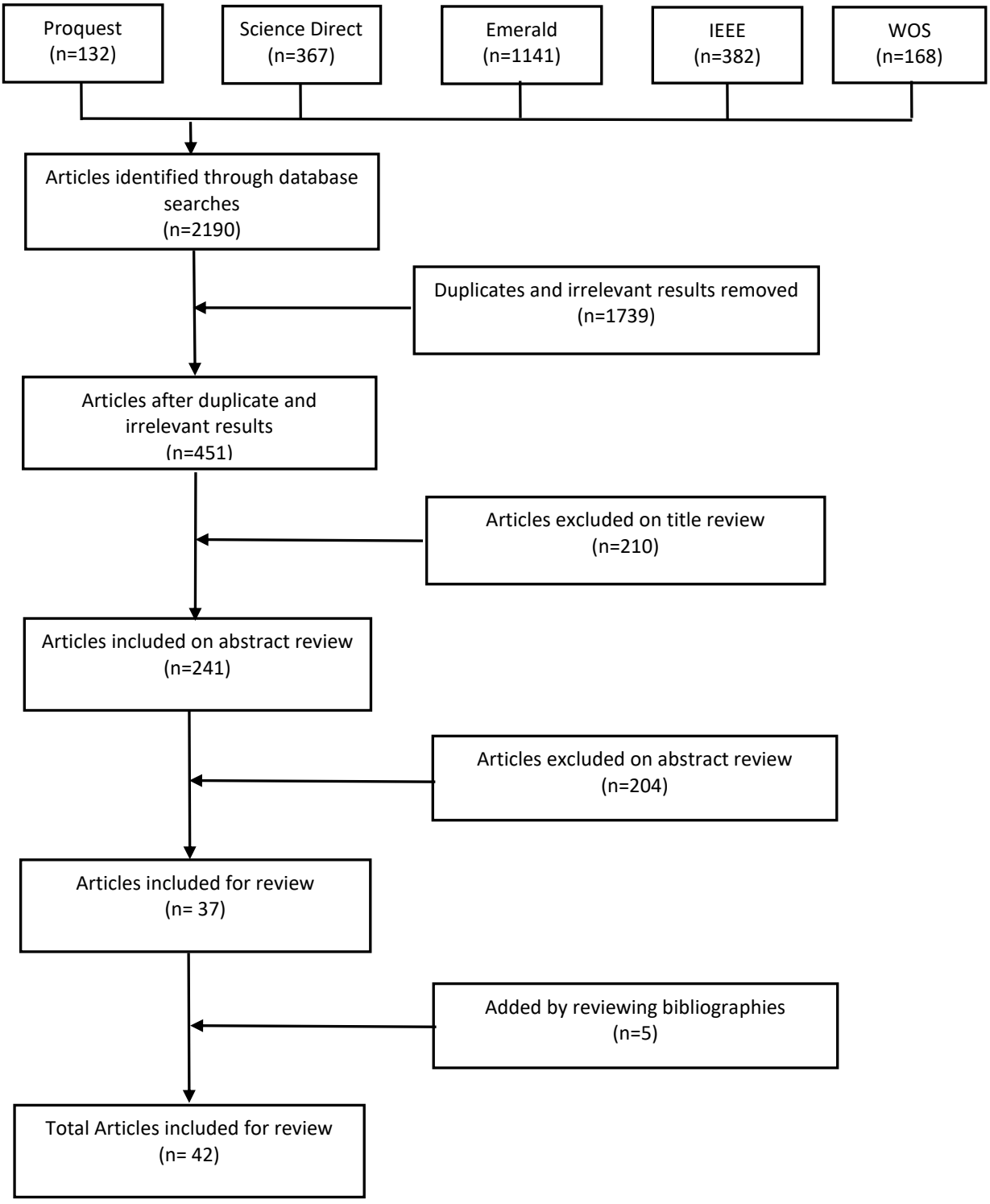


Figure 2. Systematic literature review results

*Table 3. Systematic literature review results*

| Title | Reference | Details | Key Themes |
|---|---|---|---|
| "Industry 4.0: A Survey on Technologies, Applications and Open Research Issues. Journal of Industrial Information Integration" | Lu (2017) | In this paper, a thorough examination of I4.0 is conducted, providing an extensive overview of its content, scope, and discoveries. The various aspects of I4.0 are classified into five research categories. The paper highlights the significance of interoperability as a crucial capability for I4.0 and proposes a conceptual framework for achieving interoperability within this field. | - Interoperability<br>- Integration |
| "The expected contribution of Industry 4.0 technologies for industrial performance" | Dalenogare et al. (2018) | The paper examines the correlation between the implementation of various I4.0 technologies and the potential advantages for product, operations, and side-effects aspects. It delves into the possible contributions that I4.0 technologies can make to performance within the industrial sector, particularly in developing economies. | - Digitalisation<br>- Performance |
| "Implementing Industry 4.0 principles" | Canas et al. (2021) | The article proposes an I4.0 design principles taxonomy, exploring advances, advantages, limitations, requirements, and methodologies in strategic I4.0 implementation. | - Human Factor<br>- Decentralisation<br>- I4.0 Frameworks |
| "Industry 4.0: Managing The Digital Transformation, Springer Series in Advanced Manufacturing" | Ustundag and Cevikcan (2018) | The paper emphasizes the link between design principles and technologies, presenting a conceptual framework for I4.0. This framework concentrates on smart product and process development to advance I4.0 principles. | - Integration<br>- Real-time |
| "Simulation in industry 4.0: A state-of-the-art review" | Ferreira, Armellini and De Santa-Eulalia (2020) | The study aims to explore the intersection of simulation and I4.0. It begins by proposing a conceptual framework that outlines I4.0's enabling technologies and design principles for modelling and simulating I4.0 scenarios. | - Firm performance<br>- Interoperability<br>- Modularity<br>- Virtualisation<br>- Service orientation<br>- Personalisation<br>- Integration<br>- Real-time capability |
| "A review of the meanings and the implications of the Industry 4.0 concept" | Pereira and Romero (2017) | The paper offers an all-inclusive definition of I4.0, featuring various perspectives on its visions and concepts. The enabling technologies that drive I4.0 are outlined and analyses their impact and influence on the industry. | - Customer value<br>- Integration<br>- Efficiency<br>- Competitiveness |
| "The Impact of the 4th industrial revolution on the South African financial services market" | Brits (2017) | The report explores the effects of digital disruption on South Africa's financial services sector. It examines the domestic fintech and digital adoption trends in core banking functions and investigates how traditional financial institutions are responding to the changes. | - Digitalisation<br>- Decentralisation,<br>- Service orientation<br>- Modularity |
| "Assessment of Industry 4.0 Maturity Models by Design Principles" | Dikhanbayeva et al. (2020) | The study examines the capabilities of organisations within the framework of I4.0 and emphasizes the need for a development strategy with specific steps. Design principles | - Design Principles<br>- Virtualisation<br>- Decentralisation<br>- Real-time capability |

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| | | are highlighted to help organisations to systematize their goals and develop effective steps for further growth. The findings of this study contribute to the understanding of the design principles that underpin the maturation frameworks for I4.0. | - Service orientation<br>- Modularity |
| "Improving Business Performance by Employing Virtualization Technology: A Case Study in the Financial Sector" | Lambropoulos, Mitropoulos, and Douligeris (2021) | The study explores the influence of virtualisation and other modern technologies on the transformation of legacy infrastructures within the financial industry. | - Virtualisation<br>- Real-time capability<br>- Performance |
| "Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives" | Kamble, Gunasekaran and Gawankar (2018) | The review aims to provide a comprehensive analysis of the current state of I4.0 and the various research approaches that are involved in its development. It also proposes a framework for sustainable growth underpinned by Technology, Integration, and sustainable outcomes. | - Virtualisation<br>- Decentralisation<br>- Real-time capability<br>- Service orientation<br>- Modularity |
| "Industry 4.0: key findings and analysis from the literature arena" | Rejikumar et al. (2019) | The study provides an overview of I4.0 attributes and its concept. It summarizes success and failure factors, business models, potential, and challenges in the context of I4.0. | - Digitalisation<br>- Virtualisation<br>- Decentralisation<br>- Real-time capability<br>- Service orientation<br>-Modularity |
| "Real-Time or near Real-Time? - towards a Real-Time assessment model" | Cundius and Alt (2013) | The paper argues that the real-time capability of business processes needs to provide additional value, beyond just up-to-date availability. It proposes a model for assessing and classifying the real-time level of business processes. | - Real-Time capability |
| "The future of manufacturing industry: a strategic roadmap toward Industry 4.0" | Ghobakhloo (2018) | The paper reviews the various features of I4.0 and its design principles. It identifies architecture and technology trends. A strategic roadmap for manufacturers is offered, based on the findings of the review. The study concludes that I4.0 is made up of 12 fundamental design principles and 14 significant technology trends. | - Digitalisation<br>- Virtualisation<br>- Decentralisation<br>- Real-time capability<br>- Service orientation<br>- Modularity |
| "Digital servitisation value co-creation framework for AI services: a research agenda for digital transformation in financial service ecosystems" | Manser Payne, Dahl and Peltier (2021) | The paper proposes a framework for understanding how AI services impact consumer engagement, value perceptions, and firm performance measures in the context of digital servitisation. | - Digital servitisation<br>- Customer value<br>- Digitalisation<br>- Firm Performance |
| "Industry 4.0 in Management Studies: A Systematic Literature Review" | Piccarozzi, Aquilani and Gatti (2018) | The paper explores how I4.0 is viewed within the supply chain management industry and also identifies potential areas for further study. It examines enablers and barriers and discusses I4.0 at different levels, with a particular focus on the firm level. | - Digitalisation<br>- Performance |
| "Driving forces and barriers of Industry | Horváth and Szabó (2019) | The paper investigates the perspectives of top executives on I4.0, including their | - Digitalisation<br>- Benefits |

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| 4.0: Do multinational and small and medium-sized companies have equal opportunities?" | | interpretations of the concept, the driving forces behind its adoption, and the main obstacles to its implementation. | - Value<br>- Innovation<br>- Customer value<br>- Competitive advantage |
| "Industry 4.0 – Where Does This Leave the Human Factor" | Kinzel (2017) | The paper investigates the human factor in the I4.0 concept. A modified mediation process is needed to incorporate the requirements and needs of individuals involved in the process, including workers and society. | - Human Resources |
| "Review of socio-technical considerations to ensure successful implementation of Industry 4.0" | Davies, Coole, and Smith (2017) | The paper emphasizes that I4.0 can create a competitive advantage by leveraging internal capabilities and not just cost and efficiency gains. It also highlights the importance of considering socio-technical requirements for successful implementation. | - Socio-technical<br>- Competitive Advantage |
| "Industry 4.0: A Solution towards Technology Challenges of Sustainable Business Performance" | Haseeb et al. (2019) | This study aims to explore the potential of I4.0 to improve the operational efficiency and productivity of SMEs in Thailand, and to investigate how I4.0 can contribute to sustainable business performance. | - Performance |
| "Transition towards an Industry 4.0 State of the LeanLab at Graz University of Technology" | Karre et al. (2017) | This paper discusses the development of a learning factory to prepare workers for the I4.0 environment. It includes training sessions and state-of-the-art technology to improve technology development and transfer. | - Human Resources |
| "A study to determine the effects of industry 4.0 technology components on organisational performance" | Calış Duman and Akdemir (2021) | This study aims to examine how I4.0 technologies impact business performance in Turkey. I4.0 provides advantages like efficiency, speed, and cost reduction. Adopting I4.0 is a major technological issue due to the benefits it offers. | - Firm performance<br>- Digitalisation |
| "Analyzing manufacturing strategies and Industry 4.0 supplier performance relationships from a resource-based perspective" | Salam (2019) | This paper aims to explore how manufacturing strategies affect the performance of I4.0 suppliers using the resource-based perspective in Thailand. As suppliers are vital in manufacturing supply chains, firms must identify and manage them effectively to improve their I4.0 supplier performance. | - Performance<br>- RBV<br>- Value creation |
| "Addressing the Impact of the Fourth Industrial Revolution on South African Manufacturing Small and Medium Enterprises (SMEs)" | Serumaga-Zake and Poll (2021) | This research aims to create an I4.0 framework that will aid South African manufacturing SMEs in tackling challenges arising from the implementation of I4.0. The framework explores various aspects of manufacturing and operations. It involves the interaction between people, machines, and components. | - Competitive Advantage;<br>- Performance<br>- Benefits |
| "Relationships between digital maturity, organisational agility, and Firm Performance: An | Büşra and Çallı (2021) | This study explores how digital maturity and organisational agility impact firm performance. Additionally, it explores the moderating effect of organisational agility on digital maturity's relationship with performance. | - Firm Performance<br>- Digitalisation |

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| empirical investigation on SMEs" | | | |
| "Digital technologies and Firm Performance: The role of digital organisational culture." | Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz (2020) | This paper proposes a research model showing that developing a digital culture enables business digitisation and value generation, leading to better organisational performance. | - Firm Performance<br>- Digitalisation |
| "Industry 4.0: a review and analysis of contingency and performance effects" | Szász et al. (2020) | This paper conducts empirical research to provide a more generalizable understanding of the impact of I4.0 implementation on performance. | - Firm Performance<br>- Digitalisation |
| "Servitisation and digitalisation in manufacturing: the influence on Firm Performance" | Martín-Peña, Sánchez-López and Díaz-Garrido (2019) | This paper proposes a framework that combines the concepts of servitisation and digitalisation in manufacturing. The relationship between the two is defined and measured, and their impact on firm performance is evaluated | - Firm Performance<br>- Digitalisation<br>- Servitisation |
| "A resource-based view of digital financial services (DFS): An exploratory study of Nigerian providers" | David-West, Iheanachor and Kelikume (2018) | This paper examines the supply-side dynamics of Mobile Money Services in Nigeria, including enablers, constraints, and resource capabilities for digital financial services. | - Digital financial service<br>- Competitive advantage.<br>- Resource-based view |
| "Banking Services that Influence the Bank Performance" | Chai, Tan, and Goh (2016) | The paper aims to examine the impact of service quality, innovation, technology, and employee commitment on bank performance. The goal is to identify the factors that influence bank performance. | - Performance<br>- Innovation |
| "Industry 4.0 and Competitiveness" | Bal and Erkan, (2019) | This study evaluates the effects of emerging innovations after I4.0 on countries' competitiveness. The positive and negative impacts are investigated and compared. | - Competitive advantage<br>- Innovation |
| "Pros and cons of implementing Industry 4.0 for the organisations: a review and synthesis of evidence" | Sony (2020) | This study identifies specific benefits and drawbacks of adopting I4.0 in organisations, as well as discusses future research directions. | - Competitive advantage<br>- Innovation<br>- Customer value<br>- Benefits |
| "Industry 4.0 in the product development process: benefits, difficulties and its impact in marketing strategies and operations" | Arromba et al. (2021) | The study aims to analyse the various advantages and challenges of implementing I4.0 in an organisation's product development process. | - Benefits<br>- Real-time capability<br>- Operational performance |
| "Challenges and Benefits of Industry 4.0: An overview" | Mohamed (2018) | The article provides an overview of I4.0, including its definition, current challenges, and the need for designing and implementing future business organisations. | - Industry 4.0 definitions<br>- Virtualisation<br>- Decentralisation<br>- Real-time capability<br>- Service Orientation |
| "Antecedents, consequences, and challenges of small and medium-sized | Eller et al. (2020) | The study examines how information technology, employee skills, and digital strategy affect digitalisation in SMEs and the subsequent impact on financial performance. | - RBV<br>- Digitalisation |

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| enterprise digitalisation” | | It also investigates whether digitalisation mediates the effect of resources on performance, using the resource-based view. | |
| “Business model innovation through Industry 4.0: A review” | Ibarra, Ganzarain, and Igartua (2018) | The article aimed to review the current literature on I4.0 from a business model perspective. | - Innovation |
| “Innovation Capability: From Technology Development to Transaction Capability” | Zawislak et al. (2012) | The paper proposes a framework for innovation capability comprising four key capabilities (technology development, operations, management, and transaction) that allow firms to achieve Schumpeterian profits through innovation. | - Innovation |
| “Industry 4.0– Technological Revolution and Sustainable Firm Performance” | M. N. Hassan Reza et al. (2021) | The study proposes a framework that integrates key enablers of I4.0 to assist organisations in achieving sustainable performance through the adoption of I4.0. | - Firm Performance |
| “The role of innovation in the relationship between digitalisation and economic and financial performance. A company-level research” | Fernández-Portillo et al. (2022) | This paper examines the impact of innovation on the correlation between digitalisation and the economic/financial performance of a company. | - Innovation<br>- Performance<br>- Digitalisation |
| “The Fourth Industrial Revolution (Industry 4.0): A Social Innovation Perspective” | Morrar et al. (2017) | A framework is proposed to enable the interaction between technological and social innovation for sustainable strategies that benefit the economy, society, and environment. | - Innovation |
| “Digitalisation in the financial industry: A contingency approach of entrepreneurial orientation and strategic vision on digitalisation” | Niemand et al. (2020) | The study explores the various advantages and challenges of using entrepreneurial orientation (EO) to improve the performance of banks in the digital age, as digital technologies challenge traditional business models. | - Digitalisation<br>- Performance |
| “Literature review on digitalisation capabilities: Co-citation analysis of antecedents, conceptualisation and consequences” | Annarelli et al. (2021) | The study explores digitalisation capabilities in various fields and identifies three main capabilities - digital integration, platform, and innovation - as micro-foundations for sustained competitiveness through co-citation analysis. | - Digitalisation<br>- Competitive advantage |
| “Enablers for Industry 4.0” | C. A. Havle and Ç. Üçler (2018) | This paper identifies the capabilities needed for I4.0 adoption, which is motivated by globalisation and technological advancements and requires an evolutionary transformation of advanced technologies and cyber-physical interactions in manufacturing organisations. | - I.40 framework<br>- Digitalisation<br>- Human Factor |

### 2.3.1 Industry 4.0 Capabilities

The section introduces the I4.0 capabilities and explains them in detail. Havle and Üçler (2018) provide a holistic view of the key enablers within I4.0. The study conceptualised a mind map for I4.0 enablers is organised into three primary dimensions: Human, Organisation, and Technology (refer to figure 3). To begin the journey towards I4.0, organisations must prioritize the human element of their system. The Human dimension has sub-issues that include innovation skills, effective communication skills, and continuous digital awareness. The technology dimension provides multiple concepts specific to modern technology however Digitalisation is central to financial services. Digitalisation involves the use of advanced technologies to digitise physical assets (Ghobakhloo, 2020). However, the extant literature identifies additional enablers that encompass I4.0. Kamble, Gunasekaran, and Gawankar (2018) proposed a sustainable I4.0 framework (refer to figure 4). The framework recognizes that I4.0 enables the seamless integration of various business processes and activities consisting of three main components. These are industry 4.0 technologies, process integration, and sustainable outcomes. Industry 4.0 technologies are geared towards digitisation and automation of processes. Process integration is supported by I4.0 technologies including the human element in creating intelligent products and processes which are essential to meeting the evolving demands of the market (Kamble, Gunasekaran and Gawankar, 2018). Furthermore, the framework proposes the adoption of key principles, which include Integration, Decentralisation, Virtualisation, Real-time capability, Modularity, and Service Orientation (Kamble, Gunasekaran and Gawankar, 2018; Mohamed, 2018). These principles underpin the success of I4.0 (Kamble *et al.*, 2020). Overall, a review of the enablers and the sustainable Industry 4.0 framework suggests key organisational capabilities to ensure I4.0 success. Organisational capabilities can be defined as diverse and intricate sets of assets, knowledge, and skills into cohesive bundles, which are essential for organisations to utilise their resources more effectively. By organising these bundles, organisations can better leverage their resources and achieve their goals more efficiently and effectively (Münch et al., 2022). Thus, the following are synthesised as I4.0 capabilities within financial services and are explained further in the literature review.

- Digitalisation
- Design Principles: Integration, Decentralisation, Virtualisation, Real-time capability, Modularity, and Service Orientation
- Human Resources

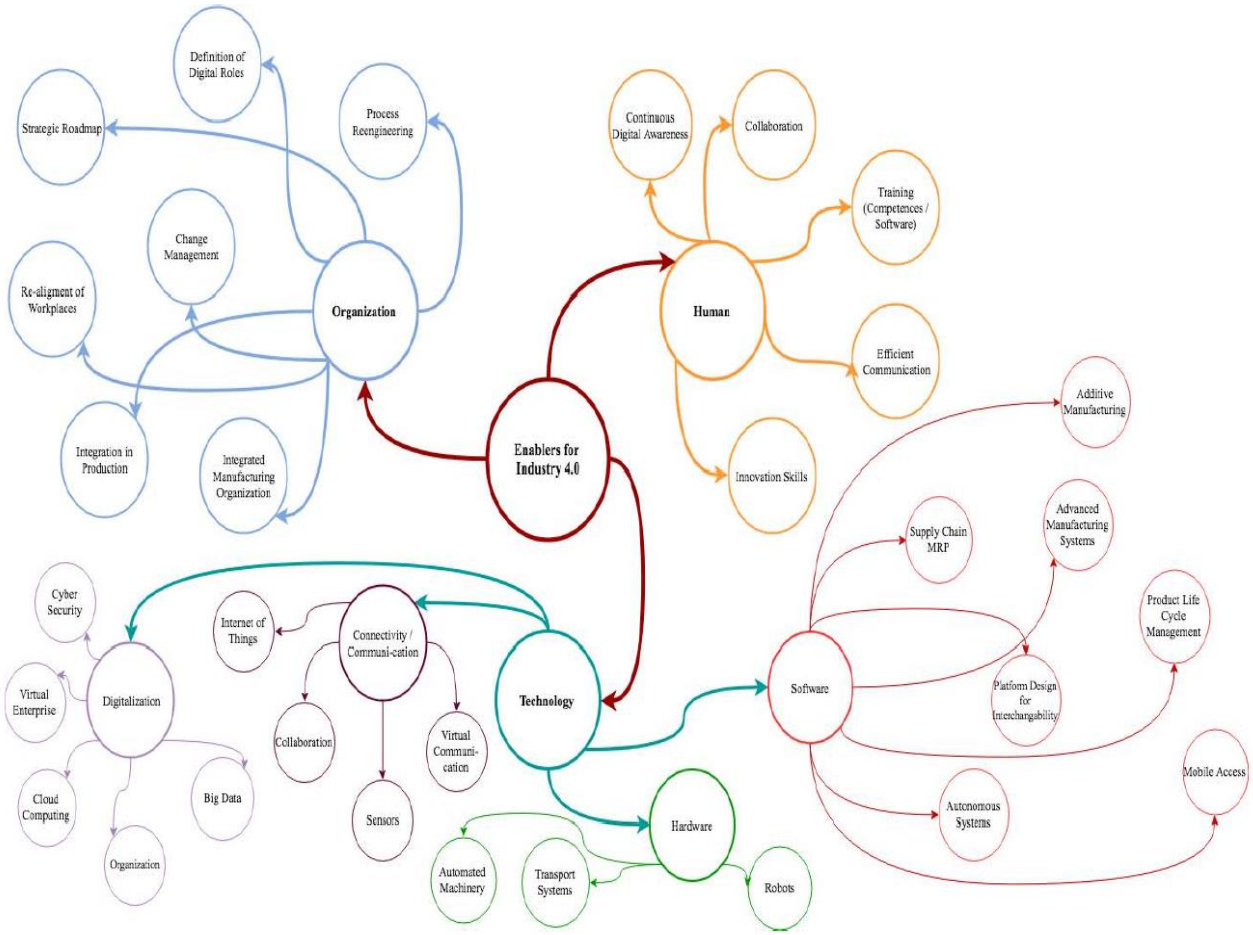


Figure 3. Mind map of enablers for Industry 4.0 Source: (C. A. Havle and Ç. Üçler 2018, p. 4)

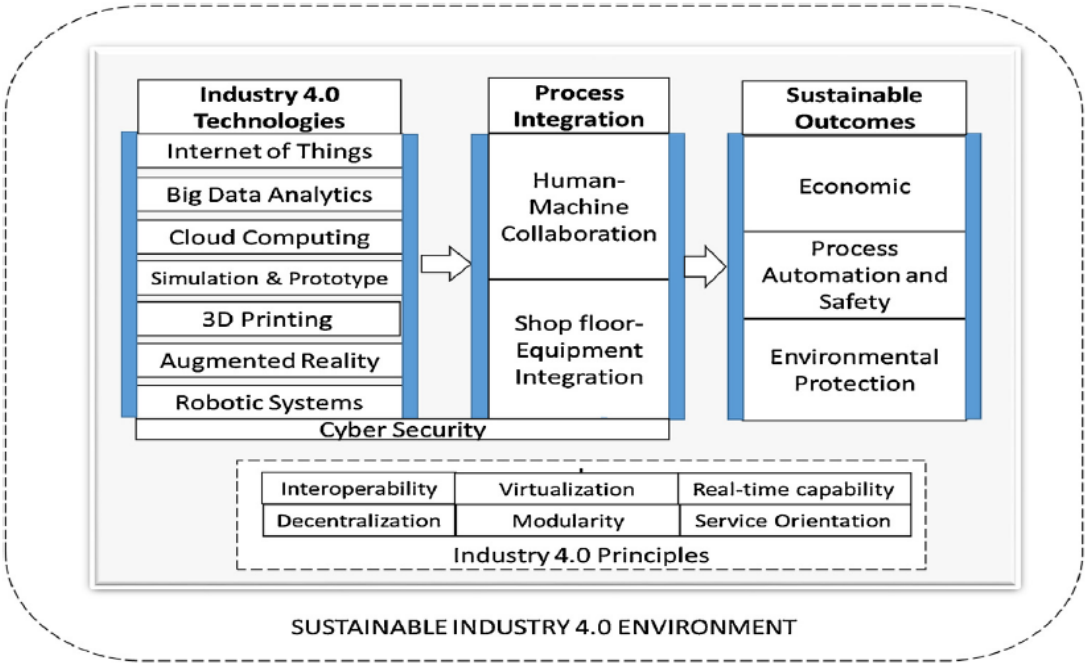


Figure 4. Sustainable Industry 4.0 Framework Source: (Kamble, Gunasekaran and Gawankar, 2018, p. 12)

### 2.3.2 Digitalisation

With the emergence and evolution of digital technologies, financial services organisations are swiftly transitioning toward digitalised value generation (Niemand *et al.*, 2020). Digitalisation, also known as digital business transformation, is a strategic approach to creating innovative business models by incorporating cutting-edge digital technologies into products, services, processes, and people to create significant value (Annarelli *et al.*, 2021; Antonucci, Fortune and Kirchmer, 2021). Annarelli et al. (2021) suggest that creating digital capabilities is an essential prerequisite for companies to achieve sustainable competitive advantage. They posit that to fully realize the advantages that come with a successful implementation of digital transformation, organisations need to take charge and develop key competencies across different levels of their organisational and operational structures. This means organisations must develop digitalisation capabilities that are formalised routines and establish structured and repeatable processes that support the integration of digital technologies, and foster the necessary skills and capabilities that enable efficient and effective use of these technologies throughout the organisation to maximize their benefits and thus stay ahead of the competition. According to the argument, companies that are able to effectively cultivate digital resources and capabilities will not only be able to handle the challenges of digital transformation, but also gain a competitive advantage from it. By investing in the development of digital skills and resources, organisations can position themselves to leverage the benefits of digital technologies to improve operational efficiency, enhance customer

experiences, and create new business models. This can result in increased market share, revenue growth, and long-term success in the digital landscape (Annarelli *et al.*, 2021).

In highly competitive industries such as financial services, companies in emerging markets are increasingly embracing digitalisation. To achieve this, they are leveraging a diverse range of advanced technologies set to shape the future of the financial sector. These include Modularised architectures, Banking APIs, Cloud Banking, Artificial Intelligence, Personal Finance, Retail Investments, Corporate Investments, P2P (peer-to-peer) lending, Mass Finance, Asset Management, Money Transfer, Data and Analysis, Financial Platforms, InsurTech, RegTech, Distributed ledgers or Blockchain and Cryptocurrency Technology, Robo Assistants and Next Generation Banking (Brits, 2017; Machkour and Abriane, 2020). In addition, more common in emerging markets are Digital Financial Services (DFS) (David-West, Iheanachor and Kelikume, 2018; Niemand *et al.*, 2020). These technologies are designed to provide consumers with essential financial services through digital channels. By utilizing DFS, companies can streamline operations, reduce costs, and improve access to financial services for their customers. Research suggests there is a positive relationship between DFS and growth. DFS encompass a wide range of technologies, from basic mobile phones to more advanced Information and Communications Technology (ICT) applications. These technologies take various forms, including structured electronic payment platforms and systems, electronic payments, and electronic banking products or services (David-West, Iheanachor and Kelikume, 2018).

The benefits of Digitalisation are abundant in the literature (Antonucci, Fortune and Kirchmer, 2021). The fundamental objective of digitalisation is to leverage technology to drive innovation, enhance performance, and gain a competitive edge in the marketplace (Annarelli et al., 2021). Antonucci et al. (2021) argue there are various aspects to successful digitalisation, such as new product development and the improvement of intra- and inter-organisational activities. It can also help them connect with their customers and develop effective communication and collaboration strategies. From an economic perspective, successful digitalisation initiatives have been found to have several additional benefits. These benefits include driving innovation, achieving financial gains, and reducing costs. Financial gains can be realised through streamlining processes and increasing efficiency, digitalisation can lead to cost savings and increased profitability. Lastly, the significance of digitalisation and Firm Performance is acknowledged through the integration of digital technologies within business processes.

### 2.3.3 Design Principles

Design Principles (DPs) are a critical component in establishing a sustainable I4.0 framework and are at the core of I4.0. They are essential for constructing I4.0 and are seen as a necessary precursor to the operationalisation of I4.0. By providing a foundation that must be comprehended before the implementation of I4.0, DPs are considered to be capabilities that add value to the I4.0 ecosystem (Dikhanbayeva *et al.*, 2020). Through the literature review, the study lists the most common design principles which are Integration, Virtualisation, Decentralisation, Real-time capability, Service orientation, and Modularity. They are further discussed:

Figure 5 presents the design principles and technologies that support the implementation. According to Ghobakhloo (2018), I4.0 design principles co-exist with the technologies within I4.0.

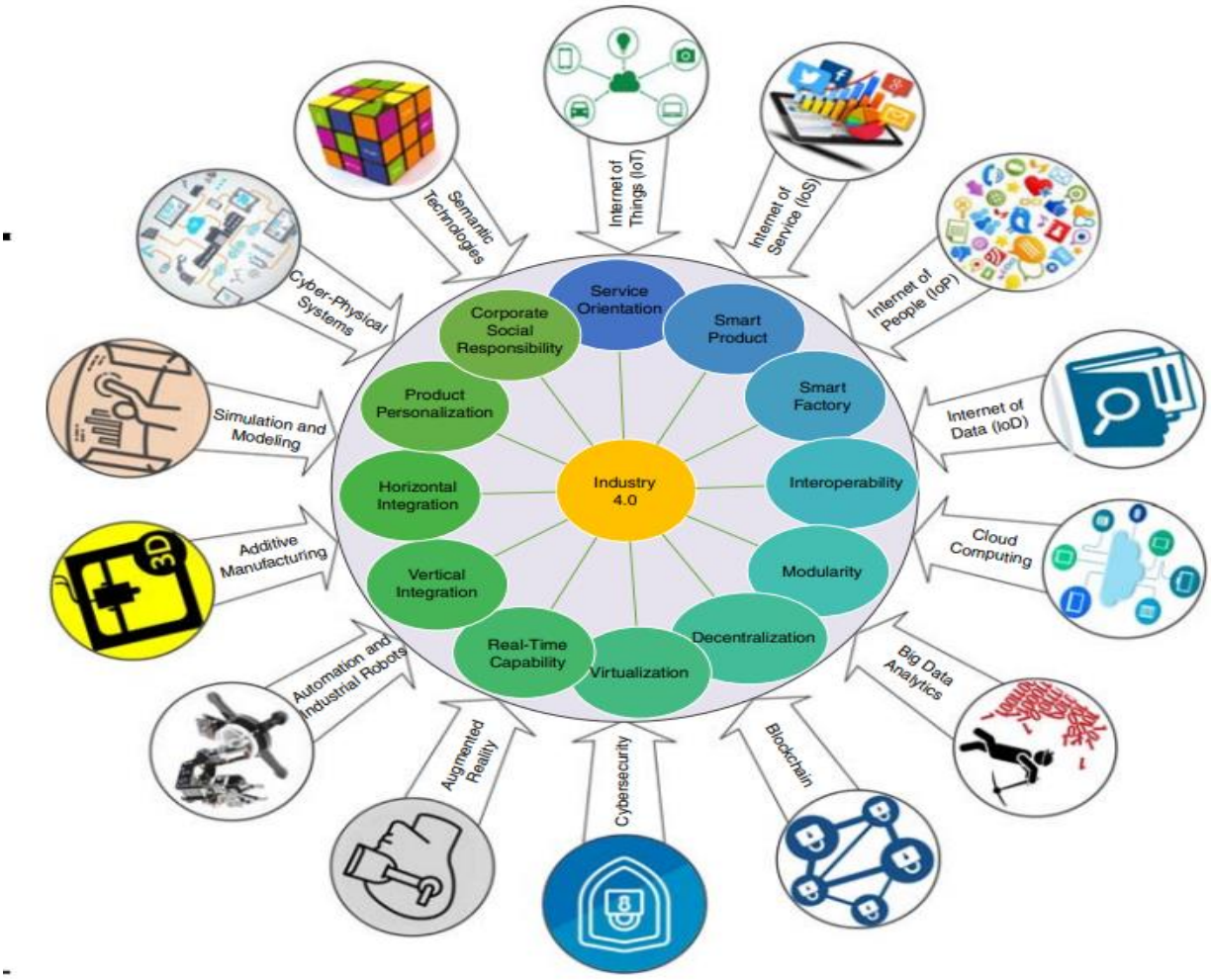


Figure 5. Design principles and technology trends of Industry 4.0 (Source: Ghobakhloo, 2018)

### 2.3.3.1 Integration

At the core of I4.0 lies the principle of integration, which is fundamental to ensuring the success of I4.0. Integration proposes structural and digital changes internal and external to an organisation to establish an interconnected value chain (Pereira and Romero, 2017; Dalenogare *et al.*, 2018). It incorporates the management of physical objects, the establishment of networks between information systems, and expansion across the entire product or service lifecycle. This concept involves the digital integration of various systems engineering disciplines across the entire value chain. It is typically done in the form of end-to-end engineering integration (Ferreira, Armellini and De Santa-Eulalia, 2020). Successful integration is dependent on interoperable platforms enabled through I4.0 technologies. Interoperability involves the ability of people, objects, and devices to seamlessly share information necessary to ensure that such integration happens at various levels (Ferreira, Armellini and De Santa-Eulalia, 2020). The various levels of integration identified are Horizontal and vertical integration. Horizontal integration is a process that enables inter-organisations to integrate various systems, processes, and people within and across organisations. This method of inter-company collaboration enables the sharing of resources and capabilities and communication in real-time across various divisions and organisations (Ferreira, Armellini and De Santa-Eulalia, 2020). Vertical integration encompasses technologies and processes combining intelligent cross-linking and digitalisation of the business areas within the organisation's structure.

Extant literature presents evidence suggesting that integrating digital technologies can result in various advantages for organisations. According to Ustundag and Cevikcan (2018), the implementation of horizontal and vertical integration allows for real-time data sharing to better adapt to changes in the market, combine resources, segregate risks across organisations, optimised planning, and increase collaboration between different stakeholders to improve operational efficiency. Integration also extends to the customer directly allowing co-design with consumers and delivering a customised product or service with a high perceived value. Organisations can gain a competitive advantage by creating a more robust, more complete interconnected environment (Y Lu, 2017; Dalenogare *et al.*, 2018; Canas *et al.*, 2021).

### 2.3.3.2 Virtualisation

Virtualisation is a technological process that transforms physical world data into a virtual form. Physical-world data can be transformed into a virtual form by taking advantage of the capabilities of a system to create a virtual environment. The main objective of a virtualised system is to improve its utilisation and performance by implementing integrated operating systems and the pooling of autonomous resources (Lambropoulos, Mitropoulos and Douligeris, 2021). Through the use of virtual data, decision-makers can improve their

understanding of the systems and perform simulations to identify potential issues. Various innovations, such as sensors, virtual reality, and augmented reality, can help enhance the digital data collected by financial organisations. These innovations will lower the cost of managing the data and enable them to avoid third-party applications (Dikhanbayeva et al., 2020). Organisations see Virtualisation as a key component of their strategy for developing their IT infrastructure, as it can allow them to consolidate their various under-used systems on one physical server. In addition, virtual machine migration between different hosts can help them save energy and resources. According to the Virtualisation in Banking Survey 2008, banks in the US and the UK have started using various Virtualisation solutions to reduce their costs and improve their operations. They also noted that these solutions have helped them improve their business continuity and reduce their IT infrastructure. As an example, Cloud computing in banking is widespread leveraging virtual technologies to migrate and run operations remotely using real-time data and virtual machines. Due to the increasing business demands for better security, flexibility, and cost-effectiveness, Virtualisation has gained widespread adoption (Lambropoulos, Mitropoulos and Douligeris, 2021).

#### 2.3.3.3 Decentralisation

Decentralisation enables the various components of an organisation to work autonomously while remaining aligned with the organisation's ultimate goal (Ferreira, Armellini and De Santa-Eulalia, 2020). This concept refers to the ability of people and machines that allow systems to autonomously make decisions without relying on a centralised decision-making body and is achieved through the use of various technologies. The principle allows for attaining quick decision-making and provides a high degree of flexibility. As an example, Distributed Ledger Technology (DLT) is a type of decentralised record-keeping system. It enables people to transact without intermediaries and governing bodies hence reducing costs by eliminating these central institutes. Bitcoin is a commonly known form of DLT (Brits, 2017). Decentralisation also helps to facilitate high volumes of customised products or services. This process allows users to manage their product requirements (Kamble, Gunasekaran and Gawankar, 2018; Dikhanbayeva *et al.*, 2020). Decentralisation simplifies planning and the synchronization of different processes and can also help in improved efficiency within organisations, agility, and profitability (Ghobakhloo, 2018). Decentralisation supports many benefits for the organisation, including supporting the growing need for customised products and services (Kamble et al., 2018) as opposed to traditional centralised systems which limit customisation. According to Lu (2017), decentralisation and autonomy are fundamental in contributing to overall performance.

#### 2.3.3.4 Real-time capability

Different perspectives can be considered when it comes to the concept of real-time. In the field of information systems, real-time refers to the process of dialogue or real-time processing, which allows users to receive immediate feedback on their enquiries without significant delays. Real-time capability is the combination of interactive processing, full networking, and integration of the functional areas utilising real-time data enabling automation of tasks and improving the efficiency of its operations (Cundius and Alt, 2013).
These capabilities can be divided into three categories: real-time monitoring, real-time data processing, and real-time decision-making (Ferreira, Armellini and De Santa-Eulalia, 2020). Big data technologies are prominent in banking to collect and analyse the huge amounts of data generated by different sources like devices, and customers. Real-time capability can help optimize decisions regarding current or future operations through the analysis and monitoring of massive amounts of data. As an example, Big data technologies such as Hadoop and cloud computing have real-time functionality to help financial organisations gain insights into their supply chains, competitors, and customers to improve their operations. I4.0 focuses on continuous improvement and real-time monitoring (Rejikumar *et al.*, 2019; Dikhanbayeva *et al.*, 2020). Real-time capabilities within organisations impact organisation profitability since the data analysed from the various sources has a significant impact on the way decisions are made; utilising resources efficiently, and increasing productivity and efficiency, therefore, is fundamental in contributing to Firm Performance (Kamble, Gunasekaran, and Gawankar, 2018).

#### 2.3.3.5 Service Orientation

In 1988, the term Servitisation was established by David Vandermerwe and Robert Rada. Servitisation involves transitioning from providing traditional products to offering comprehensive customer-oriented bundles that incorporate goods, services, support, and knowledge (Münch et al., 2022). It's a shift from product-centric to service-centric business models focusing on value co-creation, thus Service Orientation refers to the combination of people, processes, business models, and intelligent systems to design and create a product-service system to deliver precisely what a customer wants (Dikhanbayeva *et al.*, 2020; Münch *et al.*, 2022b). The concept of integration is the core of service orientation, which helps companies create a product-service system by bringing together the various components of a supply chain. It allows organisations to create a more effective and profitable product-service framework with new opportunities to increase their efficiency and revenue (Dikhanbayeva et al., 2020). Münch et al (2022) use the term digital servitisation within I4.0 which focuses on smart product-centric systems where smart digital technology is integrated with servitisation to ultimately provide a competitive advantage. I4.0 has brought about the expansion of digital technologies that transform the way value chains are operated. It fosters novel business models, encouraging interactive creativity and the emergence of innovative

products and services, flexibility to respond to changes more quickly, offering accessible personalised products or services at consumer convenience (Brits, 2017; Dikhanbayeva et al., 2020; Münch et al., 2022). Digital Servitisation has been a major factor in the evolution of the financial industry. For example, the rise of mobile banking led to the transformation of customer relationships from being primarily transacted in physical locations to being transacted digitally. Artificial intelligence (AI) is becoming prominent in banking specifically in customer data that is collected and processed. The various forms of AI include textual or auditory chatbots, which are commonly used in online transactions. Other digital services include financial advice and fraud detection (Manser Payne, Dahl and Peltier, 2021).

#### 2.3.3.6 Modularity

Modularity is a capability of I4.0 that allows organisations to adapt to changes in the way they operate (Dikhanbayeva *et al.*, 2020). The concept of modularity refers to the process of decomposing a product or system into re-combinable modules that are created from multiple components that can be adapted to meet different requirements and needs (Kamble, Gunasekaran and Gawankar, 2018; Ferreira, Armellini and De Santa-Eulalia, 2020). Brits (2017) provides a financial service perspective on modularity mentioning modularised architecture as necessary to adapt to the latest technologies. Ideally, modularity should be applied to an organisation's business layer to allow for processes to adjust to changes. There should be a standard interface to allow easy integration of data between different business lines including third parties. Furthermore, the ability to adapt and integrate customer changes is a competitive advantage that enables banks to keep up with the rapid pace of technological developments. Modularity also supports product customisation through the combination of modules and predefined features. Product personalisation is a more customer-oriented concept that refers to the customisation of a product line according to the needs and expectations of the consumers (Ghobakhloo, 2018). The advantages of Modularity are numerous. Organisations can create a variety of configurations and improve the efficiency of their operations by reducing lead time and increasing flexibility (Ferreira, Armellini and De Santa-Eulalia, 2020). This allows them to respond efficiently to changes in the market and keep their operations running smoothly. It can also increase the sustainability of their processes, reducing the complexity of the value chain, and increasing and reducing the environmental impact. It is also beneficial for the developers as it simplifies the customisation process (Dikhanbayeva *et al.*, 2020).

An illustrative example of the transformation of banking architecture enabled through modular design is provided in figure 6 below. This feature allows for the introduction, removal, and upgrades of modules (processes, products, or services) without jeopardising the integrity of the system. This capability allows financial service companies to offer a wider variety of products and services to their customers. For example, German bank Fidor offers crowd-funded and investment products from third parties through a modularised architecture.

While the majority of South African banks' legacy systems were not designed to support a modular architecture, the increasing collaboration between banks and fintech has shifted the focus away from traditional banks, which used to be the sole distributor of banking services (Brits, 2017).

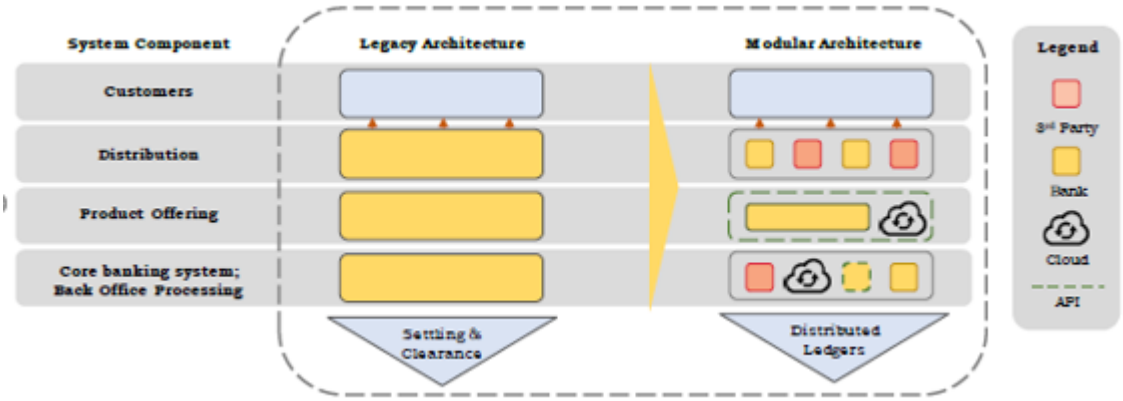


Figure 6.The Transformation of Traditional Banking (Source: Brits,2017)

### 2.3.4 Human Resource Skills

The human dimension within I4.0 is commonly regarded as the 'soft' side of organisations. It is an integral component that contributes to implementing I4.0 and to Firm Performance (Piccarozzi, Aquilani and Gatti, 2018). Human resources address the skills, competencies, and leadership that an organisation's personnel should possess to implement and operate within the new technological field (Piccarozzi, Aquilani and Gatti, 2018; Horváth and Szabó, 2019). According to Kinzel (2017), the term Socio-technical component was coined to define the integration of 'human' into a technical system within I4.0. Davies et al. (2017) provide a more detailed view describing a socio-technical system as the ecosystem that comprises the complex interaction between the machines and humans of organisational systems. The socio-technical systems approach emphasizes the need for a holistic understanding of the system and the interactions between its technical and social components. Having this knowledge can also help organisations develop effective and more efficient systems that meet the needs of their various stakeholders. In considering the technical and social interactions, there is a broad consensus within the literature, indicating the practical contributions of the socio-technical component in organisations that seek to promote change (Davies, Coole and Smith, 2017). As with the previous industrial revolutions which ushered in new disciplines in ways of work, I4.0 is still evolving through current knowledge. Hence, to draw a view of the impact of I4.0 on people interactions, ways of work, (Davies, Coole and Smith, 2017), and the level of skills and competencies, is still under review. However, Davies et al. (2017) suggest that executive levels will have to be directly involved in organisation operations to acquire the knowledge levels required to optimize the contributions of I4.0. Furthermore, mutual

engagement is necessary between leadership teams and operational levels to enhance sharing of knowledge in optimizing management decisions and driving organisation capabilities (Davies, Coole and Smith, 2017). There is an indication of traditional roles transitioning from technical experts such as computer engineers, data analysts, and scientists as well as management and knowledge workers into a merged role known as a 'knowledge worker'. This will encompass the essential elements of each discipline that will be multi-faceted and contribute to successful I4.0 implementation (Davies, Coole and Smith, 2017). Karre et al. (2017) classify the required skills and qualifications into must-have, should have, and could have, which constitute technical and personal skills. They propose that Information analytics, statistical knowledge, IT knowledge and abilities, adaptability, and social and teamwork skills are among the must-haves that foster the successful implementation of I4.0 (Karre *et al.*, 2017). Lastly, according to the Resource-based view of an organisation, IT resources are regarded as a source of competitive capability for the organisation (Haseeb *et al.*, 2019). Highly skilled and motivated individuals can also contribute to a financial services organisation's sustainable development thus they are considered to be among the industry's most crucial strategic resources.

The SLR also highlighted several benefits associated with the performance outcomes of I4.0. These are discussed in the next section.

## 2.4 Benefits of Industry 4.0

### 2.4.1 Competitive Advantage

Due to the competitive environment, companies are constantly looking for ways to improve their operational and financial performance. In general, competitiveness can be defined as the ability of an organisation to provide a premium service, and superior quality products that exhibit characteristics or functions that differentiate in comparison to their competitors (Bal and Erkan, 2019). To achieve a competitive advantage, organisations should assess the technology competency, costs, and product or service differentiation by adopting an innovation-based approach (Bal and Erkan, 2019). From the perspective of I4.0, the most compelling benefit in the literature is the achievement of competitive advantage. Piccarozzi et al. (2018), suggest that some literature defines I4.0 solely as a competitiveness concept. They go on to define I4.0 as a "necessary tool to maintain the competitiveness of organisations, suggesting that I4.0 is a must, just to maintain competitiveness"(Piccarozzi, Aquilani and Gatti, 2018, p. 12). Pereira and Romero (2017) suggests that I4.0 is an innovative tool generating a competitive advantage and ultimately is a critical success factor for organisation development and sustainability. Horváth and Szabó (2019) support this notion by mentioning the increase in innovation capacity and production through the adoption of new technologies can improve comparative advantage and provide organisations with a

decisive competitive edge over competitors. I4.0 is replacing the conventional approach to products and services with smarter ones that feature more advanced and interconnected technologies. This transformation will enable organisations to differentiate their products, segment customers, set dynamic prices, provide value-added services, and develop closer customer relationships, which can give them a competitive edge (Sony, 2020). As a result, rivalry amongst organisations will be based on product differentiation and value-added services creating various competitive advantages for them. The competitive landscape between organisations will expand from traditional pricing to include value-added customised products and result in innovative product and service development that meet consumer needs at an affordable price. The author also suggests by combining technology and I4.0 integration principles and creating a product-service-centric business model, organisations will create an opportunity to penetrate new and existing markets and ultimately gain a competitive advantage. In another study, the product development process (PDP) is proposed within I4.0 and is crucial to attaining a competitive advantage. The author posits successful organisations depend on their ability to collect and use knowledge effectively to develop and sell products and services that are of high value to consumers. Hence the business processes that develop the product or service are regarded as a critical factor to ensure competitive advantage. Through the product development process, organisations can develop innovative capabilities and increase their revenues by developing and launching new products and services faster and minimizing risk. Competitive advantage is common measure of Firm Performance (Arromba *et al.*, 2021).

### 2.4.2 Improved Operations

One of the key aspects of I4.0 is its emphasis on process optimisation, which refers to the continuous improvement of production processes or value chains to achieve maximum efficiency and productivity. In I4.0, process optimisation is considered to be a crucial step even before the realisation of value creation in practice. This means that organisations need to prioritize the optimisation of their processes early on in the value chain. (Sony, 2020). I4.0 is focused on achieving several goals, including a higher level of operational efficiency and effectiveness, increased productivity, and automation (Y Lu, 2017; Mohamed, 2018; Piccarozzi, Aquilani and Gatti, 2018). Efficiency is defined as the maximum amount of output achieved through optimal resource configuration. From a resource-based perspective, organisations must develop dynamic capabilities to effectively manage both internal and external resources to achieve efficiency (Sony, 2020). Several factors contribute to the development of reconfigurable and adaptable systems that can enhance productivity, increase quality, and reduce costs for organisations. These factors include the digitalisation of business processes, the decentralisation of decision-making, modular design, and end-to-end integration. The digitalisation of business processes adopting advanced technologies such as Artificial Intelligence (AI), Virtualisation, and the Internet of Things (IoT) to automate processes, reduce errors, and improve efficiency. Decentralisation of decision-making allows

for more agile and flexible decision-making, empowering employees to make decisions at the operational level and ensuring autonomy. Modular design enables organisations to create flexible systems that can be easily reconfigured to meet changing demands. Finally, end-to-end integration enables organisations to seamlessly integrate their existing structures with I4.0 technologies and streamline processes, resulting in increased collaboration of stakeholders, flexible production, increased reliability, reduced lead times, improved handling of volatility, and reduced costs and waste. (Mohamed, 2018; Eller *et al.*, 2020; Sony, 2020). As a result, organisations can achieve greater efficiency by effectively utilizing resources in the value chain of their products. Effectiveness is a measure of the degree to which an organisation can achieve its goals. These goals can be related to various factors such as overall success, market share, innovativeness, profitability, or growth rate (Sony, 2020). The degree of vertical and horizontal integration that an organisation has to implement will allow it to achieve its goals more effectively since it implies a high level of automation therefore high quality, effective pricing, and highly customised products or services. The competitive advantage that an organisation can gain through the use of vertical and horizontal integration could lead to a huge boost in profitability (Mohamed, 2018; Sony, 2020).

### 2.4.3 Digital Servitisation

Servitisation as highlighted under design principles is a strategic shift in which a business moves away from solely offering products and instead adopts a service-focused approach as the primary driver of growth in meeting consumer demand. Thus Digital servitisation (DS) refers to the process of using digital tools to transform a company's business model and logic from one that is product-centric to one that is service-centric for developing new value-creating revenue streams (Manser Payne, Dahl and Peltier, 2021). DS is quite distinguished in financial services exhibiting several benefits. Customer value is central to this concept focusing on value co-creation thus organisations can offer customised solutions that meet customers' unique needs and preferences, leading to higher levels of customer satisfaction and loyalty (Manser Payne, Dahl and Peltier, 2021). The concept of exchange and experience is not limited to interactions between humans alone, but can also involve interactions between consumers. Such examples are automated self-service technologies, AI-enabled actors, such as mobile banking apps, virtual assistants, and chatbots can detect and anticipate the needs of consumers, thereby potentially improving their ability to participate in the process of value co-creation. Manser Payne et al (2021) further suggest DS and value co-creation maintain that consumers play an essential role in the creation of value that they derive from service. In addition, service providers can shape consumers' perceptions of value through the incorporation of personalisation and relational factors however it is ultimately the consumers who define and realize the value cocreation process of financial advice and fraud detection. Through the use of digital innovations, service providers can increase value co-creation with consumers, leading to benefits such as increased satisfaction, loyalty, and

lower service delivery costs for the organisation (Manser Payne, Dahl and Peltier, 2021), generating high-quality products and services (Mohamed, 2018) and increasing revenue and profitability (Dikhanbayeva *et al.*, 2021). (Sony, 2020) argues the customer experience is enhanced. The concept of the customer experience is often defined as the result of a set of interactions that a customer has with a product, organisation, or parts of an organisation (Sony, 2020). With the advent of I4.0, organisations can create capabilities to collect and distribute new information to their customers creating a unique and memorable customer service experience. A study by Martín-Peña et al., 2019) also supports the argument suggesting servitisation compliments customer satisfaction since servitisation offers customers complete product-service systems underpinning the use of integrated solutions to add value to products or services.

### 2.4.4 Innovation Capability

According to Ibarra et al., (2018), I4.0 is anticipated to be the most influential catalyst for innovation in the coming decades, leading to the next wave of innovation. The essential attributes of I4.0, including real-time capability, and the integration of production systems, are seen as a solution to the challenges organisations must confront to remain competitive. Innovation within organisations can be understood as the creation of a new or improved product or service that is value-creating for the business or customers. Innovation capability refers to a company's capacity to assimilate, adjust and convert a particular technology into distinct operational, managerial, and transactional procedures that can generate Schumpeterian profits, i.e., innovation. By doing so, a company can ensure its survival and longevity (Zawislak *et al.*, 2012). Organisations that cultivate stronger innovation capabilities can enhance their innovation potential, resulting in the ability to generate valuable business outcomes through innovation (Zawislak *et al.*, 2012). Cali's Duman and Akdemir (2021) suggest that I4.0 technologies can be used to enhance innovation and competitive advantage. An organisation's continuous improvement can help organisations offer differentiated products and services. In addition, it helps organisations to keep up with the changes in the markets. It can help them gain a competitive advantage and improve their performance. A study conducted in Vietnam revealed that organisations with high levels of organisational innovation are more likely to improve their Firm Performance (Hassan Reza *et al.*, 2021). Another study by Fernández-Portillo et al (2022) states the production of innovation that emerges from Information Communication Technology (ICT) developments can affect a company's overall organisational performance .This implies that I4.0 has the potential to increase innovation capabilities which are supported by Morrar et al. (2017) who argue new innovative technologies and platforms when combined, can create a symbiosis that can alter market competition and product differentiation.

### 2.4.5 Industry 4.0 and Firm Performance

Firm performance is a measure of the level of success that a business has achieved in meeting its goals at the end of a given period. It is a reflection of how well the business has performed and the degree of success it has achieved (Calış Duman and Akdemir, 2021). The measurement and demonstration of organisational performance are critical aspects for businesses to consider. This is because the importance of measuring performance stems from the fact that what cannot be measured cannot be managed. Measuring organisational performance is also essential for assessing the efficiency and effectiveness of a business's activities since reliable performance can provide adequate insights into organisational strengths and weaknesses and identify areas of remediation (Calış Duman and Akdemir, 2021). Performance is often viewed as a subjective concept that is focused on various factors such as financial aspects and experiences (Serumaga-Zake and Poll, 2021). Naturally, the wide variety of factors that influence it can pose a challenge to establishing a single unified view of a firm's performance. The criteria to measure Firm Performance varies across the literature. Calış Duman and Akdemir (2021) and Serumaga-Zake and Poll (2021), suggest competitive advantage is a major component in measuring the success of Firm Performance whilst some researchers measure Firm Performance using financial criteria. From a financial criterion perspective, some of the measures include its profit margin, return on assets (ROI), equities return (ROE), growth in sales, and increased market share. Whereas some researchers use non-financial criteria such as level of innovation, creation of a new product or service efficiency, quality, process enhancement, production or service levels, customer satisfaction index; and even employee morale. The available research on the relationship between I4.0 and Firm Performance in the financial services sector is limited. Although some studies have investigated the link between Firm Performance and competitive advantage in financial services, most of the literature is related to I4.0 technologies, the manufacturing sector, small and medium-sized enterprises (SMEs), and Lean management. These studies are discussed further.

Salam (2019) uses the resource-based view (RBV) as the theoretical lens to assess I4.0 and Firm Performance from a supplier perspective. He suggests that I4.0 technologies have contributed to greater horizontal, vertical, and end-to-end digital integration of the entire supply chain optimizing production processes increasing efficiency, data management, and improving customer relationships, and competitiveness. Furthermore, to improve organisational performance, the organisation should align its strategy and operations with I4.0 capabilities. The underlying criteria within the study determined performance in terms of flexibility performance, flexibility in response to changing market conditions; delivery performance which looked at the response time of delivery of products and services, quality performance assessing improved product and process quality through technology integration and lastly cost performance which is assessed I4.0 technologies to reduce cost and increase customisation. The findings of the research demonstrated positive relationships between

flexibility, quality, and I4.0 supplier performance. Cost and delivery performance had no significant effect on I4.0 supplier performance (Salam, 2019). A similar study conducted by Szász et al. (2020) in manufacturing stated that the use of digital technology has a positive impact on various firm performance measures including flexibility, cost, delivery, quality, and performance. From a managerial perspective, the study revealed that I4.0 represents a tool that can help manufacturing companies cut costs and improve their quality and competitive advantage. Similar conclusions were reached across both studies on Firm Performance (Szász *et al.*, 2020).

Martínez-Caro et al., (2020) conducted a study on digital technologies and organisational performance. The study considers digital organisational culture as a key antecedent of organisational performance. A research model proposed that developing a digital culture can expedite business digitisation and value from digital technologies transforming organisation operations and improving their overall performance. Firm Performance is measured using business growth, profitability rate, and productivity. The study considers digital technology value development as a capability that is supported through digitalisation and people to develop a routine and maximised use of new digital technology until it is integrated. It implies the creation of knowledge to innovate products or services, superior decision-making, advanced customer services, development of new distribution channels within the operational ecosystem, and efficiency in processes internally and externally. This in turn results in an impact on profitability, productivity, and ultimately competitive advantage. The study found a positive relationship between digital capability and organisational performance (Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020). Büşra and Çallı (2021) also support the concept of digital capability and its ability to boost Firm Performance. The study explores digital maturity and organisational agility on Firm Performance conferring that new digital technologies can help a company improve its sales performance by providing better customer service and increasing its effectiveness in business relationships. Firm Performance is measured using financial indicators such as cash flow, revenue growth, market share, and profit growth. Conclusive findings supported that the maturity of a digital capability has a positive effect on organisational performance. Also, from a technology perspective.

Martín-Peña et al., (2019) propose a different perspective on I4.0 and Firm Performance by exploring the relationship between sovietisation and digitalisation. A framework is proposed to explore the effects of servitisation, digitalisation as a mediator, and the mechanisms that create value-adding opportunities to increase Firm Performance. The concept of servitisation within the study is defined as the process of adding value to products or services. Through the use of service-oriented technology, it can provide customers with complete, integrated product-service systems thus achieving greater customer satisfaction. It is also indicated servitisation enhances competitiveness based on the assessed literature within the study. Furthermore, the study argues digitalisation and servitisation independently may have a positive influence on Firm Performance. Firm Performance was measured using total sales.

The findings indicate the level of digitalisation and the level of servitisation has a positive influence on Firm Performance.

Although there is a lack of empirical research concerning I4.0 capabilities and Organisational Performance, a study by David-West et al., (2018) explains an exploratory study that presents a supply-side perspective on the operations of digital financial services (DFS) in emerging markets using the resource-based view as a theoretical background. The study aims to show that bank-led institutions have more resources and are better equipped to serve the needs of the customers and therefore possess more operational advantages than their non-bank peers. The fundamental findings in the study show that particular resources and organisational capabilities are required by DFS to ensure sustained competitive advantage. Some of the key resources highlighted include technology and human capital. Whereas technology resources are a common concept across studies, this study pays particular attention to the human capital category. Accordingly, it is described as the various capabilities of an individual, including knowledge, expertise, and partnership capabilities geared toward the success of digitalised financial services. The author implies human capital is an essential resource and requires a high degree of collaboration is required to create new knowledge and skills aimed toward digital enablement.

Also, within financial services, another study examined how various factors such as technology, service quality, and employee commitment affect a bank's performance. Being able to maintain and improve a bank's performance is a big challenge for banks. However, banks can still improve their performance by increasing their technology level and developing new products and services. The study revealed that banks in Malaysia are highly affected by technology and innovation, but they also contribute to maintaining their competitive advantage (Chai, Tan and Goh, 2016).

After reviewing and synthesizing the literature, several common themes emerged. One of these is that the definition of performance is subjective and varies depending on the industry or type of study. In the financial services industry, there is a significant gap in research on the relationship between I4.0 capabilities, digitalisation, and benefits. While some studies propose various benefits, there is a lack of empirical evidence to support these claims. Additionally, the underlying measures for Firm Performance are consistent across studies with positive results, suggesting that a similar approach and measures can be adopted to assess financial services. However, there are no studies that provide a holistic approach to financial services and most studies focus on specific capabilities, such as digitalisation, servitisation, and Firm Performance. Therefore, more research is needed to explore the potential benefits of I4.0 in financial services to provide a comprehensive approach to assess its impact on firm performance.

## 2.5 Chapter Summary

The first section of this chapter provided the background to the previous industrial revolutions leading up to the fourth Industrial revolution known as I4.0. This was followed by reviewing existing definitions of I4.0 and contextualising and defining I4.0 within financial services. The SLR was conducted to answer RQ1 by first identifying the I4.0 capabilities and then determining the existing relationship between I4.0 capabilities and Firm Performance outcomes providing a more in-depth review. I4.0 capabilities were conceptualised as below.

*Table 4. I4.0 capabilities*

| |
|---|
| Digitalisation |
| Human resources |
| Integration |
| Real-time capability |
| Decentralisation |
| Service Orientation |
| Modularity |
| Virtualisation |

After conducting a thorough review of the literature, it was concluded that the benefits were abundant. Key benefits identified were efficiency and effectiveness of the business value chain, increased innovative opportunities, increased customer value, operational benefits, and competitive advantage.

In the next chapter, the theoretical foundation is established. The capabilities and benefits from the SLR are synthesized to articulate the intended outcomes of the study, that being the performance outcomes of Firm Performance, Innovation capability, Improved value chain, and Servitisation outcomes. The hypotheses are then proposed.

# CHAPTER 3: THEORETICAL BACKGROUND AND RESEARCH MODEL

The theoretical background establishes the conceptual framework and provides a theoretical foundation for the research being conducted. According to Boote and Beile (2005), the theoretical background section lays out the theoretical underpinnings of the research question and provides a rationale for the study's relevance and significance.

## 3.1 Theoretical Underpinnings

The study uses the resource-based view to explore the theoretical relationship between I4.0 complementary capability and organisational performance. The resource-based view is the dominant theoretical framework used in strategic management literature and was also utilised to enhance the conceptual analysis of information technology's effects on firm performance (Bharadwaj, 2000). The primary motivation for carrying out an RBV-based approach is that it provides a compelling framework that allows researchers to integrate multiple dissimilar resources to study the varying effects on performance. The resource-based view posits that Firm Performance is influenced by an organisation's resources and capabilities. The definition of resource has posed a challenge to many theorists (Wade and Hulland, 2004) however an organisation's resource constitutes assets and capabilities that can be tangible or intangible. These include but are not limited to, organisational processes, organisation attributes, personnel-based resources, physical assets, knowledge, and employee skills (Bharadwaj, 2000; Wade and Hulland, 2004b). Assets are regarded as anything that the organisation can use in its processes to create, produce, or offer its products or services to a market. While assets are typically described as tangibles, organisational capabilities commonly associated with intangibles refer to the ability to effectively infuse and configure these valued resources in a manner to achieve competitive advantage (Bharadwaj, 2000). Therefore, a capability is defined as repeatable actions that an organisation can execute to create, produce, or offer products to a market (Wade and Hulland, 2004). Furthermore, RBV postulates that these resources have to be strategic in nature and exhibit a degree of heterogeneous properties; that is, they possess value, rarity, inimitability, and non-substitutability (VRIN) to be performance-yielding (Bharadwaj, 2000; Nevo and Wade, 2011). Value refers to the capability for which a resource can support feasible organisational strategies or protect against risks (Nevo and Wade, 2011). Rarity points out that a resource should not be easily accessible to competitors; Inimitability indicates that a resource is challenging to replicate; non-substitutability refers to the level at which a resource can easily be imitated by threats (Nevo and Wade, 2011). RBV recognises complementary relationships (Wade and Hulland, 2004). Complementarities are formed by the combined effect of multiple strategic resources and capabilities and must exhibit VRIN properties. Since their configurations are complex, they can be hard to understand and therefore difficult to imitate

by competitors. These resources can be leveraged by the organisation to support the development of strategies that improve the overall performance in terms of efficiency and effectiveness (Eloranta and Turunen, 2015) thus the assumption is that if a positive relationship exists between strategic resources and Firm Performance, then a competitive advantage must exist (Chahal *et al.*, 2020). Dynamic capabilities of an organisation allow organisations to integrate, reorganize and build their own internal and external capabilities to accommodate volatile environments (Chahal *et al.*, 2020).

From an RBV perspective, the impact of I4.0 capabilities on organisations has been studied in the past couple of years. Chauhan, Singh, and Luthra (2021) propose various principles of I4.0 which are Decentralisation, Modularity, Integration, Service Orientation, and Virtualisation can help organisations improve their operations and provide them with the competitive advantage they deserve. In addition, the SLR performed has highlighted Digitalisation and Human resources as necessary to enable successful I4.0. The potential of sustainable organisations is being unlocked through the interlinkages that digitalisation can facilitate. Various studies also show that digital technologies can help improve the efficiency and profitability of sustainable organisations (Chauhan, Singh, and Luthra, 2021). Human capital is a fundamental component within I4.0 as indicated in the study. A further observation from the literature review revealed that these factors independently or in combination contribute to Firm Performance.

## 3.2 The adoption of RBV in previous work

A study performed by Melville, Kraemer, and Gurbaxani (2004) suggests a framework (figure 7) based on the various strands of research that are combined into an integrative model to analyse the business value of information technology. Although it is valuable, the extent and dimension of information technology's value are dependent on the company's internal and external factors, such as its trading partners and competitive environment. The focal organisation's various elements are organised into four main categories: information technology, business processes, organisational performance, and complementary resources. The business value of information technology (IT) is assessed based on its deployment and organisational resources within business processes. The use of IT and its associated resources can improve business processes and enable new ones.

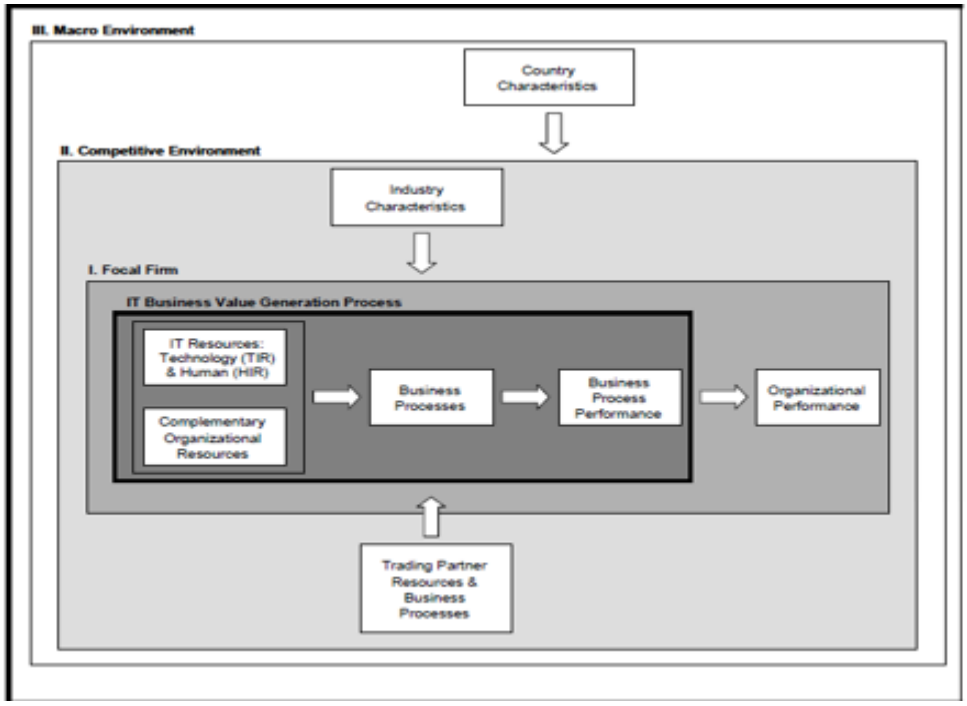


Figure 7. IT Business Value Model (Source: Melville, Kraemer, and Gurbaxani 2004, p. 293)

A reputable study done by Ravichandran and Lertwongsatien (2002) presents the resource-based perspective to examine the relationship between Information system capabilities on Firm Performance (figure 8). Based on the concept of resource complementarities, the study postulates that the ability to effectively utilise an organisation's IT resources in enhancing its core competencies can help an organisation improve its performance. The study's theoretical framework below indicates the various constructs which interrelate to the deployment of IS resources and core competencies. The constructs represented are; IS resources comprising of human capital, technological and relationship resources consistent with previous IS research, IS capabilities, IT support for core competencies, and Firm Performance. The model proposes that Firm Performance can be achieved by integrating IT within core competencies through the implementation of the IS complementary capability. The IS capability is underpinned by the optimum configuration of IS resources into routines that enable IT Support for Core Competencies and Firm Performance. The results showed a robust correlation between IT utilisation for core competencies and organisational performance enhancement. This indicates the value of complementary relationships and their effect on Firm Performance demonstrating the relevance for future research.

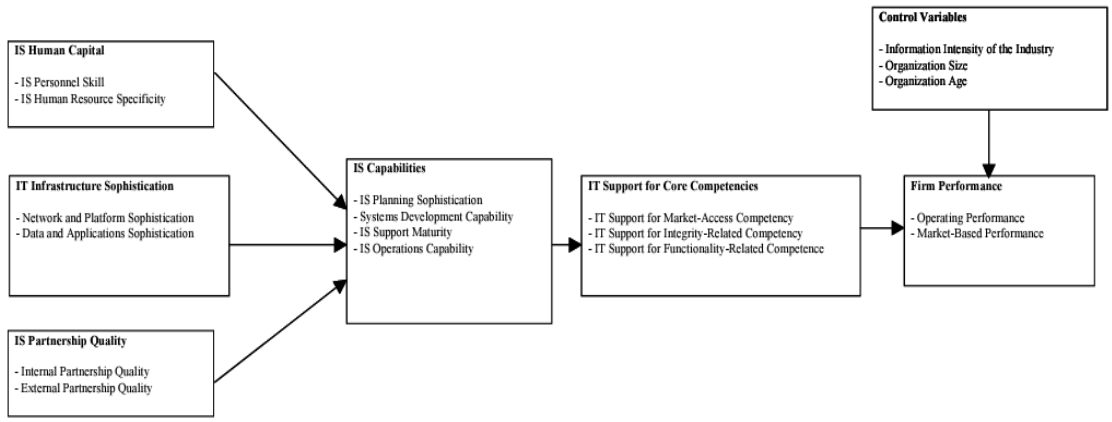


Figure 8. Research Model (Source: Ravichandran and Lertwongsatien 2005, p. 7)

Research performed by Chahal et al. (2020) applied a meta-analytic approach to analyse the application of RBV in Operational Management( OM) within organisations (figure 9). Meta-analysis is a widely employed research approach that integrates the findings of previous studies and related hypotheses. By doing so, it yields a more precise and all-encompassing estimation of the true effect size when compared to individual studies. The model investigates the correlation among operational capabilities, including flexibility, supplier chain integration, and organisational capability, and business performance. This relationship is moderated by factors such as the industry's nature, the country context, and the data collection method. Business performance encompasses operational, competitive, and financial aspects, with firm performance being the central focus. Flexibility in organizations denotes the ability to adjust and react to fluctuations in production volume or product mix, enabling them to offer novel products and services. This adaptability plays a crucial role in developing a competitive advantage. Supply Chain Integration (SCI) involves an organisation's collaborative efforts with its supply chain partners, facilitating the efficient management of both intra and inter-organizational processes. By optimizing the flow of goods, services, and finances at a reduced cost, SCI aims to enhance the overall value delivered to the final customers, ultimately leading to value creation. The underlying variables include Internal, external, customer, and supplier integration. Organisational capabilities, classified as dynamic capabilities are defined as organisation-specific processes that are created through the infusion of organisation resources over time, therefore are influential in securing competitive advantage. Business performance represents the overall performance using financial, non-financial, and operational measures. Firm performance was measured using flexibility, reduced cost, improved quality, and delivery. Competitive performance was represented by innovation, customer satisfaction, and competitive advantage, and lastly, financial measures of ROA, return on sales, and profitability represented financial performance. The results from the research identify key resources and capabilities that positively impact Firm Performance where the findings are consistent across studies examining similar resources. In addition, it is

demonstrated that RBV supports unrivalled Firm Performance when organisations shift from utilising tangible and intangible resources independently to creating valuable capabilities.

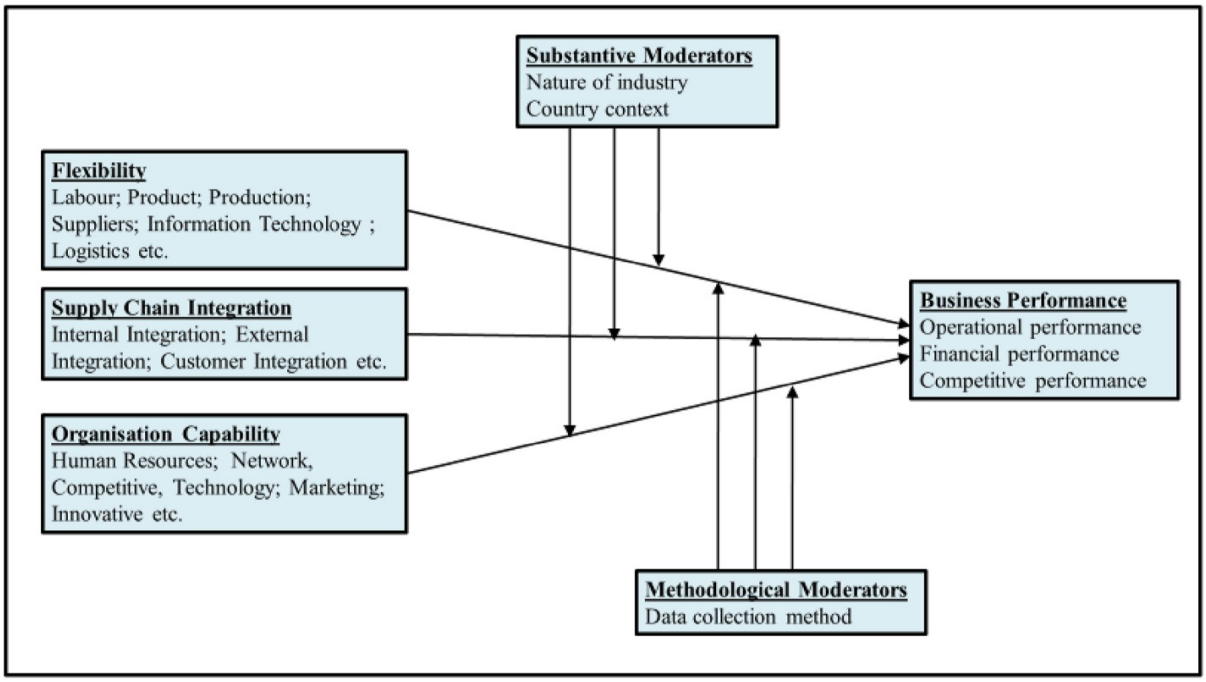


Figure 9. Conceptual framework, (Source: Chahal et al.2020, p. 4)

A more recent study on I4.0 within manufacturing adopted RBV as the theoretical framework to determine the impact of organisation strategies on supplier performance (figure 10). Salam (2019) argues the fit for utilizing resource-based theory. RBV provides the mechanisms for measuring relationships between various factors such as resources, capabilities, and profitability, and how these can be sustained over time. Secondly, if an organisation has both the necessary strategic resources and the rare capabilities, it can improve Firm Performance. Salam (2019) posits that manufacturing organisations possess unique resources and assets that can exhibit differentiation in product quality, flexibility, delivery speed, and cost leadership. Since RBV is based on the premise of how organisation resources and capabilities can be intricately combined and positioned to create a competitive advantage, it is proposed that I4.0 technology is the enabler for the organisation to build such intangible capabilities necessary to improve their supply chain operations. Accordingly, (Salam, 2019) argues that I4.0 and its associated technologies can help manufacturers achieve a competitive advantage through the combination of technology and resources. I4.0 manufacturing systems are highly flexible and can respond to changes in the market. They can provide manufacturers with immediate and cost-efficient solutions to address changing requirements. I4.0 supplier performance is a critical component of manufacturing efficiency and can be determined by various factors such as cost, quality, delivery, and flexibility supported by manufacturing strategies. The model aims to analyse the relationship between the independent variables namely, cost, delivery, flexibility, and quality, and the dependent variable is supply

performance. Cost performance is regarded as reduced costs from utilising I4.0 and its related technologies, Delivery performance implies fast and dependable delivery, Flexibility performance is defined as the ability to adapt to changes that add value to its customers and quality performance is the process of delivering products that meet the expectations of the end customer. It can result in better customer satisfaction and avoid dissatisfaction. All these constructs can be achieved with the adoption of I4.0 technologies and organisation resources to impact supplier performance. The study found that the relationship between cost and delivery performance and I4.0 supplier performance is not significant while flexibility and quality demonstrated positive relationship. The studies also show that the value derived from the interaction between business processes and technology is different from the value derived from pure IT. Moreover, the studies highlight that the value from technology-business process interaction arises from assets' non-substitutability, inimitability, and rarity

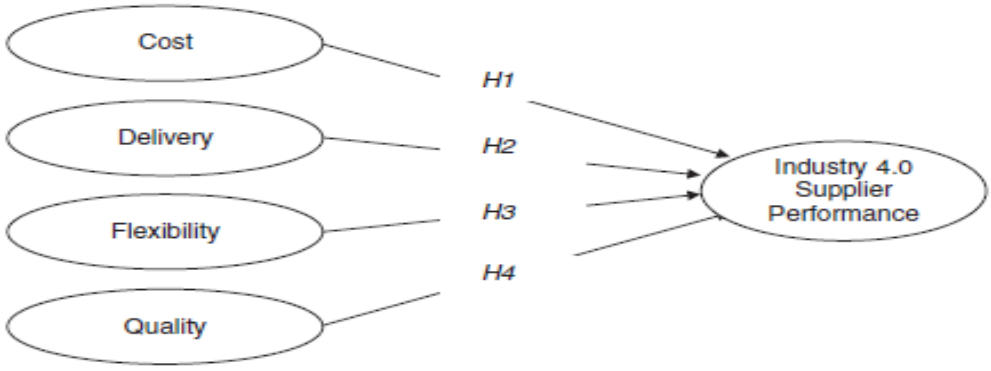


Figure 10. Conceptual framework (Source: Salam, 2019, p. 1703)

In the next section, the research model is presented for this study and discusses the hypotheses that have been put forward. The research model is based on a comprehensive review of existing literature and aims to investigate the relationship between I4.0 complementary capability and performance outcomes.

## 3.3 Research Model

This section addresses the research model proposed below. Based on a system of complementaries the model aims to examine the relationship between the independent variables that are intricately combined to form the I4.0 Complementary Capability, and the dependent variables. These consist of Firm Performance, Innovation Capability, Servitisation Outcomes, and Improved Value Chain. The resource complementary was modelled as a reflection of second-order structural attributes. It was also regarded as appropriate since first-order frameworks exhibit independence and mutual support. The constructs are further defined, and the relationships are explained following the hypotheses of the I4.0 Complementary capability.

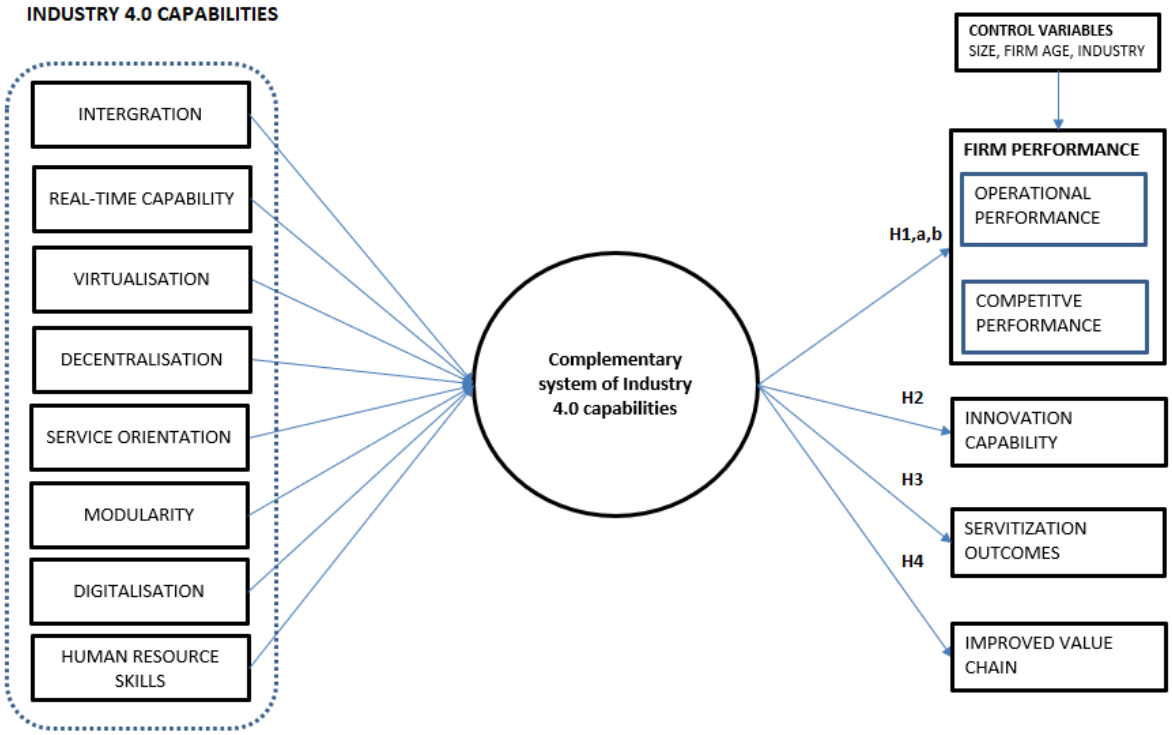


Figure 11. Research Model

### 3.3.1 Conceptualising Firm Performance

Firm Performance is conceptualised as an overall performance measure and constitutes operational performance and competitive performance. Although the terminology used is Firm Performance, this also represents business area performance within financial services.

### 3.3.1.1. Operational performance

Operational performance is typically perceived as higher efficiency when used effectively. Some of these include a reduction in costs and an increase in revenue (Nevo and Wade, 2011). Operational performance represents the performance of an organisation in terms of cost reduction, increased revenue, increased quality, reliability, and faster delivery (Chahal et al., 2020; Demeter and Losonci, 2020; Nevo and Wade, 2011).

### 3.3.1.2 Competitive Performance

Competitive performance can be regarded as the degree to which an organisation's ability to produce and sell products and services that outperform its domestic competitors (Bal and Erkan, 2019; Liu, 2017). Nevo and Wade (2011) primarily represent competitive performance in terms of effectiveness to achieve strategic benefit within an organisation. These are best indicated by the ability to respond to changes in the market and improve its competitive position. Previous studies have shown financial performance indicators of competitive performance to be relevant. Therefore, competitive performance for this study relates to the capacity of an organisation to increase market share, and financial profitability, improve its competitive positioning, and flexibility to respond to market changes.

## 3.3.2 Industry 4.0 Complementary Capability

I4.0 is a complex and multifaceted concept that comprises various pillars. Because of the diverse nature of I4.0, it is challenging to have a comprehensive view that encompasses its entire application within the financial services industry. Keeping to the notion of complementariness, the model proposes the construct of an I4.0 complementary capability that is enabled through intricately combining and integrating resources and capabilities that possess VRIN (Nevo and Wade, 2011b; Chahal *et al.*, 2020; Mikalef *et al.*, 2020) and thus may have a significant effect in creating Firm Performance. I4.0 complementary capability is posited as, organisation-specific, path-dependant, and difficult to imitate by competitors, which catalyses converting IT tangible and intangible resources into Firm Performance (Chahal *et al.*, 2020).

These intangible and tangible resources are represented by the I4.0 capabilities namely, Digitalisation, Integration, Virtualisation, Decentralisation, Real-time capability, Service Orientation, Modularity, and Human resource skills (Ghobakhloo, 2018; Kamble, Gunasekaran and Gawankar, 2018; Mohamed, 2018; Piccarozzi, Aquilani and Gatti, 2018; Horváth and Szabó, 2019). The competitive advantage of an organisation arises from its various unique and disparate capabilities to create economic value and competitive advantage (Chahal *et al.*, 2020). Research has indicated that I4.0 also affects creating innovation capabilities, improving the value chain, and lastly customer value therefore the

model also seeks to determine the relationship between the I4.0 complementary capability and these dependent variables.

Information Technology (IT) is an umbrella term that describes various technological devices that foster computing capabilities to facilitate information processing, decision making, improve communication and collaboration to achieve goals, such as increasing customer value and gaining a competitive advantage (Brosig, Westner and Strahringer, 2020; Chahal *et al.*, 2020). According to Chahal et al (2020), there is a clear relationship between Digitalisation and IT, in that IT contributes to the development of new digital artifacts, digital platforms, and infrastructure solutions to deliver new value propositions. Bharadwaj (2000, p. 171) defines an IT capability as an "organisation's ability to mobilise and deploy IT-based resources in combination with other resources and capabilities." Furthermore, Brosig, Westner, and Strahringer (2020) posit a new perspective on IT capability in that digital technologies are the foundation of enhanced IT capabilities and are consistent with the effects on positive Firm Performance. Secondly, design principles are described as the fundamental constituents of I4.0 for practical application (Nosalska *et al.*, 2019) enabled through digitalisation, and therefore are suited to the RBV theory from an asset and resource perspective. Therefore, I4.0 Complementary capability can be defined as:

The ability of an organisation to assemble, integrate and deploy I4.0 technologies, capabilities, skills, competencies, and design strategies in a different and dynamic frame, and to create other capabilities, processes, tools, and combinations of them, to ensure proper strategy implementation involving the entire organisation, starting with a focus on people (Bharadwaj, 2000; Piccarozzi et al., 2018).

The definitions for each underlying construct are provided in table 5:

*Table 5. I4.0 capability definitions*

| Construct | Definition | Source |
|---|---|---|
| Digitalisation | Digitalisation, also known as digital business transformation, is a strategic approach to creating innovative business models by incorporating cutting-edge digital technologies into products, services, processes, and people to create significant value. | (Annarelli *et al.*, 2021; Antonucci, Fortune and Kirchmer, 2021) |
| Integration | Integration proposes structural and digital changes internal and external to an organisation to establish an interconnected value chain. | (Pereira and Romero, 2017; Dalenogare et al., 2018) |
| Virtualisation | Virtualisation is a technological process that transforms physical world data into a virtual form. | (Lambropoulos, Mitropoulos and Douligeris, 2021) |

| | | |
|---|---|---|
| Decentralisation | Refers to the ability of people and machines that allow systems to autonomously make decisions without relying on a centralised decision-making body and is achieved through the use of various technologies. | (Ferreira, Armellini and De Santa-Eulalia, 2020) |
| Real-time capability | Real-time capability is the combination of interactive processing, full networking, and integration of the functional areas utilising real-time data enabling automation of tasks and improving the efficiency of its operations. | (Cundius and Alt, 2013) |
| Service Orientation | Involves designing a service-orientated architecture that is embedded within processes to deliver precisely what a customer wants. | (Dikhanbayeva *et al.*, 2020; Münch *et al.*, 2022a) |
| Modularity | The concept of modularity refers to the process of decomposing a product or system into re-combinable modules that are composed of multiple components which can be adapted to meet different requirements and needs | (Kamble, Gunasekaran, and Gawankar, 2018; Ferreira, Armellini and De Santa-Eulalia, 2020) |
| Human Resource Skills | Human resources address the skills, competencies, and leadership that an organisation's personnel should possess to implement and operate within the new technological field. | (Piccarozzi, Aquilani, and Gatti, 2018; Horváth and Szabó, 2019). According to Kinzel (2017) |

Studies have indicated positive associations between some of the I4.0 capabilities and Firm Performance, as noted in the literature review. We, therefore, can deduce that an I4.0 complementary capability comprised of intangible and tangible resources which possess VRIN represented as Digitalisation, Integration, Virtualisation, Decentralisation, Real-time capability, Service Orientation, Modularity, and Human resource skills can yield Firm Performance, therefore:

***H1a - A complementary system of Industry 4.0 capabilities will have a significant effect on the operational performance of financial organisations***

***H1b - A complementary system of Industry 4.0 capabilities will have a significant effect on the competitive performance of financial organisations***

### 3.3.3 Innovation capability

According to Ibarra, Ganzarain, and Igartua (2018), I4.0 is said to be the most compelling influence that would lead toward an innovation-based economy, more so integration and real-time capabilities play an integral role. Innovation can be defined as the process of introducing and implementing new ideas, processes products, or services to create value for customers and within an organisation that can result in increased Firm Performance (Chai, Tan, and Goh, 2016). Innovation capability is the ability and competencies of the organisation to absorb, adapt and transform technologies into management and operational routines that will yield organisation profits based on the innovative activities implemented (Calantone, Cavusgil, and Zhao, 2002; Zawislak *et al.*, 2012). Digitalisation enables innovation capabilities in several ways, through the use of digital technologies and data analytics, organisations can collect and analyse data about their customers. This method of decision-making can create more collaborative innovations. Park (2018) mentions that the flexibility of digital technologies enhances product innovation since organisations can continuously produce new products or services and encourage customisation. Closely related to flexibility are customisation and personalisation following the principle of modularity which when implemented within service offerings results in service innovations (Brax *et al.*, 2017) therefore better and more unique products and services for customers. In addition, decentralised, flat structures are more conducive to the generation and implementation of innovative ideas throughout the organisation. New ideas and knowledge can easily flow within the organisation if all of the expertise is integrated into a decision-making process. The people involved in a decision-making process rely on horizontal communication to determine the course of action due to their knowledge and expertise. Therefore the probability of emergent innovations is high (Wilkesmann and Wilkesmann, 2018). In summary, the combination of the underlying I4.0 capabilities can lead to the creation of innovation capabilities, therefore,

***H2 - A complementary system of Industry 4.0 capabilities will have a significant effect on the innovation capability of financial organisations***

### 3.3.4 Improved Value chain

In essence, the value chain refers to a series of tasks and processes that are integral in the creation and distribution of a product or service. It encompasses all aspects of production, ranging from the ideation and planning phase to the actual development and delivery to end-users (Piccarozzi, Aquilani and Gatti, 2018). I4.0 suggests digitizing and integrating the entire product or service lifecycle (Ghobakhloo, 2020) thus optimizing the entire value chain through collaboration among suppliers and customers, utilizing real-time information, as well as vertically integrating systems and structures within the organisation (Dalenogare *et al.*, 2018; Calış Duman and Akdemir, 2021). In addition I4.0 technologies coupled with modular

structures and systems enhance sustainability by simplifying the value chain and providing highly flexible and responsive processes that can adapt quickly and efficiently to changes in customer and process requirements (Salam, 2019; Dikhanbayeva *et al.*, 2020). By leveraging these capabilities, businesses can enhance their flexibility and responsiveness, enabling them to respond rapidly to new opportunities and challenges. This increased flexibility can result in more cost-efficient and streamlined business processes, improved decision-making due to decentralised structures, and increased product or service quality ultimately leading to improved performance outcomes (Dalenogare *et al.*, 2018; Salam, 2019). The availability of real-time information at all levels is advantageous since flexible processes allow for large amounts of data to be analysed for insights that contribute to operational and strategic decision-making (Dalenogare *et al.*, 2018). In sum, by embracing these principles, businesses can create a more optimised and effective value chain, leading to improved outcomes and increased efficiencies. Therefore,

***H3 - A complementary system of Industry 4.0 capabilities will have a significant effect on improving the business value chain***

### 3.3.5 Servitisation outcomes

Service orientation considers the complementary of internal and external resources such as human agents, physical resources, and technology, to build a service eco-system to deliver smart services (Martín-Peña, Sánchez-López, and Díaz-Garrido, 2019). It poses many advantages to an organisation, such as the ability to create modular, accessible, and well-described services (Janssen and Joha, 2008). Servitisation is defined as the process where value-added services are bundled as a total offering with products and services to deliver customised solutions that are designed to meet specific customer needs increasing customer satisfaction (Martín-Peña, Sánchez-López, and Díaz-Garrido, 2019; Jang, Bae, and Kim, 2020; Münch *et al.*, 2022) thus Servitisation outcomes measures the customer value. Researchers have recognised the various benefits of servitisation mainly, customer loyalty and satisfaction (Brax *et al.*, 2021). The process involves value co-creation with customers in the integrated development of service offerings which allows organisations to provide their consumers with a wider variety of experiences, which can help improve their business performance (Jang, Bae, and Kim, 2020; Münch *et al.*, 2022). Based on the premise of service-orientated architecture, organisations can create new channels that enable them to interact and develop new products and services (Münch *et al.*, 2022a). As part of the capability, Martín-Peña, Sánchez-López, and Díaz-Garrido (2019) indicate that digitalisation plays a significant role in the design of new product-service systems to meet customer needs therefore digitalisation acts as an enabler for organisations to increase customer satisfaction and provide support services. Brax *et al* (2017) also consider modularity as a key pillar that aims to increase flexibility and customisation through the standardisation of service production utilising service modules. A service module is an interoperable system composed of components that can be easily

modified to provide a well-defined set of services (Janssen and Joha, 2008; Brax *et al.*, 2017). Furthermore, Lambropoulos, Mitropoulos, and Douligeris (2021) suggest that organisations are adopting virtualisation-based solutions due to the increasing need to provide more customer services. As an example, Cloud computing is an outsourced service that provides various features such as storage and management capabilities. These capabilities can help drive insights into customer needs (Serumaga-Zake and Poll, 2021) therefore improving customer satisfaction. Together with the implementation of horizontal, and vertical integration and real-time capabilities, there is strengthened customer involvement in designing, creating, and the delivery of customer needs. This will increase the level of information availability and responsiveness enhancing the value delivered to customers (Martín-Peña, Sánchez-López, and Díaz-Garrido, 2019; Sony, 2020). Therefore, servitisation outcomes can be understood as the customer value effects of the I4.0 complementary capability thus,

***H4- A complementary system of Industry 4.0 capabilities will have a significant effect on the servitisation outcomes of financial organisations***

### 3.3.6 Control Variables

The control variables were identified as follows:

- Organisation size (number of employees): The study can be affected by organisation size as larger teams may have greater resource accessibility, but may also struggle with adapting to changes rapidly such as slower transition and more complex processes and systems that need to be updated, making it more difficult to adapt to I4.0 implementation.
- Organisation industry: refers to the specific market focus within financial services. The industry may influence since specific Industries such as Banking may be more likely to develop I4.0 capabilities as opposed to Non-Banking.
- Organisation age (in years) – this may influence the model since younger organisations tend to be riskier and seek more innovative opportunities as compared to older organisations with a traditional culture technology and processes.

## 3.4 Chapter Summary

This chapter analysed the literature on the resource-based view as the theoretical foundation and reviewed its past applications. The research model and the supporting hypotheses were then developed. The model investigates the relationship between the I4.0 complementary capability and the various dependent variables of Firm Performance, Innovation Capability, Servitisation Outcomes, and Improved Value Chain. The I4.0 complementary capability was conceptualised in terms of nine dimensions, which include: namely, Digitalisation, Integration, Virtualisation, Decentralisation, Real-time capability, Service Orientation, Modularity, and Human Resource Skills. The hypotheses are summarised below:

*Table 6. Summary of hypotheses*

| | |
|---|---|
| ***Hypothesis 1 a*** | **A complementary system of Industry 4.0 capabilities will have a significant effect on the operational performance of financial organisations** |
| ***Hypothesis 1 b*** | **A complementary system of Industry 4.0 capabilities will have a significant effect on the competitive performance of financial organisations** |
| ***Hypothesis 2*** | **A complementary system of Industry 4.0 capabilities will have a significant effect on the innovation capability of financial organisations** |
| ***Hypothesis 3*** | **A complementary system of Industry 4.0 capabilities will have a significant effect on improving the business value chain** |
| ***Hypothesis 4*** | **A complementary system of Industry 4.0 capabilities will have a significant effect on the servitisation outcomes of financial organisations** |

In the next chapter, the research methodology is explained further. The research methodology entails the overall research design and methods used for the data collection and analysis to investigate the hypotheses proposed.

# CHAPTER 4: RESEARCH METHODOLOGY

## 4.1 Research methodology

Creswell and Tashakkori (2007) define research methodology as the research approach for collecting and analysing data that constitutes the research design, sampling, data collection, and analysis strategies to test the research model. The research follows a positivist using the quantitative approach highlighted below in the research onion. The research onion developed by Saunders, Lewis, and Thornhill (2009) is depicted in figure 12. The research onion can be interpreted as a framework that portrays the various stages when determining the research methodology to be used (Melnikovas, 2018). However, it is necessary first to understand the research paradigm to appreciate the research approach fully.

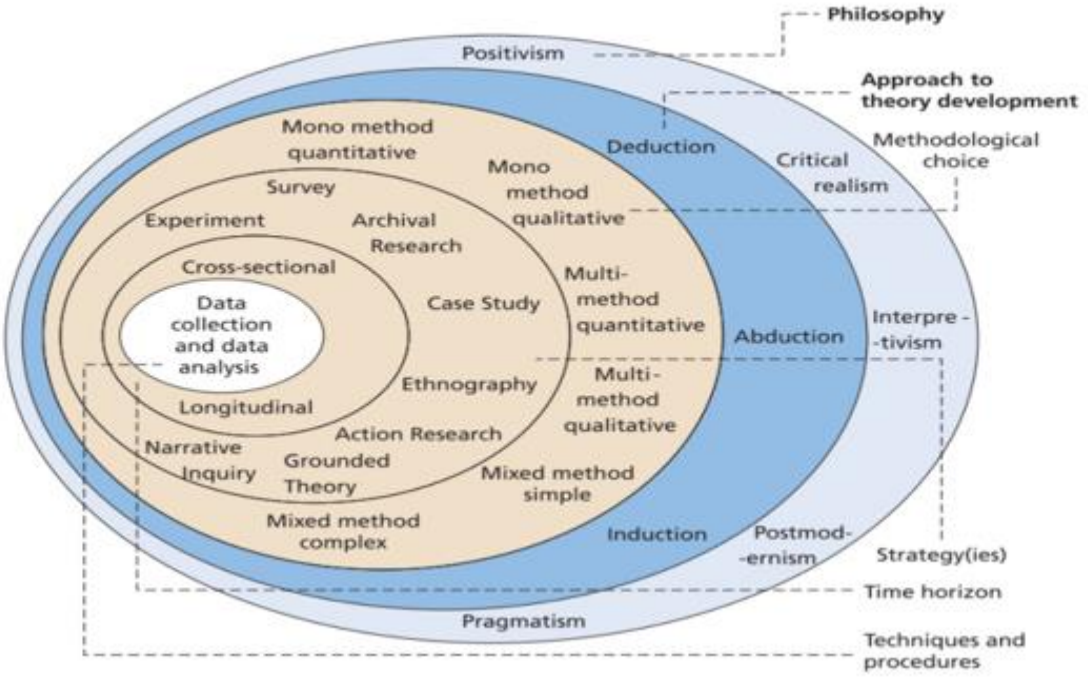


Figure 12. Research Onion (Source: Saunders, Lewis, and Thornhill, 2009, p. 108)

### 4.1.1 Research Paradigm and Approach

The research paradigm can be understood as the school of thought or perspective interpretation that informs the meaning or interpretation of research (Kivunja and Kuyini, 2017). The research paradigm can be described as a researcher's views, beliefs, and assumptions used to interpret the world that they understand. It serves as the theoretical lens through which a phenomenon can be interpreted and understood by a researcher based

on their opinions and decisions to gain knowledge about the world around them (Mackenzie and Knipe, 2006). The paradigm establishes the research study's intent, motivation, and expectations (Mackenzie and Knipe, 2006). Several theoretical paradigms exist, such as positivist, interpretivist, transformative, constructivist, critical, pragmatism, and deconstructivism (Mackenzie and Knipe, 2006). Research paradigms can be fundamentally differentiated through the following philosophical concepts, Ontology, Epistemology and Methodology, and Axiology. Ontology is a field of study that explores the nature of reality and how it is affected by the actions of humans. It acknowledges the existence of the empirical world as objective, existing autonomously from human action. However, it also recognizes the subjective nature of reality, which is formed by social agents and moulded by human contributions. The concept of epistemology is a set of assumptions that describe the process by which knowledge about a phenomenon can be constructed. The methodology evaluates the research methods appropriate for collecting the empirical evidence for the study whilst Axiology is concerned with ethics, as it relates to the various roles of values in the research process and the researcher's position on the subject (Orlikowski and Baroudi, 1991; Wahyuni, 2012).

Interpretivism adheres to the concept of social constructivism, which states that reality is not an independent entity but rather, is made up of social actors and people's perceptions. Ontologically, interpretivism believes that individuals with different backgrounds and assumptions contribute to the construction of reality in their social context (Orlikowski and Baroudi, 1991; Wahyuni, 2012). The epistemology for interpretivism is that knowledge is collected through subjective experiences therefore social reality can have multiple perspectives. This means that the idea of a single truth is rejected and rejects the concept of objectivism. They prefer to interact with the participants and to have a dialogue about the constructs discussed. The research methods typically use qualitative data, which provides detailed descriptions of various social constructs. They also use narrative analysis to describe their findings (Wahyuni, 2012). In contrast, Positivism states that the world is external to humans and that the existence of reality is independent therefore ontologically social reality is external and independent of humans (Orlikowski and Baroudi, 1991; Wahyuni, 2012). Positivism is based on the assumption that our world is an organised system of events that exhibit a certain degree of predictability in which phenomena of interest can be examined and explained objectively (Oates, 2013). The epistemology for positivists assumes that the physical and social world can be characterised and measured therefore they advocate for the use of scientific methods to generate appropriate knowledge. The positivist approach to research incorporates the manipulation of theoretical suggestions using a logical and deductive approach so that the hypothesis satisfies testability and is falsifiable (Lee, 1991). The hypothetico-deductive scientific method, often regarded as the true scientific method indicates that an empirical approach is applied in evaluating a subject area to deduce further inferences using a hypothesis that is testable and falsifiable (Sankey, 2008). Testable follows the notion of proving or disproving a hypothesis by testing using scientific methods, while

falsifiability asserts that for a hypothesis to be credible, it should be disprovable. The hypothetico-deductive reasoning uses existing theories where results are predictive and focus on logical implications (Sankey, 2008). The researchers maintain the separation between themselves and the studies they are working on by taking the stance of the outsider perspective (Orlikowski and Baroudi, 1991; Wahyuni, 2012).

This research follows a positivist paradigm using the hypothetico-deductive approach to understand the effects of an I4.0 complementary capability on Firm Performance. This method of conducting research is commonly used by researchers to test a theory or a previous hypothesis. Through a positivist researcher's lens, this study seeks to assess the influence of I4.0 complementary capabilities on the dependent variables of Firm Performance, Innovation Capability, Servitisation Outcomes, and Improved Value Chain. The study aims to find a statistically significant and deductive conclusion after studying a sample population.

## 4.2 Research Design and Methodology

The Research design serves as a comprehensive framework that helps develop the approach or methodology for data collection to adequately answer the research question or test hypotheses (Bhattacherjee, 2012). The research design governs the research strategy's execution, which includes the research methods, data collection, analysis techniques, and sampling approach used in the research process (Bryman and Bell, 2007; Bhattacherjee, 2012). The research study explores the relationship between independent and dependent variables and hence will follow the relational research design. Relational research aims to investigate how constructs within a context or phenomena of interest are related to one another, seeking to discover the degree to which the constructs influence each other (Fawcett and Downs, 1986). This type of research usually happens when the attributes of the phenomena are known through descriptive theories (Fawcett and Downs, 1986).
The research aims to understand the relationships that aim to determine the effect of I4.0 as a complementary capability that is; Integration, Real-time capability, Virtualisation, Decentralisation, Service Orientation, Modularity, Digitalisation, Human Resource Skills on Firm Performance within a South African context. The approach would involve attaining organisation data through individuals to support scientific findings; however, since all organisations within the population cannot be reached, a subset of the population would be used for data collection. Hence a survey strategy is suitable for the research study. Surveys allow researchers to measure a range of intangible data such as characteristics, attitudes, or behaviour of the population (Bhattacherjee, 2012). Researchers can generalise the findings from a subset or sample of data to a population to support the statistical deductions within the research boundaries. More specifically, a survey using structured questionnaires will be distributed to organisations in financial services within South Africa. Structured questionnaires allow participants to respond within a predefined set of choices

(Bhattacherjee, 2012). Questionnaires are simple to administer and cost-effective; more importantly, they cater to the extensive collection of data; hence are suitable for this study.

## 4.3 Data Collection Methods

### 4.3.1 Operationalisation

Researchers are often faced with the process of conceptualising the phenomenon of interest when conducting research. In doing so, the constructs that emerge from the topic are required to be measured. Operationalisation is the process of measuring these constructs by creating indicators that are representative of the construct to quantify the construct (Bhattacherjee, 2012). Operationalising involves describing a construct in a manner where one can specify the activities or operations to measure it (Sethi and King, 1991). By quantifying the response, we can measure the construct. The study will use existing indicators from previous studies to demonstrate validity and reliability in measuring the constructs of Integration, Real-time capability, Virtualisation, Decentralisation, Service Orientation, Modularity, Digitalisation, Human Resource Skills, Servitisation Outcomes, Innovation Capability, Improved Value Chain, and Firm Performance. Generating a sample of items involves reviewing previous literature to discover the construct dimensions and items that can be used to measure the construct (Sethi and King, 1991). Existing literature can provide the item measures instead of having to create a new measure that needs to follow its process of rigor (Bhattacherjee, 2012). The instrument selection will utilise a structured questionnaire using a seven-point Likert scale to assess the responses ranging from 1-"Strongly Agree" to 7 "Strongly Disagree". Likert scales measure ordinal data and use constructed statements where the user can respond according to the extent of agreement or disagreement on a five or seven-point scale (Bhattacherjee, 2012). Likert scales offer more refined responses compared to binary items and provide simplicity for participants to read and complete (Bhattacherjee, 2012). Furthermore, Likert scales are likely to provide reliable scales (Bertram, 2016). Structured questionnaires are closed-ended questions preselected by the researcher to measure the constructs and are commonly used in quantitative studies. Refer to appendix B.

The research instrument assessed 13 constructs with 62 questions, including 4 control questions in total. However, after the data analysis was performed, the total number of constructs was reduced to 10. I4.0 capabilities consisted of 8 constructs, these being Integration, Real-time capability, Virtualisation, Decentralisation, Service Orientation, Modularity, Digitalisation, Human Resource Skills. Integration was measured using 7 items to reflect the variations and integration present within the business area or organisation. Real-time was measured using 3 items to determine the presence of real-time systems internal and external to the organisation or BU; Decentralisation was measured using 3 items to

determine the presence of decentralised decision-making; Service Orientation was measured using 5 items to determine the focus and degree of service offerings by the organisation or BU; Modularity was measured using three items to determine if systems use a modular design; Virtualisation used 3 measures to determine the current presence and the ability for an organisation or BU to become virtual; Human resources was measure using 5 items to determine leadership and employee skills and competence and presence of I4.0 knowledge; Digitalisation was measured using 7 items to determine the degree of digitalisation within the organisation or BU. The dependent variable, Servitisation Outcomes were measured using 5 items to determine the customer value from the I4.0 complementary capability. Innovation Capability was measured using 4 items to evaluate the level of innovation, Improved Value Chain was measured using 3 items to determine the product or service efficiencies and lastly, Firm Performance, consisting of Operational and Competitive Performance, was measured by these 2 constructs. Operational performance measures consisted of five items representing cost reduction, reliability, quality, and reduced delivery time (Nevo and Wade, 2011). Competitive performance was evaluated through 5 items which indicate improved effectiveness, competitive positioning, market share, profitability, and market adaptability (Kim and Baek, 2018; Nevo and Wade, 2011). Table 7 provides a summary of these constructs. The full table of constructs is available in appendix A.

*Table 7. Summarised Constructs*

| **Construct** | **Conceptual Definition** | **Quantity of items** | **Example** | **Reference** |
|---|---|---|---|---|
| Integration | The capability of an organisation or business area to establish an interconnected value chain. It is the ability to establish networks between information systems, people, and structures. | 7 | "There is a business and Information Technology (IT) integration across different levels of the organisation or business area." | (Fan and Luo, (Sarantis, Charalabidis and Psarras, 2008; Majeed and Rashid, 2010; Ranganathan, Teo and Dhaliwal, 2011; Marin-Garcia, Alfalla-Luque and Medina-López, 2013; Fan and Luo, 2014; Mikalef and Pateli, 2016) |
| Real-time capability | Real-time capability is the combination of interactive processing, full networking, and integration of the | 3 | "Our organisation measures product or service delivery in real-time." | (Yazici, 2014; Ghouri and Mani, 2019; |

| | | | | |
|---|---|---|---|---|
| | functional areas utilising real-time data | | | Akesson *et al.*, 2021) |
| Decentralisation | It is the ability of companies, operation staff, and even devices can make independent decisions rather than depending on the centralised decision-making. | 3 | "Decision-making is done faster and is automated where possible" | (Andersen and Segars, 2001; Juul Andersen, 2005; Futcher and Sunjka, 2018) |
| Service Orientation | The capability of an organisation or business to build a service-orientated architecture and processes to achieve customer value. | 5 | "The product is designed appropriately for service by our organisation or business area" | (Sousa and da Silveira, 2017; Abou-Foul, Ruiz-Alba and Soares, 2020; Jang, Bae and Kim, 2020) |
| Modularity | The ability for organisations or business areas to develop a modular architecture using modules that can be independently developed, maintaining autonomy, easily configurable, and flexible to support changing features of a system or product when required. | 3 | "Information Technology (IT) systems are modular" | (Tu *et al.*, 2004; Cohen and Olsen, 2013) |
| Virtualisation | The ability to build virtual capabilities to support business objectives. | 3 | "Our organisation or business area is able to become virtual" | (Liu, Sia and Wei, 2008) |
| Digitalisation | The ability to implement capabilities or resources that a business will need to operate in a digital environment. | 6 | "There is a high level of digitalisation in your organisation business model." | (Abou-Foul, Ruiz-Alba and Soares, 2020; Niemand *et al.*, 2020) |
| Human Resources | The human enablers constitute skills and competencies from employees that maximize the effective implementation of I4.0 principles and capabilities. | 5 | "There is a development of employee skills, capabilities, and improvement processes with regard to Industry 4.0 technologies and capabilities" | (Bermúdez and Juárez, 2017; Futcher and Sunjka, 2018) |
| Servitisation outcomes | The ability to achieve customer value through service-orientated structures. | 6 | "The digital products or services provided by our organisation meets customer needs" | (Wang, Tang and Tang, 2001; Petrick, 2002; Korda and Snoj, 2010) |

| | | | | |
|---|---|---|---|---|
| Innovation Capability | The organisation's capacity to foster innovation by creating products and services that generate profits and provide a competitive advantage. | 4 | "The Industry 4.0 complementary capability enables the organisation or business area to provide innovative products or services." | (Nagaraju, 2015) |
| Improved value chain | The ability to optimize the value chain activities to produce products and services of value. | 3 | "The Industry 4.0 complementary capability enables the organisation or business area to provide reliable high-quality products or services" | (Wang, Tang and Tang, 2001; Carlos Fandos Roig *et al.*, 2006; Dalenogare *et al.*, 2018; Salam, 2019) |
| Operational advantage | The ability to optimize operations through cost reduction, reliability, quality and reduced delivery time. | 4 | "The Industry 4.0 complementary capability helps the organisation or business area to reduce costs." | (Nevo and Wade, 2011) |
| Competitive advantage | The ability to outperform competitors by adapting to changing conditions achieving profitability, market share and adaptability. | 5 | "The Industry 4.0 complementary capability provides the organisation or business area with a competitive advantage." | (Nevo and Wade, 2011a; Alkhalaf *et al.*, 2012; Kim and Baek, 2018) |

### 4.3.2 Sampling and Respondents

The unit of analysis is the principal subject that the study will investigate (Bhattacherjee, 2012). Sampling involves selecting a specific target population of interest, based on criteria being representative of the general population so that the results can be measured statistically to derive specific outcomes (Bhattacherjee, 2012). This study investigated the effect of I4.0 as a complementary capability on Firm Performance within financial services in South Africa. Therefore, the unit of analysis for this study comprises the business areas within financial services organisations in South Africa. Specifically, the sampling frame comprised a list of South African financial services organisations with their underlying organisational structure. For smaller to medium financial services organisations, the organisation as a whole would be the unit of analysis. As an example, some banking organisations have a federated business model that has various divisions focusing on different target markets, each with a Chief Executive Officer (CEO) responsible for the decision-making within the area. A small to medium financial services organisation may not have divisions; hence, the organisation as a whole was targeted. The sampling frame is a subset of the target population, from which the sample is collected (Bhattacherjee, 2012). Non-probability expert-based sampling was followed in selecting the financial organisations for the study. Non-probability expert

sampling follows an approach in which the researcher selects participants that can be accurately determined based on their expertise in the research study (Bhattacherjee, 2012). The sampling frame made use of accessible online directories containing the names of financial services in South Africa. The survey targeted business and IT decision-makers. Business and IT decision-makers are categorised as those individuals with the authority to make decisions on the organisation and IT strategy and capabilities. This comprised of CEOs or mandated representation, Chief Information Officers (CIOs) or mandated representation, Chief Financial Officers (CFOs) or mandated representation, Chief Operating Officers (COOs), or mandated representation, strategic managers, technical managers, and project managers. The sample size was determined by the size of the target population within financial services. The total population size was estimated at 1500 with a confidence level of 70%, margin of error of 5% with a population proportion of 50%. The sample size of 100 participants across financial organisations was calculated.

### 4.3.3 Strategy for pre-and pilot testing

Pilot testing ensures rigor by sending out a sample to a small target population to ensure there is construct validity and reliability in the measures. The approach allows for the feedback loop to provide insight into ensuring that the instruments used are actually measuring what they are supposed to accommodate for changes based on the feedback (Bhattacherjee, 2012). A limited group from the target population underwent pilot testing. The questionnaire was distributed and seven pilot responses were received to discover biases, ambiguity, and missing values in the question-wording. This process identified inconsistencies in the questionnaire which were then corrected and aligned. The final items and constructs being measured can be found in Appendix A. The intent was to ensure the survey instrument was an adequate tool for collecting data in testing the proposed hypotheses.

### 4.3.4 Questionnaire administration

For the study, the questionnaire administration was conducted using web-based questionnaires that were distributed via a web survey link. In addition, the snowballing effect is used to ensure success in data collection. The snowball approach refers to a methodology in which survey participants are selected based on specific target audience criteria and then asked to share the survey with others in their network who match the same profile. The permission letter can be found in Appendix G. The Human Resources departments of the respondents and clearance from the University of Witwatersrand were obtained before the distribution of the questionnaires to respondents. The questionnaire accommodated for anonymity, and the context of the study was provided to the potential respondents through electronic communication.

## 4.4 Data Analysis Methods

The data analysis methods within quantitative analysis consist of descriptive and inferential analysis whereby the former uses statistical methods to explain the data collected, and the latter is the statistical method used for hypothesis testing (Bhattacherjee, 2012). The study made use of both methods as discussed below:

### 4.4.1 Reliability and validity

Reliability is the extent to which the item is actually measuring the construct consistently in that the scores in one indicator are also associated with the scores on other indicators (Bryman and Bell, 2007; Bhattacherjee, 2012). The same results should ideally be produced every time the construct is being measured (Bhattacherjee, 2012). There are multiple ways to measure reliability; they are Test-Retest reliability, inter-rater reliability, split-half reliability, and internal reliability. For this study, the internal reliability test was conducted using Cronbach's Alpha. Since internal reliability measures the steadiness between the items of a construct (Bhattacherjee, 2012), Cronbach's Alpha indicated the correlation between the items. Cronbach Alpha calculates the average of split-half reliability coefficients (Bryman and Bell, 2007). Higher Cronbach Alpha scores between items within the constructs imply stronger internal consistency and hence, higher stability (Bryman and Bell, 2007). An acceptable score of 0.7 and above indicates good reliability (Bhattacherjee, 2012). Convergent validity assesses how well items measure the intended construct, while discriminant validity gauges how distinct the item is from measuring other constructs (Sethi and King, 1991). The study made use of factor analysis to assess convergent validity, where the loadings against each construct are measured against itself, indicating the degree of convergent validity. Item loadings greater than 0.70 indicates strong convergent validity. Secondly, convergent validity is assessed by observing the square root of the average variance extracted, since it indicates the average deviation that the construct accounts for at least 50% of the measured variance (Nevo and Wade, 2011). Discriminant validity was tested by assessing the square root of the average extracted (AVE). The ave for a construct's measures must be higher than the correlations between the construct and other constructs in the research model (Nevo and Wade, 2011). Lower loadings against other constructs, meaning the items of a construct, do not measure another construct.

### 4.4.2 Hypothesis testing

Hypothesis testing makes use of inferential statistics. Multiple and hierarchical regression with interaction terms analysis was used for hypothesis testing. Multiple regression is a statistical method that examines how one or more independent variables are related to a dependent variable (Mooi and Sarstedt, 2014). Field (2013) explains that hierarchical regression involves entering independent variables into the model in stages, with each stage

representing a different set of predictors. By examining the change in variance explained by each set of predictors, researchers can determine the incremental contribution of each set of variables to the prediction of the dependent variable since there are multiple independent variables. The independent variables are Integration, Decentralisation, Virtualisation, Modularity, Real-time capability, Servitisation, Digitalisation. And Human Resource Skills. The primary objective of regression analysis is to understand how changes in the independent variables are related to changes in the dependent variable. This indicates how changes in the independent variables are related to changes in the dependent variable and to use of this information to make predictions or inferences about the relationship between the variables in a larger population (Field, 2013). The level of statistical significance of a regression coefficient is noted by the p-value, where P is the probability that the observed sample is significant and not by chance. A p-value of <= 0.05 is significant, this means for every 100 samples, the chances of being incorrect may lie in less than 5 observations, and is an indication of confidence in the significance level (Bhattacherjee, 2012). A p-value <= 0.05 is considered to support the hypotheses and suggest inferences, and reject the null hypothesis (Bhattacherjee, 2012).

## 4.5 Ethical Considerations

Several ethical codes have been developed to establish principles and provide guidance when conducting research. Rosenthal (1994) raises several ethical considerations when conducting research studies. Some of the concerns that were addressed were to ensure the research is adequately designed and to avoid inefficiencies. The recruitment process ensured the selection of participants is conducted fairly, also resulting in fair outcomes (Marczyk, DeMatteo, and Festinger, 2005). It is important to inform the participant of the purpose and rationale of the research where the researcher should avoid hype claiming and causism (Rosenthal, 1994). Participants were allowed voluntary consent to participate and were allowed to withdraw from the study at any time (Marczyk, DeMatteo, and Festinger, 2005). Following the notion of informed consent, a consent form should accompany the study approved by the associated institute and signed by the participant in language that is understandable and clear (Marczyk, DeMatteo, and Festinger, 2005). All consent by the conducting institute and participant organisations were approved. Adherence to anonymity and confidentiality was followed in the research process avoiding disclosure of the participant's identity (Bhattacherjee, 2012). The study informed participants about how they are assessed and reported in the results of the study (Bhattacherjee, 2012). This research study followed the rules and regulations presented by the University of Witwatersrand. Ethical clearance for the instrument was obtained from the ethical committee of the university, and adherence to ethical conduct was followed diligently. Consent from participants was obtained before issuing the questionnaire. All data collected was kept private and confidential, ensuring all risks are minimised. There was no influence on

participants to feel obligated to participate. Withdrawal to participate was accommodated, and no harm was inflicted upon the participants.

## 4.6 Summarised Limitations and Threats to Validity

Internal Validity ensures that the question around the relational relationship between the independent and dependent variable does exist and to what extent (Bryman and Bell, 2007). The administration of the questionnaires and survey demonstrated consistency. By performing a pre-test on the instrument, consistency, and hence, internal validity was ensured. External validity refers to the extent to which a study's results are generalizable to the wider population (Bhattacherjee, 2012). This study focused on financial institutions within South Africa and is not generalisable for global economies or organisations outside the domain of study.

## 4.7 Conclusion

The chapter also introduced the various aspects of the research process which are the research methodology and the study's design. The chapter then introduced the various components of the data collection process, such as the collection of samples, the pre-designed questionnaires, and data analysis. In conclusion, ethical considerations and study limitations were addressed. In the next section, the data collected is reviewed and analysed to draw conclusions based on the proposed hypotheses.

# CHAPTER 5 – DATA ANALYSIS

## 5.1 Introduction

This chapter presents data analysis results. After screening, missing data and outliers are handled, and response patterns checked. Descriptive analysis portrays responses, followed by instrument reliability and validity testing. The chapter concludes with correlation and regression analyses for hypothesis and mediation testing.

## 5.2 Data Screening

Data collected through the outlined survey method yielded 102 responses, including 7 from the pilot study. These were excluded. 95 responses were further evaluated. 19 of the 95 were excluded based on incomplete data with a substantial amount of missing data. The survey was active for 7 months. There were 21 incomplete responses of which 19 were excluded resulting in 76 completed and valid responses which were included for data analysis. The achieved response rate fell below the target rate. The survey strategy adopted involved identifying target participants through social media platforms such as Linked In and emailing the survey to the participants. This strategy failed to produce the results that were expected therefore the snowball strategy was also adopted that utilised participants to distribute the survey to suitable individuals within the financial industry.

### 5.2.1 Missing Data

The missing data analysis on the remaining 95 responses was conducted, generating descriptive frequency tables for each question refer to Appendix D. Table 8 shows the summary of the findings. Most participants completed all the questions with an exception of 21 incomplete surveys. Initially, there were 19 items above the 10% missing variable threshold considered. These were excluded. In addition, 2 items were missing below 10% of the data i.e. The last 2 items from each survey were missing. An independent sample T-test was utilised for missing data and to assess correlations with the other variables. The test results revealed random missing responses, unrelated to the other variables. The mean replacement strategy was then used to determine the missing values. This resulted in 76 survey responses before the outlier analysis that was considered.

*Table 8. Distribution of Total Missing Responses before Outliers*

| Total number of questions | Number of questions with missing Data | Items with above 10% missing variables | Items with below 10% missing variables | Items used on Mean replacement strategy | Total number of surveys considered |
|---|---|---|---|---|---|
| 95 | 21 | 19 | 2 | 2 | 76 |

### 5.2.2 Outlier Analysis

An essential consideration for researchers is outlier analysis to ensure responses align with the study's population. This method assists in identifying individuals who were not from the study's interest group. According to Bhattacherjee (2012), standardised scores that deviate from the mean by more or less 3 standard deviations should be considered extreme values. As part of the outlier analysis, the standardized scores were determined on SPSS and assessed (refer to appendix E). Responses 35, 28, and 38 were identified as extreme outliers with composite scores of more or less 3 standard deviations. These responses were removed as indicated in table 9. Table 10 provides a summary of the final valid number of surveys considered in the study after excluding the outliers.

*Table 9. Extreme outlier descriptives*

| Respondent | Construct | Count | % of the construct items |
|---|---|---|---|
| 35 | Innovation capability | 1 | 25% |
| | Operational performance | 1 | 20% |
| | Competitive Performance | 1 | 20% |
| 28 | Operational performance | 1 | 20% |
| | Competitive Performance | 1 | 20% |
| 38 | Service Orientation | 1 | 20% |

*Table 10. Summary of the total missing responses*

| Total number of questions | Number of questions with missing Data | Items with above 10% missing variables | Items with below 10% missing variables | Items used on Mean replacement strategy | Extreme outliers excluded | Total number of surveys considered |
|---|---|---|---|---|---|---|
| 95 | 21 | 19 | 2 | 2 | 3 | 73 |

## 5.3 Respondent Profile

### 5.3.1 Job Titles

The descriptive statistics for the 73 participants are classified in table 11 below. The survey's target audience focused on Business and IT decision-makers. The job titles reflect respondents that are suited to business and IT initiatives related to I4.0 capabilities. The survey results show that department heads, IT managers, and project or scrum masters were the top respondents at 27.4%, 24.7%, and 21.9%, respectively. This indicates a high level of confidence in the survey responses, as these individuals are likely to have a good understanding of the long-term and operational strategies of their business area or the overall organisation. The senior executive's response rate fell within the lower quartile, with CIOs providing an 8.2% response rate and CEOs providing only 1.4%. Senior executives are typically involved in strategic decision-making and their input would provide greater confidence in the collected data. Therefore, a higher response rate was anticipated from this group. However, overall, the respondents indicate a good confidence level for the study. Figure 13 indicates the graphical histogram of the participants.

*Table 11. Statistical Summary per Title*

| Title | Count | Percent (%) |
|---|---|---|
| CIO | 6 | 1% |
| CEO | 1 | 1.4% |
| Department head | 20 | 27.4% |
| IT Manager | 18 | 24.7% |
| Product Owner | 1 | 1.4% |
| Project Manager/ Scrum Master | 16 | 21.9% |
| Strategy or Development Manager/ Lead | 11 | 15.1% |
| **Total** | **73** | **100%** |

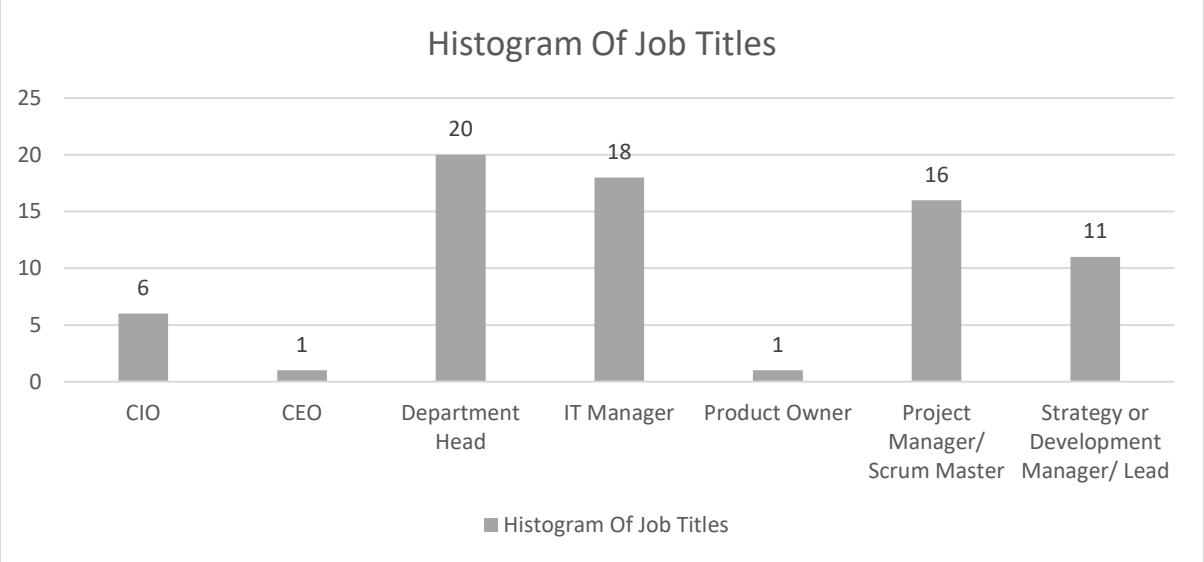


Figure 13. Histogram of Job Titles

### 5.3.2 Industry

Industries were subcategorised indicating all possible sectors within the financial services. Financial services were included as one of the options to cover sectors not catered for or missed from the list. Technology is considered as IT or Technology services rendered in financial services. Fintech represented as tech start-ups are also regarded as technology services. The survey results show that banking represented by Retail and Commercial banking and Investment management were the top respondents at 27.4%, and 15% respectively. This indicates a good representation in the survey responses, since banking accounts for the majority of South Africa's assets (International Monetary Fund. Monetary and Capital Markets Department, 2022). The response rates from the Technology and Legislation and Regulation sectors were lower than anticipated, at 3% and 7% respectively. This was unexpected since the distribution of the survey covered the respective sectors equally. A higher response rate was expected from these sectors to ensure a more balanced representation in the study. Despite this, the overall industry sector splits were deemed adequate for the study. Figure 14 provides a graphical histogram of the industries involved in the study.

*Table 12. Statistical Summary per Industry*

| Industry | Count | Valid Percent |
|---|---|---|
| Digital Bank | 3 | 4% |
| Financial Services | 2 | 3% |
| Fintech | 9 | 12% |
| Insurance | 8 | 11% |
| Investment Management | 11 | 15% |
| Legislation and Regulation | 5 | 7% |
| Retail and Commercial bank | 33 | 45% |
| Technology | 2 | 3% |
| **Total** | **73** | **100%** |

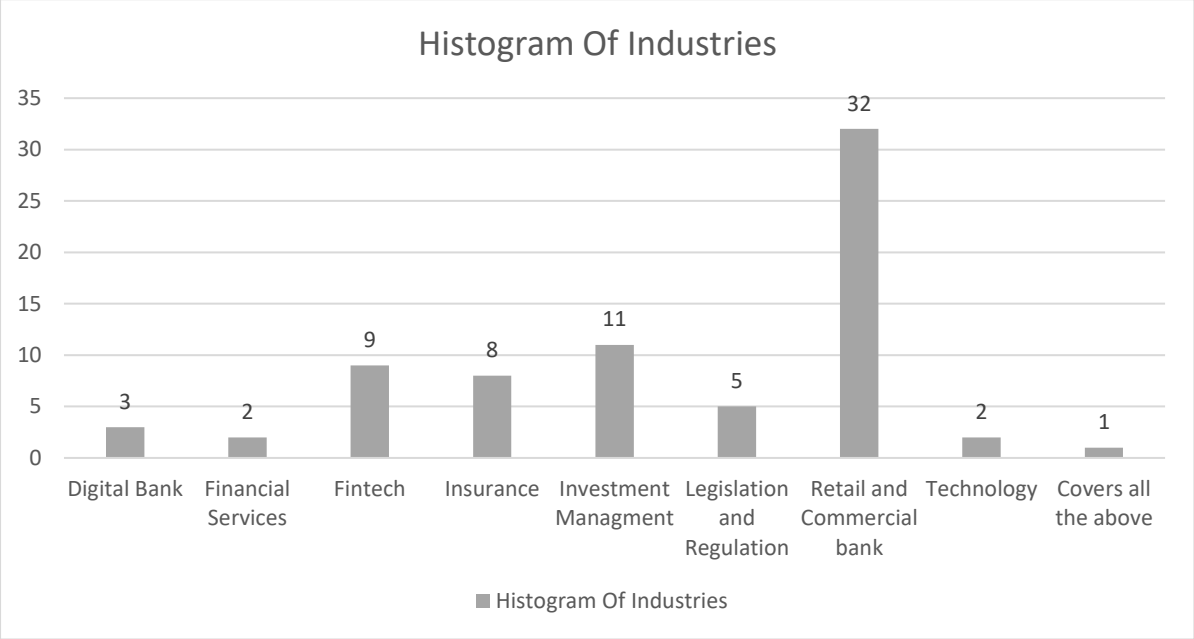


Figure 14. Histogram of Industries

### 5.3.3 Organisation or business area size

Size relates to a business area or organisation size measured as the number of employees. This skews the view since some participants may have indicated the business area size. This has been noted as a limitation of the study since additional control questions could mitigate the issue. Size as a control indicated the highest overall response from smaller to medium-sized organisations at 31.5%. It is important to note that SMEs, which are defined as organisations with 1 to 500 employees, constituted a significant proportion of the total responses at 43.8%. However, larger organisations with a size greater than 500 accounted for 57.5% of the total responses. This provides a well-rounded perspective on the organisation

size of the study participants, with a balanced representation of both smaller and larger organisations. Figure 15 provides a graphical histogram of organisation size involved in the study.

*Table 13. Statistical Summary per Size*

| Size | Count | Percent |
|---|---|---|
| 1-200 | 23 | 31,5% |
| 201-500 | 8 | 11,0% |
| 501-1000 | 9 | 12,3% |
| 1001- 5000 | 7 | 9,6% |
| 5001-10000 | 8 | 11% |
| 10001-40000 | 9 | 12,3% |
| >40001 | 9 | 12,3% |
| **Total** | **73** | **100,0** |

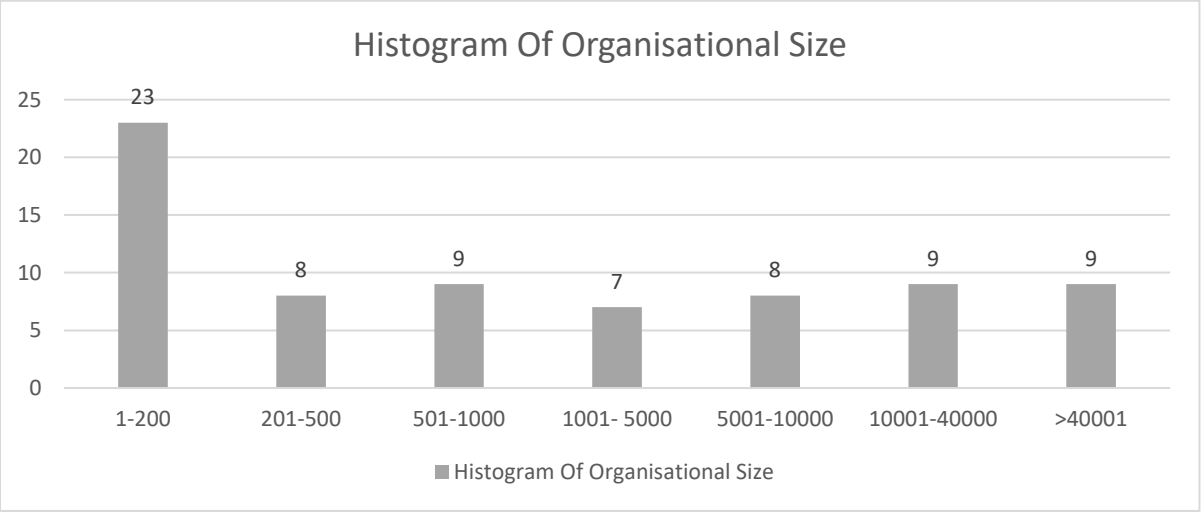


Figure 15. Histogram of Organisational Size

## 5.3.4 Organisational Age

Organisational age indicates years operational. According to the survey results, the majority of responses were received from older, well-established organisations that have been in operation for over 21 years, accounting for 67.1% of the total responses. On the other hand, the organisations that have been operational for 11-15 years had the lowest number of responses. It should be noted that startups are typically defined as organisations that have

been operating for 1-10 years, while mature organisations are those that have been operating for more than 10 years. This suggests that the majority of responses were provided by well-established organisations, with a total of 83.6% of responses coming from older organisations and 16.4% coming from startups. Therefore, the survey results can provide valuable insights into the practices of established organisations. Figure 16 provides a graphical histogram of organisation age involved in the study.

*Table 14. Statistical Summary based on Age*

| Organisational Age (Years) | Count | Percent |
|---|---|---|
| 0-5 | 6 | 8,2% |
| 6-10 | 6 | 8,2% |
| 11-15 | 4 | 5,5% |
| 16-20 | 8 | 11% |
| >21 | 49 | 67.1% |
| Total | 73 | 100 |

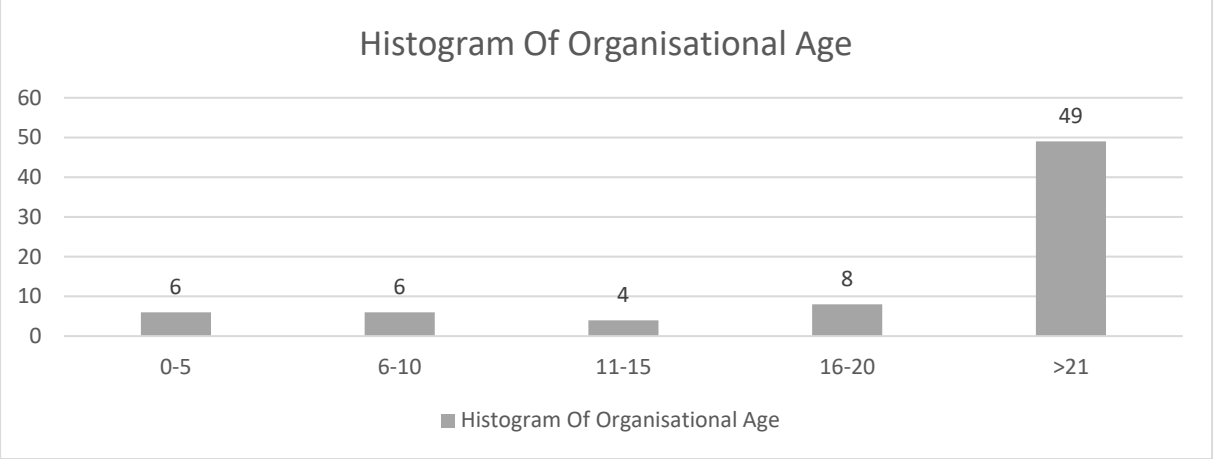


Figure 16. Histogram of Age

## 5.3.5 Descriptive statistics on the Industry 4.0 Complementary capability

The I4.0 Complementary capability used 8 constructs each with its measures.

- Integration
- Real-time capability
- Decentralisation
- Service Orientation
- Modularity
- Virtualisation

- Digitalisation
- Human Resource Skills

These are discussed individually.

### 5.3.5.1 Integration

The construct employed seven measures (Integration1, Integration2, Integration3, Integration4, Integration5, Integration6, and Integration7) to assess the level of integration between IT and business within organisations or business areas. The results presented in Table 15 show that Integration1, Integration2, and Integration5 have a mean score greater than 5, indicating on average, the respondents generally agreed with the statement that their organisation or business areas have IT and business integration, including functional system integration. Furthermore, the descriptive statistics reveal that there is a presence of digital service applications that are compatible with information systems. Integration3, Integration 4, Integration6 and Integration7 have mean scores closer to five, which suggests that on average, the respondents leaned towards somewhat agreeing that the organisation or business areas can aggregate information from stakeholders, there's also horizontal streamlined processes, compatibility of external applications with existing information systems and operability between internal and external stakeholders. Overall, the items suggest that there is a moderate level of integration in the surveyed organisations or business areas, with some aspects being more established better than others.

*Table 15. Integration Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Integration1** | "There is a business and Information Technology (IT) integration across different levels of the organisation or business area." | 3 | 7 | 5,47 | 1,131 |
| **Integration2** | "There is system integration of similar functionality across different levels of our organisation or business area. For example, an internal system that links various branches of an organisation to share a single view of customer data." | 2 | 7 | 5,21 | 1,462 |
| **Integration3** | "There are streamlined business processes with suppliers, distributors, and customers. For example, automation of the supply chain management." | 1 | 7 | 4,67 | 1,214 |
| **Integration4** | "Our organisation can aggregate relevant information from business partners, service providers, and | 1 | 7 | 4,85 | 1,266 |

| | | | | | |
|---|---|---|---|---|---|
| | customers. For example, operating information or business customer performance." | | | | |
| **Integration5** | "There is a compatibility of digital service applications with existing information systems." | 2 | 7 | 5,05 | 1,29 |
| **Integration6** | "There is a compatibility of external enterprise applications with existing information systems." | 1 | 7 | 4,7 | 1,371 |
| **Integration7** | "There is a degree of interoperability between the organisation stakeholders, business partners and customers." | 1 | 7 | 4,93 | 1,171 |

### 5.3.5.2 Real-Time Capability (RT)

The construct employed three measures (RT1, RT2, RT3) to assess the level of real-time capabilities within organisations or business areas. The results presented in Table 16 show that RT1 has a mean score closer to five indicating that on average, most respondents somewhat agree that their organisation or business areas have real-time systems projects in development. RT2 suggests on average, the respondents leaned towards somewhat agreeing that there are real-time data within the organisation or business areas. However, RT3 suggests on average respondents were unsure if service delivery was measured in real-time. Overall, the items suggest that there is a low to moderate level of real-time capabilities in the surveyed organisations or business areas, with some aspects being more established better than others.

*Table 16. Real-Time Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **RT1** | "There are development projects for real-time embedded systems in our organisation or business area." | 1 | 7 | 4,92 | 1,561 |
| **RT2** | "Data and other valuable resources are accessible in real time from business partners, service providers, and customers." | 1 | 7 | 4,56 | 1,374 |
| **RT3** | "Our organisation measures product or service delivery in real time." | 1 | 7 | 4,07 | 1,636 |

### 5.3.5.3 Decentralisation

The construct of Decentralisation employed three measures, namely (Decentralisation1, Decentralisation2, Decentralisation3) to assess the level of Decentralised capabilities within organisations or business areas. The results presented in Table 17 show that Decentralisation2 has a mean score greater than five indicating that most respondents on average somewhat agree that their organisation or business areas use data for decision-making. Decentralisation3 showed on average, the respondents leaned towards somewhat agreeing on decentralised decision-making being present within the organisation or business area. However, Decentralisation1 suggests on average, respondents were unsure about faster and automated decision-making. Overall, the items suggest that there is a moderate level of decentralisation within the surveyed organisations or business areas, with some aspects being more established better than others.

*Table 17. Decentralisation Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Decentralisation1** | "Decision-making is done faster and is automated where possible." | 2 | 7 | 4,30 | 1,288 |
| **Decentralisation2** | "Decision-making is enabled by data and analysis." | 2 | 7 | 5,32 | 1,223 |
| **Decentralisation3** | "Decision-making is dispersed amongst empowered employees." | 2 | 7 | 4,70 | 1,340 |

### 5.3.5.4 Service Orientation

The construct of Service Orientation employed five measures, namely (Service Orientation 1, Service Orientation 2, ServiceOrientation3, ServiceOrientation4, ServiceOrientation5) to assess the level of Service Orientated capabilities within organisations or business areas. The results presented in Table 18 show that ServiceOrientation1, ServiceOrientation3, and ServiceOrientation4 have a mean score greater than five indicating that respondents on average somewhat agree that there is senior leadership driving servitisation, the product is designed adequately for servitisation and their operational functions to expand servitisation within the organisation or business areas. ServiceOrientation2 and ServiceOrientation5 Decentralisation3 showed on average, the respondents leaned strongly towards somewhat agreeing on the skills and capabilities and the implementation of post-product service within the organisation or business area. Overall, the items suggest that there is a moderate level of service orientation present within the surveyed organisations or business areas.

*Table 18. Service Orientation Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Service Orientation1** | "Our senior leaders are actively promoting a vision of the future that involves servitised offerings." | 2 | 7 | 5,32 | 1,246 |
| **Service Orientation2** | "The organisation has invested in the necessary skills and capabilities to provide servitised offerings." | 2 | 7 | 4,93 | 1,388 |
| **Service Orientation3** | "The product is designed appropriately for service by our organisation or business area." | 2 | 7 | 5,07 | 1,134 |
| **Service Orientation4** | "There is a high level of implementation for expanding the service offering to your customers. (e.g., by investing in new service development)" | 3 | 7 | 5,33 | 1,081 |
| **Service Orientation5** | "There is a high level of implementation for designing products or services so that the after-sales service is easier to manage. (e.g., design for maintenance)" | 2 | 7 | 4,77 | 1,161 |

### 5.3.5.5 Modularity

The construct employed three measures, namely (Modularity1, Modularity2, Modularity3) to assess the level of modularity within organisations or business areas. The results presented in Table 19 suggest that for all items on average, the respondents leaned towards somewhat agreeing that systems and products or services are built in a modular way within the organisation or business areas. Overall, the items suggest that there is a moderate level of modularity in the surveyed organisations or business areas.

*Table 19. Modularity Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Modularity1** | "Information Technology (IT) systems are modular." | 1 | 7 | 4,62 | 1,391 |
| **Modularity2** | "Our product or service uses a modularised design. " | 1 | 7 | 4,53 | 1,375 |
| **Modularity3** | "Our products or services can be customised by adding feature modules as requested." | 1 | 7 | 4,58 | 1,404 |

### 5.3.5.6 Virtualisation

The construct employed three measures, namely (Virtualisation1, Virtualisation2, Virtualisation3) to assess the level of virtualised capabilities within organisations or business areas. The results presented in Table 20 have a mean score greater than five indicating that respondents on average generally agree that the organisation or business areas have the potential to create and use virtual capabilities. In general, the results suggest that the surveyed organisations or business areas have a moderate level of capabilities to become virtual.

*Table 20.Virtualisation  Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Virtualisation1** | "Our organisation or business area is able to become virtual." | 2 | 7 | 5,37 | 1,439 |
| **Virtualisation2** | "It is possible for my organisation or business area to become virtual." | 2 | 7 | 5,55 | 1,179 |
| **Virtualisation3** | "Becoming virtual is within my organisation or business area's capabilities." | 2 | 7 | 5,34 | 1,250 |

### 5.3.5.7 Human Resource Skills (HRS)

The construct employed five measures, namely (HRS1, HRS2, HRS3, HRS4, HRS5) to assess the level of human resources skills required for I4.0 capabilities within organisations or business areas. The results are presented in Table 21. HRS2 and HRS3 have a mean score greater than five showing that on average, respondents generally agreed that employees work in a culture of empowerment, risk-taking, innovation, and flexibility. There was also agreement that leadership and employees possess the necessary skills for digital transformation. For HRS1, HRS4, and HRS5, respondents leaned towards generally agreed that leaders have digital knowledge and skills and that there is a focus on employee skills development with knowledge bases that support I4.0 capabilities. In general, the results suggest that the surveyed organisations or business areas have a moderate level of people skills that support I4.0 capabilities.

*Table 21. Human Resources Skills Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **HRS1** | "Leaders are be digitally fluent and knowledgeable in the organisation or business area." | 2 | 7 | 4,85 | 1,255 |
| **HRS2** | "There is a culture in the organisation or business area that promotes flexibility, innovation and encourages risk-taking, and employees are empowered." | 1 | 7 | 5,05 | 1,332 |
| **HRS3** | "Leaders have the ability to transform their organisations, and employees have the ability to implement digital initiatives." | 3 | 7 | 5,08 | 1,140 |
| **HRS4** | "There is knowledge, management of software and interfaces that support Industry 4.0 capabilities within the organisation or business area." | 2 | 7 | 4,85 | 1,186 |
| **HRS5** | "There is development of employee skills, capabilities and improvement processes with regard to Industry 4.0 technologies and capabilities." | 1 | 7 | 4,88 | 1,142 |

## 5.3.5.8 Digitalisation

The construct employed seven measures, namely (Digitalisation1, Digitalisation2, Digitalisation3, Digitalisation4, Digitalisation5, Digitalisation6, Digitalisation7) to assess the level of Digitalisation required for I4.0 capabilities within the organisations or business areas. The results, presented in Table 22 indicate a mean score greater than five for all items except Digitalisation2. They show that on average, respondents generally agreed that there is a high level of digitalisation including the use of digital technologies to enhance product and service value and create channels to provide drive customer value. For Digitalisation2, respondents leaned towards generally agreed to processes are automated. In general, the results suggest that the surveyed organisations or business areas have a high level of digitalisation to support I4.0 capabilities.

*Table 22. Digitalisation Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Digitalisation1** | "There is a high level of digitalisation in your organisation business model." | 2 | 7 | 5,10 | 1,260 |
| **Digitalisation2** | "Our core processes are automated." | 2 | 7 | 4,85 | 1,277 |
| **Digitalisation3** | "We are using digital technologies (such as analytics, social media, mobile, and embedded devices) to understand our customers better." | 1 | 7 | 5,36 | 1,398 |
| **Digitalisation4** | "We market and sell our products and services through digital channels." | 2 | 7 | 5,47 | 1,365 |
| **Digitalisation5** | "We use digital channels to collaborate with business partners and to provide customer services." | 1 | 7 | 5,36 | 1,337 |
| **Digitalisation6** | "We use digital technologies to increase the performance or added value of our existing products and services." | 2 | 7 | 5,62 | 1,221 |
| **Digitalisation7** | "The digital products or services provided by our organisation meets customer needs." | 2 | 7 | 5,14 | 1,032 |

## 5.3.6 Dependent variables

## 5.3.6.1 Servitisation Outcomes (SO)

The construct employed five measures, namely (SO1, SO2, SO3, SO4, SO5) to investigate whether a correlation exists between I4.0 complementary capability and Servitisation Outcomes. The findings of the study are presented in Table 23. Based on the results, it appears that the respondents generally agreed that there is an improvement in customer satisfaction and an increased understanding of customer concerns due to the implementation of the I4.0 complementary capability indicated under SO3 and SO5. Furthermore, the data suggest that on average, the respondents tended to agree that products and services can be customised, and that the pricing and support provided are relevant and reasonably represented under SO1, SO2, and SO4. Overall, the result suggests there is a favourable relationship between I4.0 complementary capability and Servitisation Outcomes.

*Table 23. Servitisation Outcomes Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **SO1** | "The Industry 4.0 complementary capability enables the organisation to offer products or services that are customised for each individual customer." | 1 | 7 | 4,64 | 1,408 |
| **SO2** | "The Industry 4.0 complementary capability enables the organisation to offer a reasonable price and ensure cost savings for customers." | 1 | 7 | 4,82 | 1,183 |
| **SO3** | "Customer needs are satisfied through products and services provided by the Industry 4.0 complementary capability." | 3 | 7 | 5,00 | 0,986 |
| **SO4** | "The Industry 4.0 complementary capability enables consistent support to be provided during the use of the product and service." | 3 | 7 | 4,93 | 0,991 |
| **SO5** | "The Industry 4.0 complementary capability enables the organisation or business area to better understand customer problems and requests." | 3 | 7 | 5,18 | 1,072 |

### 5.3.6.2 Improved Value Chain (VC)

The construct employed three measures, namely (VC1, VC2, VC3) to investigate whether a correlation exists between I4.0 complementary capability and Improved Value Chain. The findings of the study are presented in Table 24 with favourable mean scores. The results suggest that the respondents generally agreed that the implementation of the I4.0 complementary capability has led to reliable, high-quality, adaptable, and better decision-making within the value chain's products and services, resulting in an overall improvement in the value chain. Overall, the result suggests, that the implementation of I4.0 complementary capability has a favourable effect on improving the value chain.

*Table 24. Improved Value Chain Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **VC1** | "The Industry 4.0 complementary capability enables the organisation or business area to provide reliable high-quality products or services." | 3 | 7 | 5,34 | 0,961 |
| **VC2** | "The Industry 4.0 complementary capability allows for the ability to make rapid design changes." | 3 | 7 | 4,97 | 1,130 |

| | | | | | |
|---|---|---|---|---|---|
| **VC3** | "The Industry 4.0 complementary capability improved the decision-making process." | 2 | 7 | 5,16 | 1,106 |

### 5.3.6.3 Innovation Capability (IC)

The construct employed three measures, namely (IC1, IC2, IC3, IC4) to investigate whether a correlation exists between I4.0 complementary capability and Innovation capabilities. The findings of the study are presented in Table 25. The results suggest that the respondents generally agreed that the implementation of I4.0 complementary capability has resulted in the development of innovative products or services and the utilisation of innovative technologies within the organisation or business area that impacts the financial services industry. These are represented under IC1 and IC2. Furthermore, the data suggest that on average, the respondents tended to agree that the implementation of I4.0 complementary capability resulted in the development of performance-driving and competitive advantage innovations, which are represented under IC3 and IC4. Overall, the result suggests, that the implementation of I4.0 complementary capability has a favourable effect on creating innovative capabilities.

*Table 25. Innovation Capability Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **IC1** | "The Industry 4.0 complementary capability enables the organisation or business area to provide innovative products or services." | 3 | 7 | 5,33 | 1,068 |
| **IC2** | "The Industry 4.0 complementary capability enables the organisation or business area to use innovations which use technologies that have an impact on or cause significant changes in the whole industry." | 3 | 7 | 5,15 | 1,101 |
| **IC3** | "A majority of our organisation or business area's innovations use new technologies that permit quantum leaps in performance through the implementation of the Industry 4.0 complementary capability." | 2 | 7 | 4,56 | 1,118 |
| **IC4** | "The majority of our innovations offer our customers a unique advantage over competitors' products through the implementation of the Industry 4.0 complementary capability." | 2 | 7 | 4,67 | 1,119 |

### 5.3.6.4 Firm performance: Operational Performance (OP) and Competitive Performance (CP)

Firm Performance employed five measures, namely OP1, OP2, OP3, OP4, OP5 to investigate the relationship between I4.0 complementary capability and Operational Performance. The results of the study, as presented in Table 26 show favourable mean scores in all five measures. This suggests that the respondents generally agreed that the implementation of the I4.0 complementary capability led to cost reduction, increased revenue, improved operational quality, better efficiency and reliability of operations and products, and services. Overall, the result suggests, that the implementation of I4.0 complementary capability has a favourable effect on Operational Performance.

*Table 26. Operational performance Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **OP1** | "The Industry 4.0 complementary capability helps the organisation or business area to reduce costs." | 2 | 7 | 5,12 | 1,213 |
| **OP2** | "The Industry 4.0 complementary capability helps the organisation or business area to increase revenue." | 2 | 7 | 5,07 | 1,159 |
| **OP3** | "The Industry 4.0 complementary capability built improves quality of operations." | 3 | 7 | 5,41 | 0,879 |
| **OP4** | "The Industry 4.0 complementary capability enables the organisation or business area to reduce lead time for products or services delivered." | 3 | 7 | 5,42 | 1,053 |
| **OP5** | "The Industry 4.0 complementary capability improves the reliability of operations." | 3 | 7 | 5,32 | 1,117 |

Competitive Performance employed five measures, namely (CP1, CP2, CP3, CP4, CP5) to investigate the relationship between I4.0 complementary capability and Competitive Performance. The results of the study, as presented in Table 27 show favourable mean scores in all five measures. This suggests that the respondents generally agreed that the implementation of I4.0 complementary capability led to competitive advantage, increased profitability, driven delivery efficiency, and enhanced the organisation or business area to adapt to changes. CP7 with a mean score of 4.75 suggests that on average, the respondents tended to agree that the implementation of I4.0 complementary capability resulted in an increased market share. Overall, the result suggests, that the implementation of I4.0 complementary capability has a favourable effect on Competitive Performance.

*Table 27. Competitive performance Statistical Summary*

| Item | Survey Question | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **CP6** | "The Industry 4.0 complementary capability provides the organisation or business area with a competitive advantage." | 3 | 7 | 5,30 | 1,076 |
| **CP7** | "The Industry 4.0 complementary capability has expanded our market share consistently." | 3 | 7 | 4,75 | 1,103 |
| **CP8** | "The Industry 4.0 complementary capability helps us to improve financial profitability." | 3 | 7 | 5.00 | 1,061 |
| **CP9** | "The Industry 4.0 complementary capability provides the ability to introduce new products or services more quickly than competitors." | 3 | 7 | 5,05 | 1,053 |
| **CP10** | "The Industry 4.0 complementary capability enables the organisation or business area to respond more quickly to change." | 3 | 7 | 5,23 | 1,074 |

## 5.4 Scale Validity and Reliability

A review was undertaken to analyse the different constructs and their components. The review involved utilising various methods such as bivariate correlation analysis, reliability testing, and principal components analysis (PCA). Bivariate analysis was employed to evaluate the extent to which items within the same set were related to each other. A stronger correlation (convergent validity) should be observed among items from the same construct, compared to different constructs (discriminant validity). To evaluate the validity of a variable's construct, it is necessary to ensure that the items from the same set are highly correlated. This can be accomplished using the principal components approach.

The principal components analysis is a technique that can be used to look closely at the underlying structure of a variable's data. It can provide us with evidence of the variable's unidimensionality by showing that the various measurements of the variable are highly correlated to a single component. Convergent validity measures of a given variable should be similar to other similar measures to provide a comprehensive analysis. On the other hand, a discriminant validity measure should be different from other similar measures to provide a more accurate and reliable analysis. The principal components analysis provides us with proof of convergent validity by showing that all of the items that are related to the variable's construct are highly correlated with one another. Additionally, it offers evidence of discriminant validity by demonstrating that items with low cross-loadings perform inadequately when compared to other components. The Kaiser-Meyer-Olkin (KMO)and Bartlett test of sphericity factor analysis procedure take into account sampling adequacy, which is the minimum acceptable value for the sample. A value closer to 1 is more suitable indicating that there is enough variance in the data for factor analysis and the p-value

indicates the underlying variables are significantly correlated. It also takes into account the commonalities of the items and the minimum acceptable value. The reliability test, on the other hand, is a measure of internal consistency that is derived from Cronbach's Alpha. The Cronbach Alpha is a measure of the extent to which the scale or group of questions are related indicating how well these items measure the latent variable or construct. All dimensions were assessed for reliability and validity within the model to provide a more holistic assessment of the reliability of items.

### 5.4.1 Industry 4.0 Complementary Capability and Dependent Variables analysis

I4.0 Complementary Capability has 8 variables namely Integration, Real-time capability, Decentralisation, Service Orientation, Modularity, Virtualisation, Human resource skills, and Digitalisation. The dependent variables consist of 4 variables namely Firm Performance, Innovation capability, Servitisation outcomes, and Value creation. The initial PCA was conducted on all the model variables and revealed a 12-component solution. A significance level of 0.5 and greater was considered on the PCA loadings for all components. The values below were suppressed. The KMO and Bartlett's tests were conducted to indicate if the items are factorable and the reliability test was for internal consistency. Each construct is discussed which followed an iterative process to achieve a stable final solution. Lastly, the summary of the final scale is discussed.

#### 5.4.1.1 Integration

Integration was measured using 7 items. The initial PCA was run to demonstrate unidimensionality, and convergent and discriminant validity. Reliability was tested using the Cronbach alpha revealing a significant value of .884 KMO of .832 with an item-to-total correlation above 0.3. Integration is regarded as new IT arrangements composed of various segments such as technology, business applications, infrastructure, and internal and external expansion to support its implementation. All items were retained.

*Table 28.: Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Integration1 | | .652 | | | | | | | | |
| Integration2 | | .669 | | | | | | | | |
| Integration3 | | .733 | | | | | | | | |
| Integration4 | | .739 | | | | | | | | |
| Integration5 | | .682 | | | | | | | | |
| Integration6 | | .590 | | | | | | | | |
| Integration7 | | .762 | | | | | | | | |

### 5.4.1.2 Real-Time

Real-time was measured using 3 items with an initial Cronbach alpha of .817 with a KMO above 0.500 at 0.687 with an item-to-total correlation above 0.3. The real-time capability allows organisations and devices to share real-time information and make optimised decisions regarding current or future operations. RT1 initially displayed an insignificant loading considering that all values were suppressed below 0.5. RT2 and RT3 loaded highly on a single component. A single-factor solution was also run showing significant loadings on a single factor. Thus, all items were retained and assessed after the multiple iterations considering other constructs to see if a stable solution emerged. The final loading resulted in a stable single-factor loading on all RT variables which were retained.

*Table 29. Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| RT1 | | | | | | | | | | | | |
| RT2 | | | | | | | | | | .705 | | |
| RT3 | | | | | | | | | | .828 | | |

*Table 30. Final loading of retained real-time items*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| RT1 | | | | | | | | | .548 | |
| RT2 | | | | | | | | | .814 | |
| RT3 | | | | | | | | | .805 | |

### 5.4.1.3 Decentralisation and Service Orientation (D_SO)

Decentralisation was measured using 3 items with an initial Cronbach alpha of .761 with a KMO of 0.680 and an item-to-total correlation above 0.3. Decentralisation1 loaded highly on another factor and a review against the definition was performed. Decentralisation can be defined as the ability of people and machines that allow systems to autonomously make decisions without relying on a centralised decision-making body and is achieved through the use of various technologies. Decentralisation 1 was removed and the PCA was rerun.
Decentralisation1 and 2 then loaded strongly against the same factors as Service Orientation indicating a conceptual overlap. Service Orientation involves designing a service-orientated architecture that is embedded within processes to deliver precisely what a customer wants. Service Orientation 1 and 5 were insignificant and removed. The final rerun produced single-factor loadings across Decentralisation and Service Orientation. A single-factor solution was also run showing significant loadings on a single factor for both constructs. The results showed that Decentralisation and Service orientation items loaded together and therefore a combined construct was created, “Decentralisation and Service Orientation” (D_SO). The construct is measured by 5 items that reflect the service-oriented architecture and process which requires the existence of a decentralised system design and decision-making to better

offer goods and services to precisely meet customer wants. The final measures of the Cronbach alpha of .891 with a KMO of 0.833 and an item-to-total correlation above 0.3

*Table 31. Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Decentralisation1 | | | | | | | | | | .759 | | |
| Decentralisation2 | | | | | .670 | | | | | | | |
| Decentralisation3 | | | | | | | | | | | | |
| ServiceOrientation1 | | | | | .509 | | | | | | | |
| ServiceOrientation2 | | | | | .672 | | | | | | | |
| ServiceOrientation3 | | | | | .640 | | | | | | | |
| ServiceOrientation4 | | | | | .634 | | | | | | | |
| ServiceOrientation5 | | | | | | | | | | | | |

*Table 32. Single factor model*

| | Component 1 |
|---|---|
| Decentralisation2 | .830 |
| Decentralisation3 | .757 |
| ServiceOrientation2 | .847 |
| ServiceOrientation3 | .874 |
| ServiceOrientation4 | .864 |

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

*Table 33. Retained factor loading for decentralisation and service orientation items*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Decentralisation2 | | | | .777 | | | | | | |
| Decentralisation3 | | | | .541 | | | | | | |
| ServiceOrientation2 | | | | .690 | | | | | | |
| ServiceOrientation3 | | | | .600 | | | | | | |
| ServiceOrientation4 | | | | .603 | | | | | | |

### 5.4.1.4 Modularity

Modularity was measured using 3 items with a Cronbach alpha of .918at a KMO of 0.726 and an item-to-total correlation above 0.3. The PCA was also run to demonstrate unidimensionality, and convergent and discriminant validity. All items displayed strong loadings against a single component demonstrating convergent and discriminant validity. The concept of modularity refers to the process of decomposing a product or system into re-combinable modules that are composed of multiple components which can be adapted to meet different requirements and needs. All items were retained.

*Table 34. Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Modularity1 | | | | | | | .738 | | | |
| Modularity2 | | | | | | | .750 | | | |
| Modularity3 | | | | | | | .666 | | | |

### 5.4.1.5 Virtualisation

Virtualisation was measured using 3 items with a strong Cronbach alpha of .918 with a KMO of 0.767 and an item-to-total correlation above 0.3. The PCA indicated significant loadings on a single component. A review of the definition, Virtualisation involves developing a virtual model of the physical world resulting in all items being retained.

*Table 35. Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Virtualisation1 | | | | | | | | .840 | | |
| Virtualisation2 | | | | | | | | .881 | | |
| Virtualisation3 | | | | | | | | .847 | | |

### 5.4.1.6 Human Resource Skills (HRS)

Human resources were measured using 5 items with a strong Cronbach alpha of .899 with a KMO of 0.866 and an item-to-total correlation above 0.3. The PCA indicated significant loadings on a single component illustrating convergent and discriminant validity. A review of the definition. The human enablers that constitute skills and competencies from employees that maximise the effective implementation of I4.0 resulted in all items to be retained. All items were retained.

*Table 36. Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| HS1 | | | | | .657 | | | | | |
| HS2 | | | | | .682 | | | | | |
| HS3 | | | | | .646 | | | | | |
| HS4 | | | | | .703 | | | | | |
| HS5 | | | | | .745 | | | | | |

### 5.4.1.7 Digitalisation

Digitalisation was measured using 7 items with an initial Cronbach alpha of .888 with a KMO of 0.890. The PCA indicated significant loadings on a single component except items 1 &2. Digitalisation represents an approach to developing new business models through the integration of products, services, processes, and people based on emerging digital technologies (Yvonne Lederer Antonucci, Fortune, and Kirchmer, 2021). Upon review of the definition and the cross-loading, Items 1 and 2 were removed the PCA was rerun. The final PCA demonstrated singles loading for which a forced single-factor solution was run showing single loadings. Digitalisation 3,4,5,6,7 was retained at a Cronbach alpha of 0.906 with a KMO of .884 and an item-to-total correlation above 0.3.

*Table 37. Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Digitalisation1 | | | | | | | | | | | |
| Digitalisation2 | | | | | | | | | | | .718 |
| Digitalisation3 | | | .739 | | | | | | | | |
| Digitalisation4 | | | .716 | | | | | | | | |
| Digitalisation5 | | | .856 | | | | | | | | |
| Digitalisation6 | | | .747 | | | | | | | | |
| Digitalisation7 | | | .540 | | | | | | | | |

*Table 38. Retained factor loading for Digitalisation items*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Digitalisation3 | | | .753 | | | | | | | |
| Digitalisation4 | | | .740 | | | | | | | |
| Digitalisation5 | | | .864 | | | | | | | |
| Digitalisation6 | | | .769 | | | | | | | |
| Digitalisation7 | | | .550 | | | | | | | |

### 5.4.1.8 Servitisation Outcomes (SO) and Improved Value Chain (VC)

Servitisation Outcomes and improved Value Chain were assessed together since the different constructs measured against the same factor indicated a conceptual overlap. Servitisation involves transitioning from providing traditional products to offering comprehensive customer-oriented bundles that incorporate goods, services, support, and knowledge(Münch *et al.*, 2022a) thus it is customer-centric. A review of the survey measures indicates alignment to value outcomes. SO were measured using 4 items at an initial Cronbach alpha of .851 with a KMO of .785. SO1 loaded against another factor and was removed. The PCA rerun however the loadings against the same factor loadings remained. Improved Value chain with 4 measures was also assessed. VC3 and VC4 were removed due to insignificance and cross-loadings. The PCA was rerun however the single factor loading across both constructs pertained. A review of the survey items was then done. VC3 and VC4 measures also indicated it is more aligned with the objective of Servitisation Outcomes which measures the extent of value outcomes. A single-factor solution was run and displayed significant loadings against a single component with a Cronbach alpha of .854, KMO of .777, and an item-to-total correlation above 0.3. The loadings were acceptable against a single factor thus a decision to combine the SO and VC to create a combined variable called, Value Outcomes (VO). Value outcomes were synthesised to measure the outcomes of having a customer-centric capability with value-added services bundled as a total offering with products and services to deliver customized solutions that are designed to meet specific customer needs increasing customer satisfaction (Martín-Peña, Sánchez-López, and Díaz-Garrido, 2019; Jang, Bae, and Kim, 2020; Münch *et al.*, 2022). This also impacted hypotheses 3 and 4 which are discussed in the section on hypothesis testing.

*Table 39. Retained factor loading for Digitalisation items*

| | Component | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| SO1 | | | | | | .503 | | | | | |
| SO2 | | | | | | | | | .752 | | |
| SO3 | | | | | | | | | .674 | | |
| SO4 | | | | | | | | | .643 | | |
| VC1 | | | | | | | | | .578 | | |
| VC2 | | | | | | | | | .512 | | |
| VC3 | | | | | | | | | | | |
| VC4 | | | | | | | .530 | | | | |

*Table 40: Single factor model*

**Component Matrix[a]**

| | Component 1 |
|---|---|
| SO2 | .789 |
| SO3 | .862 |
| SO4 | .826 |
| VC2 | .858 |
| VC3 | .632 |

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

*Table 41. Retained factor loading for servitsation outcomes and improve value chain renamed Value Outcomes items*

| | Component 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| SO2 | | | | | | .725 | | | | |
| SO3 | | | | | | .685 | | | | |
| SO4 | | | | | | .691 | | | | |
| VC1 | | | | | | .614 | | | | |
| VC2 | | | | | | .630 | | | | |

### 5.4.1.9 Innovation Capability (IC)

Innovation was measured using 4 items with an initial Cronbach alpha of .888 with a KMO of 0.890. The PCA indicated significant loadings on a single component except for IC1 and IC2. Innovation capability is the ability and competencies of the organisation to absorb, adapt and transform technologies into management and operational routines that will yield organisation profits based on the innovative activities implemented (Calantone, Cavusgil, and Zhao, 2002; Zawislak et al., 2012). Upon review of the definition and the cross-loading, Items 1 and 2 were removed the PCA was rerun. The final PCA demonstrated single loading for which a forced single-factor was run showing single loadings. IC3 and IC4 were retained at a Cronbach alpha of 0.773 with a KMO of .500 and an item-to-total correlation above 0.3.

*Table 42. Principal Component Analysis (PCA) using Varimax rotation*

| Component 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IC1 | | | | | | | | | | | |
| IC2 | .652 | | | | | | | | | | |
| IC3 | | | | | | | .746 | | | | |
| IC4 | | | | | | | .759 | | | | |

*Table 43. Single-factor single factor model*

**Component Matrix[a]**

| | Component 1 |
|---|---|
| IC3 | .944 |
| IC4 | .944 |

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

*Table 44. Retained factor loading for Innovation capabilities items*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| IC3 | | | | | | | | | | .767 |
| IC4 | | | | | | | | | | .741 |

### 5.4.1.10 Firm Performance (FP)

Firm Performance was measured using 10 items in total. Firm performance constitutes Firm performance and competitive performance. All items loaded against a single factor therefore this construct was assessed under Firm performance.

Firm performance was measured using 5 items with an initial Cronbach alpha of .901 with a KMO of 0.846 and an item-to-total correlation above 0.3. Firm performance represents the performance of an organisation in terms of cost reduction, increased revenue, increased quality, reliability, and faster delivery (Chahal et al., 2020; Demeter and Losonci, 2020; Nevo and Wade, 2011). Competitive performance was measured using 5 with an initial Cronbach alpha of .907 with a KMO of 0.814 and an item-to-total correlation above 0.3 Competitive performance can be regarded as the degree to which an organisation's ability to produce and sell products and services that outperform its domestic competitors. Therefore, competitive performance for this study relates to the capacity of an organisation to increase market share, and financial profitability, improve its competitive positioning, and flexibility to adapt to market changes. The PCA indicated significant loadings on a single component except for the cross-loading on CP5. CP5 was removed and the PCA was rerun resulting in a more stable

solution. A single-factor solution was run. The retained items were treated as a single construct due to the single loadings. This construct is referred to as Firm Performance (FP) resulting in a Cronbach alpha of .941 with a KMO of 0.915 and an item-to-total correlation above 0.3.

*Table 45. Principal Component Analysis (PCA) using Varimax rotation*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| OP1 | .860 | | | | | | | | | |
| OP2 | .794 | | | | | | | | | |
| OP3 | .700 | | | | | | | | | |
| OP4 | .585 | | | | | | | | | |
| OP5 | .652 | | | | | | | | | |
| CP1 | .792 | | | | | | | | | |
| CP2 | .721 | | | | | | | | | |
| CP3 | .791 | | | | | | | | | |
| CP4 | .613 | | | | | | | | | |
| CP5 | .573 | | | | | | .531 | | | |

*Table 46. Single factor model*

**Component Matrix[a]**

| | Component 1 |
|---|---|
| FP1 | .874 |
| FP2 | .830 |
| FP3 | .861 |
| FP4 | .752 |
| FP5 | .799 |
| FP6 | .851 |
| FP7 | .839 |
| FP8 | .882 |
| FP9 | .734 |

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

*Table 47. Retained factor loading for Innovation capabilities items*

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| FP1 | .860 | | | | | | | | | |
| FP2 | .794 | | | | | | | | | |
| FP3 | .700 | | | | | | | | | |
| FP4 | .585 | | | | | | | | | |
| FP5 | .652 | | | | | | | | | |
| FP6 | .781 | | | | | | | | | |
| FP7 | .767 | | | | | | | | | |
| FP8 | .820 | | | | | | | | | |
| FP9 | .611 | | | | | | | | | |

## 5.5 Summary of Final Loadings

The final PCA resulted in 11 items being dropped due to cross-loading and insignificant loadings to arrive at a more stable solution.

*Table 48. Items dropped after testing*

| Construct | Variable Number | Item |
|---|---|---|
| **Decentralisation** | Decentralisation1 | Decision-making is done faster and is automated where possible. |
| **Digitalisation** | Digitalisation1 | There is a high level of digitalisation in your organisation business model. |
| | Digitalisation2 | Our core processes are automated. |
| **Service Orientation** | ServiceOrientation1 | Our senior leaders are actively promoting a vision of the future that involves servitised offerings. |
| | ServiceOrientation5 | There is a high level of implementation for designing products or services so that the after-sales service is easier to manage. (e.g., design for maintenance) * |
| **Servitisation outcomes** | SO1 | The Industry 4.0 complementary capability enables the organisation to offer products or services that are customised for each individual customer. |
| **Value Chain** | VC3 | The Industry 4.0 complementary capability allows for the ability to make rapid design changes. |
| | VC4 | The Industry 4.0 complementary capability improved the decision-making process. |

| | | |
|---|---|---|
| **Innovation Capability** | IC1 | The Industry 4.0 complementary capability enables the organisation or business area to provide innovative products or services. |
| | IC2 | The Industry 4.0 complementary capability enables the organisation or business area to use innovations which use technologies that have an impact on or cause significant changes in the whole industry. |
| **Competitive Performance** | CP5 | The Industry 4.0 complementary capability enables the organisation or business area to respond more quickly to change. |

The final model resulted in 47 items with a 10-factor solution with a final KMO and Bartlett's test of sphericity value of 0.798 at a significance or p-value <.001 and a Cronbach alpha of .965.

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .798 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 3247.566 |
| | df | 1081 |
| | Sig. | <,001 |

**Reliability Statistics**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .963 | .965 | 47 |

Figure 17. KMO and bartlett's test and Cronbach alpha reliability statistics

## 5.5.1 Communalities Between Items

Communalties measure the amount of variance accounted for by each item in the scale. The extraction values all are above 0.5 which is acceptable for the respective variation explained.

*Table 49. Communalities between items*

| **Communalities** | | |
|---|---|---|
| | Initial | Extraction |
| Integration1 | 1,000 | 0,757 |
| Integration2 | 1,000 | 0,767 |
| Integration3 | 1,000 | 0,684 |
| Integration4 | 1,000 | 0,765 |
| Integration5 | 1,000 | 0,790 |
| Integration6 | 1,000 | 0,623 |
| Integration7 | 1,000 | 0,730 |
| RT1 | 1,000 | 0,753 |
| RT2 | 1,000 | 0,834 |
| RT3 | 1,000 | 0,795 |

| | | |
|---|---|---|
| Decentralisation2 | 1,000 | 0,808 |
| Decentralisation3 | 1,000 | 0,687 |
| ServiceOrientation2 | 1,000 | 0,770 |
| ServiceOrientation3 | 1,000 | 0,736 |
| ServiceOrientation4 | 1,000 | 0,765 |
| Modularity1 | 1,000 | 0,834 |
| Modularity2 | 1,000 | 0,858 |
| Modularity3 | 1,000 | 0,785 |
| Virtualisation1 | 1,000 | 0,878 |
| Virtualisation2 | 1,000 | 0,888 |
| Virtualisation3 | 1,000 | 0,899 |
| HRS1 | 1,000 | 0,721 |
| HRS2 | 1,000 | 0,756 |
| HRS3 | 1,000 | 0,725 |
| HRS4 | 1,000 | 0,767 |
| HRS5 | 1,000 | 0,772 |
| Digitalisation3 | 1,000 | 0,813 |
| Digitalisation4 | 1,000 | 0,772 |
| Digitalisation5 | 1,000 | 0,875 |
| Digitalisation6 | 1,000 | 0,854 |
| Digitalisation7 | 1,000 | 0,690 |
| VO1 | 1,000 | 0,782 |
| VO2 | 1,000 | 0,790 |
| VO3 | 1,000 | 0,842 |
| VO4 | 1,000 | 0,837 |
| VO5 | 1,000 | 0,817 |
| IC3 | 1,000 | 0,827 |
| IC4 | 1,000 | 0,832 |
| FP1 | 1,000 | 0,859 |
| FP2 | 1,000 | 0,825 |
| FP3 | 1,000 | 0,795 |
| FP4 | 1,000 | 0,750 |
| FP5 | 1,000 | 0,772 |
| FP6 | 1,000 | 0,846 |
| FP7 | 1,000 | 0,801 |
| FP8 | 1,000 | 0,837 |
| FP9 | 1,000 | 0,759 |
| Extraction Method: Principal Component Analysis. | | |

### 5.5.2 Factor extraction

The total variance explains how factors are retained to explain the variance in the model. Eigenvalues less than 1 are excluded. The retained components account for the observed variance in the data. The cumulative rotation sums of squared have a value of 79%. This

indicates that 10 factors explain 79%% of the total variance which is acceptable as it exceeds 60%.

*Table 50. Total variance*

| **Total Variance Explained** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 18,233 | 38,794 | 38,794 | 18,233 | 38,794 | 38,794 | 6,389 | 13,593 | 13,593 |
| 2 | 4,044 | 8,605 | 47,398 | 4,044 | 8,605 | 47,398 | 4,498 | 9,570 | 23,163 |
| 3 | 2,876 | 6,120 | 53,518 | 2,876 | 6,120 | 53,518 | 4,135 | 8,797 | 31,960 |
| 4 | 2,640 | 5,616 | 59,135 | 2,640 | 5,616 | 59,135 | 3,924 | 8,349 | 40,309 |
| 5 | 2,108 | 4,486 | 63,620 | 2,108 | 4,486 | 63,620 | 3,871 | 8,236 | 48,545 |
| 6 | 1,733 | 3,688 | 67,308 | 1,733 | 3,688 | 67,308 | 3,339 | 7,103 | 55,649 |
| 7 | 1,680 | 3,575 | 70,883 | 1,680 | 3,575 | 70,883 | 3,324 | 7,072 | 62,721 |
| 8 | 1,469 | 3,125 | 74,008 | 1,469 | 3,125 | 74,008 | 3,140 | 6,681 | 69,402 |
| 9 | 1,176 | 2,503 | 76,510 | 1,176 | 2,503 | 76,510 | 2,323 | 4,943 | 74,344 |
| 10 | 1,163 | 2,475 | 78,985 | 1,163 | 2,475 | 78,985 | 2,181 | 4,641 | 78,985 |
| 11 | 0,892 | 1,897 | 80,882 | | | | | | |
| 12 | 0,797 | 1,695 | 82,577 | | | | | | |
| 13 | 0,755 | 1,606 | 84,184 | | | | | | |
| 14 | 0,696 | 1,481 | 85,664 | | | | | | |
| 15 | 0,611 | 1,300 | 86,965 | | | | | | |
| 16 | 0,576 | 1,226 | 88,190 | | | | | | |
| 17 | 0,512 | 1,090 | 89,280 | | | | | | |
| 18 | 0,447 | 0,952 | 90,232 | | | | | | |
| 19 | 0,396 | 0,843 | 91,075 | | | | | | |
| 20 | 0,394 | 0,839 | 91,914 | | | | | | |
| 21 | 0,354 | 0,754 | 92,668 | | | | | | |
| 22 | 0,320 | 0,681 | 93,349 | | | | | | |
| 23 | 0,311 | 0,662 | 94,011 | | | | | | |
| 24 | 0,282 | 0,599 | 94,610 | | | | | | |
| 25 | 0,251 | 0,534 | 95,144 | | | | | | |
| 26 | 0,239 | 0,509 | 95,654 | | | | | | |
| 27 | 0,232 | 0,493 | 96,147 | | | | | | |
| 28 | 0,201 | 0,427 | 96,574 | | | | | | |
| 29 | 0,195 | 0,416 | 96,990 | | | | | | |
| 30 | 0,172 | 0,365 | 97,355 | | | | | | |
| 31 | 0,162 | 0,345 | 97,700 | | | | | | |
| 32 | 0,157 | 0,334 | 98,034 | | | | | | |
| 33 | 0,141 | 0,300 | 98,334 | | | | | | |
| 34 | 0,116 | 0,248 | 98,582 | | | | | | |
| 35 | 0,099 | 0,211 | 98,792 | | | | | | |
| 36 | 0,088 | 0,188 | 98,980 | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 37 | 0,078 | 0,166 | 99,147 | | | | | | |
| 38 | 0,068 | 0,145 | 99,291 | | | | | | |
| 39 | 0,062 | 0,131 | 99,423 | | | | | | |
| 40 | 0,053 | 0,112 | 99,535 | | | | | | |
| 41 | 0,047 | 0,101 | 99,635 | | | | | | |
| 42 | 0,039 | 0,083 | 99,719 | | | | | | |
| 43 | 0,033 | 0,071 | 99,790 | | | | | | |
| 44 | 0,031 | 0,065 | 99,855 | | | | | | |
| 45 | 0,027 | 0,058 | 99,913 | | | | | | |
| 46 | 0,026 | 0,055 | 99,968 | | | | | | |
| 47 | 0,015 | 0,032 | 100,000 | | | | | | |
| Extraction Method: Principal Component Analysis. | | | | | | | | | |

## 5.5.2 Final PCA Loading

The final PCA loading indicates single loadings across all variables. This indicates consistent reliability and validity across the items.

**Rotated Component Matrix[a]**

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Integration1 | | .652 | | | | | | | | |
| Integration2 | | .669 | | | | | | | | |
| Integration3 | | .733 | | | | | | | | |
| Integration4 | | .739 | | | | | | | | |
| Integration5 | | .682 | | | | | | | | |
| Integration6 | | .590 | | | | | | | | |
| Integration7 | | .762 | | | | | | | | |
| RT1 | | | | | | | | | .548 | |
| RT2 | | | | | | | | | .814 | |
| RT3 | | | | | | | | | .805 | |
| Decentralization2 | | | | .777 | | | | | | |
| Decentralization3 | | | | .541 | | | | | | |
| ServiceOrientation2 | | | | .690 | | | | | | |
| ServiceOrientation3 | | | | .600 | | | | | | |
| ServiceOrientation4 | | | | .603 | | | | | | |
| Modularisation1 | | | | | | | .738 | | | |
| Modularisation2 | | | | | | | .750 | | | |
| Modularisation3 | | | | | | | .666 | | | |
| Virtualisation1 | | | | | | | | .840 | | |
| Virtualisation2 | | | | | | | | .881 | | |
| Virtualisation3 | | | | | | | | .847 | | |
| HRS1 | | | | | .657 | | | | | |
| HRS2 | | | | | .682 | | | | | |
| HRS3 | | | | | .646 | | | | | |
| HRS4 | | | | | .703 | | | | | |
| HRS5 | | | | | .745 | | | | | |
| Digitalisation3 | | | .753 | | | | | | | |
| Digitalisation4 | | | .740 | | | | | | | |
| Digitalisation5 | | | .864 | | | | | | | |
| Digitalisation6 | | | .769 | | | | | | | |
| Digitalisation7 | | | .550 | | | | | | | |
| VO2 | | | | | | .725 | | | | |
| VO3 | | | | | | .685 | | | | |
| VO4 | | | | | | .691 | | | | |
| VO5 | | | | | | .614 | | | | |
| VO6 | | | | | | .630 | | | | |
| IC3 | | | | | | | | | | .767 |
| IC4 | | | | | | | | | | .741 |
| FP1 | .860 | | | | | | | | | |
| FP2 | .794 | | | | | | | | | |
| FP3 | .700 | | | | | | | | | |
| FP4 | .585 | | | | | | | | | |
| FP5 | .652 | | | | | | | | | |
| FP6 | .781 | | | | | | | | | |
| FP7 | .767 | | | | | | | | | |
| FP8 | .820 | | | | | | | | | |
| FP9 | .611 | | | | | | | | | |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 11 iterations.

Figure 18: Final Principal Component Analysis (PCA) using Varimax rotation

## 5.6 Hypothesis Testing

After following the reliability and validity testing the PCA indicated the dependent variables namely SO and VC loaded against a single factor resulting in combining the measures into a single new variable called Value Outcomes (VO). Hypothesis 3 and 4 were thus impacted and combined into a single hypothesis. The loading for OP and CP also indicated a single factor loading which was combined into a single overall variable indicated as FP. Hypothesis 1a and 1b were thus impacted and combined into a single hypothesis. Hypothesis 2 was not impacted and remained the same. The updated hypotheses are indicated below:

*Table 51. Initial Hypotheses*

| | |
|---|---|
| *Hypothesis 1 a* | A complementary system of Industry 4.0 capabilities will have a significant effect on the operational performance of financial organisations |
| *Hypothesis 1 b* | A complementary system of Industry 4.0 capabilities will have a significant effect on the competitive performance of financial organisations |
| *Hypothesis 2* | A complementary system of Industry 4.0 capabilities will have a significant effect on the innovation capability of financial organisations |
| *Hypothesis 3* | A complementary system of Industry 4.0 capabilities will have a significant effect on improving the business value chain of financial organisations |
| *Hypothesis 4* | A complementary system of Industry 4.0 capabilities will have a significant effect on the servitisation outcomes of financial organisations |

*Table 52. Adjusted Hypotheses*

| | |
|---|---|
| *Hypothesis 1* | A complementary system of Industry 4.0 capabilities will have a significant effect on the firm performance of financial organisations |
| *Hypothesis 2* | A complementary system of Industry 4.0 capabilities will have a significant effect on the innovation capability of financial organisations |
| *Hypothesis 3* | A complementary system of Industry 4.0 capabilities will have a significant effect on the value outcomes of financial organisations |

### 5.6.1 Composite Scores: Correlation analysis

Composite scores were obtained by calculating the arithmetic mean for all independent variables that were retained i.e., Integration, Real-time capability, Modularity, Decentralisation & Service Orientation, Virtualisation, Digitalisation, and Human resource skills. Composite scores were also calculated on the dependent variables Value outcomes, Innovation capability, and Firm Performance. All composite scores are denoted by "Composite" and the variable name or alias. A concept of an overall composite I4.0 capability was constructed by taking into account the dimensions of the framework. The analysis

revealed that the dimensions could be combined to form an overall composite I4.0 score. This was done using the component matrix with a single-factor forced solution. The newly formed construct, named Composite_I4.0 capability (CI4C) with a Cronbach Alpha of .860.

*Table 53. Single factor model*

**Component Matrix[a]**

| | Component 1 |
|---|---|
| Composite_Integration | .734 |
| Composite_RT | .680 |
| Composite_D_SO | .824 |
| Composite_Modularisation | .742 |
| Composite_Virtualisation | .662 |
| Composite_HRS | .829 |
| Composite_Digitalisation | .689 |

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Pearson correlation was used since the research used ratio measures. The value of the Pearson correlation shows the strength of a relationship between a variable and another in a linear relationship. Values that are close to one indicate a stronger connection.

*Table 54. Pearson Correlations (R-squared) – I4.0 Complementary capability Firm Performance, Innovation Capability, and Value Outcomes*

| **Correlations** | | | | | |
|---|---|---|---|---|---|
| | | Composite_IC | Composite_VO | Composite_FP | Composite_CI4C |
| Composite_Integration | Pearson Correlation | .302** | .381** | .374** | .714** |
| | Sig. (2-tailed) | 0,010 | 0,001 | 0,001 | 0,000 |
| Composite_RT | Pearson Correlation | .368** | .349** | .393** | .699** |
| | Sig. (2-tailed) | 0,001 | 0,002 | 0,001 | 0,000 |
| Composite_D_SO | Pearson Correlation | .383** | .495** | .499** | .806** |
| | Sig. (2-tailed) | 0,001 | 0,000 | 0,000 | 0,000 |
| Composite_Modularity | Pearson Correlation | .388** | .508** | .455** | .753** |
| | Sig. (2-tailed) | 0,001 | 0,000 | 0,000 | 0,000 |
| Composite_Virtualisation | Pearson Correlation | .355** | .323** | .341** | .692** |
| | Sig. (2-tailed) | 0,002 | 0,005 | 0,003 | 0,000 |

| | | | | | |
|---|---|---|---|---|---|
| Composite_HRS | Pearson Correlation | .466** | .522** | .519** | .810** |
| | Sig. (2-tailed) | 0,000 | 0,000 | 0,000 | 0,000 |
| Composite_Digitalisation | Pearson Correlation | .441** | .606** | .526** | .684** |
| | Sig. (2-tailed) | 0,000 | 0,000 | 0,000 | 0,000 |
| Composite_IC | Pearson Correlation | 1 | .564** | .582** | .525** |
| | Sig. (2-tailed) | | 0,000 | 0,000 | 0,000 |
| Composite_VO | Pearson Correlation | .564** | 1 | .651** | .615** |
| | Sig. (2-tailed) | 0,000 | | 0,000 | 0,000 |
| Composite_FP | Pearson Correlation | .582** | .651** | 1 | .601** |
| | Sig. (2-tailed) | 0,000 | 0,000 | | 0,000 |
| Composite_CI4C | Pearson Correlation | .525** | .615** | .601** | 1 |
| | Sig. (2-tailed) | 0,000 | 0,000 | 0,000 | |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The correlation analysis revealed significant correlations between the dependent variables to the independent variables with an acceptable range of skewness and kurtosis. Firm Performance has a positive and significant relationship with all the independent variables, Integration, Real-time capability, Decentralisation and Service Orientation, Virtualisation, Digitalisation, and Human skills including the overall composite I4CC with significant p values. Innovation Capability has a positive and strong relationship with Integration, Real-time capability, Decentralisation and Service Orientation, Virtualisation, Digitalisation, and Human skills including Composite_I4.0 capability (CI4C) with significant p values. Lastly, Value Outcomes have a positive and significant relationship with Integration, Real-time capability, Decentralisation and Service Orientation, Virtualisation, Digitalisation, and Human skills including the overall composite CI4C with significant p values.

### 5.6.2 Regression Analysis

Firstly, the control variable's Size, Industry, and Organisational Age were assessed in the research model. Thereafter the independent variables for the I4.0 capabilities were considered. Although a bivariate analysis is useful, it does not provide us with the necessary information about the cumulative effect of independent variables on a dependent variable hence multiple regression was used. Multiple regression analysis was further performed since there are multiple independent variables considered within the complementary variable.

### 5.6.2.1 Assumptions

Besides the common assumptions about the reliability of the tests and the normality of the variables, four additional assumptions should not be ignored in the multiple regression analysis. Multicollinearity, Linear Relationships, Heteroscedasticity, and Normality of the residual distribution tests were conducted. The results are available in Appendix F and show non-violations of these assumptions.

### 5.6.2.2 Control Variables

The environmental and organisational characteristics of organisations of varying sizes, ages, and industry may affect their performance hence these factors were included as controls in the model. The dataset incorporated the control values. Industry was recoded into Banks vs Non-Banks. As an example, 'Retail and Commercial bank' was coded as a Bank whilst 'Insurance' was coded as Non-Bank. Age was recoded as follows, 0-10 years is regarded as a start-up, and greater than 11 and established. Lastly, Size (number of employees) was recoded into large organisations where Large is greater than 500 and SME is between 1 and 500. A test to see if the control variables make a difference to the dependent variables was conducted. The Independent T-test was run to determine any significance of the dependent variables.

#### 5.6.2.2.1 Independent T-Test: Organisation Size

*Table 55. Independent T-Test: Organisation Size*

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Significance | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | One-Sided p | Two-Sided p | Mean Difference | Std. Error Difference | Lower | Upper |
| Composite_VO | Equal variances assumed | 4.166 | .045 | 1.500 | 71 | .069 | .138 | .30829 | .20559 | -.10165 | .71824 |
| | Equal variances not assumed | | | 1.559 | 70.842 | .062 | .123 | .30829 | .19774 | -.08601 | .70260 |
| Composite_IC | Equal variances assumed | 2.690 | .105 | -.422 | 71 | .337 | .675 | -.10599 | .25144 | -.60735 | .39537 |
| | Equal variances not assumed | | | -.438 | 70.837 | .331 | .663 | -.10599 | .24186 | -.58827 | .37629 |
| Composite_FP | Equal variances assumed | .023 | .879 | 1.083 | 71 | .141 | .283 | .22794 | .21054 | -.19187 | .64775 |
| | Equal variances not assumed | | | 1.074 | 62.832 | .143 | .287 | .22794 | .21223 | -.19619 | .65207 |

The Levene's sig. values on Value Outcomes is significant at 0.45 however there is no significant difference between the size of organisation on achieving value outcomes, t (71) = 1.559, p= .123. The Levene's sig. values on Innovation Capability are insignificant at .105. There was no significant difference between large and SME organisations in their ability to develop innovation capabilities, t (71) = -.422, p =.675. The Levene's sig. values of 0.105 (Firm Performance) are insignificant. There was no significant difference between large and SME organisations in achieving Firm Performance, t (71) = 1.083, p =.283.

## 5.6.2.2.2 Independent T-Test: Organisation Industry

*Table 56. Independent T-Test: Organisation Industry*

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Significance | | Mean | Std. Error | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | One-Sided p | Two-Sided p | Difference | Difference | Lower | Upper |
| Composite_VO | Equal variances assumed | 1.228 | .272 | -.998 | 71 | .161 | .322 | -.21358 | .21405 | -.64040 | .21323 |
| | Equal variances not assumed | | | -1.054 | 60.339 | .148 | .296 | -.21358 | .20265 | -.61890 | .19173 |
| Composite_IC | Equal variances assumed | 1.401 | .241 | 1.167 | 71 | .124 | .247 | .30033 | .25741 | -.21293 | .81359 |
| | Equal variances not assumed | | | 1.211 | 57.494 | .115 | .231 | .30033 | .24808 | -.19635 | .79701 |
| Composite_FP | Equal variances assumed | .245 | .622 | -.779 | 71 | .219 | .439 | -.16994 | .21818 | -.60498 | .26510 |
| | Equal variances not assumed | | | -.805 | 56.879 | .212 | .424 | -.16994 | .21109 | -.59265 | .25277 |

The Levene's sig. values on Value Outcomes is insignificant at .272, thus there is no significant difference between Banks and Non-Banks on achieving value outcomes, t (71) = -.998, p= .322. The Levene's sig. values on Innovation Capability are insignificant at .241, thus there is no significant difference between Banks and Non-Banks ability to develop innovation capabilities, t (71) = 1.167, p =. 247.The Levene's sig. values of 0.622 on Firm Performance is insignificant, thus there is no significant difference between Banks and Non-Banks organisations in achieving Firm Performance, t (71) = -.779, p =.439.

## 5.6.2.2.3 Independent T-Test: Organisation Age

*Table 57. Independent T-Test: Organisation Age*

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Significance | | Mean | Std. Error | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | One-Sided p | Two-Sided p | Difference | Difference | Lower | Upper |
| Composite_VO | Equal variances assumed | 1.703 | .196 | -.410 | 71 | .342 | .683 | -.11393 | .27817 | -.66860 | .44073 |
| | Equal variances not assumed | | | -.509 | 20.328 | .308 | .616 | -.11393 | .22400 | -.58071 | .35284 |
| Composite_IC | Equal variances assumed | 1.126 | .292 | -.477 | 71 | .317 | .635 | -.15984 | .33522 | -.82825 | .50858 |
| | Equal variances not assumed | | | -.535 | 17.660 | .300 | .600 | -.15984 | .29901 | -.78890 | .46923 |
| Composite_FP | Equal variances assumed | .630 | .430 | .284 | 71 | .388 | .777 | .08045 | .28294 | -.48373 | .64462 |
| | Equal variances not assumed | | | .314 | 17.342 | .379 | .757 | .08045 | .25626 | -.45940 | .62030 |

The Levene's sig. values on Value Outcomes is insignificant at .196, thus there is no significant difference between start-ups and established organisations on achieving Value Outcomes, t (71) = -.410, p= .683. The Levene's sig. values on Innovation Capability is insignificant at .292, thus there is no significant difference between start-ups and established organisations in their ability to develop innovation capabilities, t (71) = -.477, p =. 635.The Levene's sig. values of 0.430 on Firm Performance is insignificant, thus there is no significant difference between Start-ups and established organisations in achieving Firm Performance, t (71) = -.284, p =.777.

### 5.6.2.3 Industry 4.0 complementary capability variables – Hypotheses testing

## Hypotheses 1-3

Hierarchical regression and interaction terms were used to test the hypotheses. This was done to determine the variance and significance of each underlying independent variable i.e., allows for reporting on the change in $^2$ at each stage and to determine moderation effects. Also, it provides a clear indication of the contributing and non-contributing factors. Firstly, the complementary score was determined by the interactions between the independent variables i.e., interaction variables. This was done by calculating the product of z scores of all the independent variables due to the complementary nature of the I4.0 complementary capability presented in table 56. It is represented by the variable **Industry 4.0 Complementary capability (I4CC).** This was used to test hypotheses 1-3.

*Table 58. Industry 4.0 Complementary capability (I4CC)*

| | | |
|---|---|---|
| Industry 4.0 Complementary capability (I4CC) | = | Z score (Integration * RT * D_SO * Modularity * Virtualisation * HRS* Digitalisation) |

In addition, several two-way complementary scores were calculated using Digitalisation in Table 57. The product of z scores was used. Digitalisation is recognised as an essential capability within I4, based on the previous literature (Martín-Peña, Sánchez-López and Díaz-Garrido, 2019; Büşra and Çallı, 2021; Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020; Manser Payne, Dahl and Peltier, 2021; Münch *et al.*, 2022b; Niemand *et al.*, 2020; Fernández-Portillo *et al.*, 2022), thus interaction terms were also created using Digitalisation as a primary determinant. It is beneficial to determine this component of the analysis since it may identify other two-way complementary capabilities other than I4CC that could affect Firm Performance, Value Outcomes, and Innovation capabilities. The additional complementary could contribute to the research topic. There has been a consideration for the other combination and three-way interactions however this exceeds the scope of the study.

*Table 59. I4.0 two-way Complementary Scores*

| Two-way Complementary Scores | Z score (Digitalisation * Integration) |
|---|---|
| | Z score (Digitalisation * RT) |
| | Z score (Digitalisation * D_SO) |
| | Z score (Digitalisation * Modularity) |
| | Z score (Digitalisation * Virtualisation) |
| | Z score (Digitalisation * HRS) |

Eight models were analysed using hierarchical regression to measure the significance and variations between the control variables, I4CC, and interaction complementary variables, and their effect on the dependent variables Firm Performance, Innovation capability, and Value Outcomes. Lastly, the additive effect was also tested using the Composite_Industry 4.0 capability (CI4C). The additive effect typically refers to a situation where the combined effect of two or more components is equal to the sum of their individual effects (Wang *et al.*, 2011). When it comes to complementary capabilities, an additive effect would suggest that the combined capabilities of two or more variables are simply the sum of their individual capabilities. Multiple regression tests were used to investigate the additive effect as shown below.

*Table 60. Multiple Regression Beta Values*

| | **Value Outcome** | **Innovation Capability** | **Firm Performance** |
|---|---|---|---|
| **Control 2 -Size** | -.184 | .026 | -.104 |
| **Control 3 - Industry** | -.052 | -.214 | .068 |
| **Control 4- Age** | .028 | .078 | -.083 |
| **Composite_Industry 4.0 capability (CI4C)** | .608** | .537** | .602** |
| **$R^2$** | .413** | .317** | .384** |

+ p<0.1; * p<0.05; ** p<0.01

The below tables were used to determine support for hypotheses 1 to 3.

Based on Table 59 below, the impact of various control variables, individual effects, and interaction combinations of I4.0 capabilities on Firm Performance can be observed. The table presents a comprehensive analysis of the effects of these variables on Firm Performance

*Table 61. I4.0 Complementary capability interaction testing – H1: Firm Performance*

| Restricted model Control Regressed against dependent variables (hypotheses testing) | Controls Variables plus complementary dimensions of Industry 4.0 Complementary capability regressed against overall Firm Performance | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H1– Firm Performance | | | | | | | | |
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 | |
| | *Control Variables* | Industry 4.0 Capabilities | Digitalisation X Integration | Digitalisation X Real -Time | Digitalisation X Decentralization_ Service Orientation | Digitalisation X Modularisation | Digitalisation X Virtualisation | Digitalisation X Human Resource Skills | Integration X Real-time X Decentralization X Service Orientation X Modularisation X Virtualisation X Human Skills X Digitalisation |
| *Control Variables* | | | | | | | | | |
| Organisational Size | -0,116 | -0,092 | -0,092 | -0,077 | -0,080 | -0,081 | -0,084 | -0,076 | -0,027 |
| Organisation Industry | 0,106 | 0,073 | 0,081 | 0,084 | 0,072 | 0,070 | 0,045 | 0,026 | 0,011 |
| Organisational Age | -0,038 | -0,079 | -0,090 | -0,121 | -0,128 | -0,124 | -0,129 | -0,133 | -0,202+ |
| *Independent Variables* | | | | | | | | | |
| Integration | | -0,015 | -0,008 | -0,005 | -0,006 | -0,001 | -0,014 | -0,040 | -0,192 |
| RT | | 0,147 | 0,150 | 0,130 | 0,131 | 0,131 | 0,150 | 0,162 | 0,170 |
| Decentralisation and Service Orientation | | 0,064 | 0,067 | 0,073 | 0,097 | 0,102 | 0,151 | 0,175 | 0,253 |
| Modularisation | | 0,117 | 0,113 | 0,088 | 0,103 | 0,099 | 0,125 | 0,139 | 0,123 |
| Virtualisation | | -0,002 | 0,006 | 0,041 | 0,034 | 0,040 | 0,016 | -0,001 | -0,042 |
| Human Resource Skills | | 0,225 | 0,211 | 0,263 | 0,222 | 0,220 | 0,171 | 0,144 | 0,049 |
| Digitalisation | | **0,275*** | **0,277*** | 0,235+ | 0,237+ | 0,224 | 0,217 | 0,243 | 0,220 |
| *Complementary Dimensions* | | | | | | | | | |
| Digitalisation X Integration | | | 0,054 | -0,048 | 0,000 | 0,021 | 0,021 | 0,008 | 0,175 |
| Digitalisation X Real -Time | | | | 0,165 | 0,197 | 0,182 | 0,157 | 0,159 | 0,152 |
| Digitalisation X Decentralisation_ Service Orientation | | | | | -0,105 | -0,091 | -0,167 | -0,195 | -0,200 |
| Digitalisation X Modularisation | | | | | | -0,037 | -0,047 | -0,107 | -0,200 |
| Digitalisation X Virtualisation | | | | | | | 0,150 | 0,168 | **0,300*** |
| Digitalisation X Human Resource Skills | | | | | | | | 0,099 | 0,248 |
| Integration X Real-time X Decentralization X Service Orientation X Modularisation X Virtualisation X Human Skills X Digitalisation | | | | | | | | | **0,432**** |
| $R^2$ | 0,026 | 0,419** | 0,422** | 0,436** | 0,442** | 0,442** | 0,454** | 0,456* | 0,524** |
| Adjusted $R^2$ | -0,017 | 0,326** | 0,318** | 0,324** | 0,319** | 0,308** | 0,310** | 0,300* | 0,377** |

+ p<0.1; * p<0.05; ** p<0.01

Table 59 results indicate no significance on the control variables. Model 1 indicates the I4.0 capabilities were then included indicating a significant increase in $R^2$. In Models 1 and 2, Digitalisation shows a positive statistically significant beta coefficient of 0.275 (p = <0.05) and 0.277 (p = <0.05) respectively, thus on its own is a significant predictor of FP. The $R^2$ = 0.419 and 0.422 respectively which explains approximately 42% of the variance in FP. Models 2 to 7 show the inclusion of the two-way interactions between Digitalisation and the remaining constructs. None of these were statistically significant up to model 7. Lastly, in Model 8 the full complementary capability of I4CC was included. I4CC shows a positive statistically significant beta coefficient of 0.432 (p = <0.01) and is a significant predictor of FP, thus hypothesis 1 is supported. This indicates that each I4.0 capability does interact and strengthen each other to positively influence FP. However, the two-way complementary

(Digitalisation *Virtualisation) also shows a positive and statistically significant beta coefficient of 0.300 (p = <0.05) and is a significant predictor of FP. This indicates that Digitalisation and Virtualisation do interact and strengthen each other to positively influence FP. The overall $R^2$ = 0.524 which explains approximately 52% of the variance in FP. However, the CI4C also showed a significant and positive relationship to FP in table 58, which means they also combine to create an additive effect.

In summary, Digitalisation when not interacting with other variables, the two-way complementary (Digitalisation *Virtualisation), I4CC, and CI4C positively influence FP and are positive predictors of FP.

Based on Table 60 below, the impact of various control variables, individual effects, and interaction combinations of I4.0 capabilities on the Innovation Capability of a firm can be observed. The table presents a comprehensive analysis of the effects of these variables on Innovation Capability.

*Table 62. I4.0 Complementary capability interaction testing – H2: Innovation Capability*

| **Restricted model Control Regressed against dependent variables (hypotheses testing)** | **Controls Variables plus complementary dimensions of Industry 4.0 Complementary capability regressed against Innovation Outcome** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **H2- Innovation Capability (IC)** | | | | | | | | |
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 | |
| | Industry 4.0 Capabilities | Digitalisation X Integration | Digitalisation X Real -Time | Digitalisation X Decentralization_ Service Orientation | Digitalisation X Modularisation | Digitalisation X Virtualisation | Digitalisation X Human Resource Skills | Integration X Real-time X Decentralization X Service Orientation X Modularisation X Virtualisation X Human Skills X Digitalisation | |
| *Control Variables* | | | | | | | | | |
| Organisational Size | 0,015 | 0,029 | 0,029 | 0,027 | 0,015 | 0,011 | 0,008 | 0,007 | 0,009 |
| Organisation Industry | -0,180 | -0,249* | -0,253* | -0,253* | -0,308** | -0,313** | -0,339** | -0,338** | -0,338** |
| Organisational Age | 0,118 | 0,093 | 0,098 | 0,101 | 0,070 | 0,082 | 0,077 | 0,077 | 0,075 |
| *Independent Variables* | | | | | | | | | |
| Integration | | -0,063 | -0,066 | -0,066 | -0,069 | -0,054 | -0,067 | -0,065 | -0,070 |
| RT | | 0,220 | 0,219 | 0,221 | 0,222 | 0,222 | 0,242 | 0,241+ | 0,242 |
| Decentralisation and Service Orientation | | -0,025 | -0,027 | -0,028 | 0,076 | 0,091 | 0,143 | 0,141 | 0,144 |
| Modularisation | | 0,188 | 0,190 | 0,193 | 0,259 | 0,247 | 0,274 | 0,273+ | 0,272 |
| Virtualisation | | 0,039 | 0,036 | 0,032 | 0,003 | 0,020 | -0,004 | -0,003 | -0,004 |
| Human Resource Skills | | 0,097 | 0,104 | 0,098 | -0,082 | -0,088 | -0,139 | -0,137 | -0,140 |
| Digitalisation | | **0,297*** | **0,296*** | **0,301*** | **0,311*** | 0,271+ | 0,263+ | 0,261 | 0,261 |
| *Complementary Dimensions* | | | | | | | | | |
| Digitalisation X Integration | | | -0,025 | -0,014 | 0,199 | 0,267 | 0,266 | 0,267 | 0,273 |
| Digitalisation X Real -Time | | | | -0,019 | 0,123 | 0,078 | 0,051 | 0,051 | 0,051 |
| Digitalisation X Decentralisation_ Service Orientation | | | | | **-0,466**** | **-0,423**** | **-0,502**** | **-0,500**** | **-0,500**** |
| Digitalisation X Modularisation | | | | | | -0,115 | -0,126 | -0,121 | -0,124 |
| Digitalisation X Virtualisation | | | | | | | 0,155 | 0,154 | 0,158 |
| Digitalisation X Human Resource Skills | | | | | | | | -0,007 | -0,002 |
| Integration X Real-time X Decentralisation X Service Orientation X Modularisation X Virtualisation X Human Skills X Digitalisation | | | | | | | | | 0,013 |
| $R^2$ | 0,032 | 0,356* | 0,357* | 0,357* | 0,462** | 0,467** | 0,480** | 0,480** | 0,480* |
| Adjusted $R^2$ | -0,010 | 0,252* | 0,241* | 0,228* | 0,343** | 0,339** | 0,343** | 0,331** | 0,319* |

+ p<0.1; * p<0.05; ** p<0.01

Table 60 results indicate the control variable, Organisation Industry shows a consistent negative significant beta coefficient across all 8 models tested. This suggests that the banking and non-banking sectors are associated with lower levels of innovation. Model 1 indicates the I4.0 capabilities were then included indicating a significant increase in $R^2$. Digitalisation shows a positive statistically significant beta coefficient of 0.297 ($p < 0.05$) and on its own is a significant predictor of IC. Digitalisation is also a predictor of IC in Models 2,3 and 4 with significant beta coefficients of 0.296 ($p < 0.05$), 0.301 ($p < 0.05$), and 0.311 ($p < 0.05$) respectively. The overall $R^2 = 0.356$ which explains approximately 36% of the variance in IC in Model 1 however there is no change in $R^2$ between Model 2 and 3 at 0.357 respectively. Models 2 to 7 show the inclusion of the two-way interactions between Digitalisation and the remaining constructs. The two-way complementary (Digitalisation * Decentralisation_ Service Orientation) shows negative statistically significant beta coefficients of -0.466 ($p < 0.01$), -0.423 ($p < 0.01$), -0.502 ($p < 0.01$), -0.500 ($p < 0.01$) and -0.500 ($p < 0.01$) for Model 4, Model 5, Model 6, Model 7, and Model 8 respectively. This finding suggests that Digitalisation may be less effective in driving Innovation when combined with a significant component of a Decentralised Service Orientated capability, thus higher levels of Digitalisation and D_SO imply an organisation is less innovative. Lastly, in Model 8 the full complementary capability of I4CC was included. I4CC showed no statistical significance to IC thus hypothesis 2 is rejected. That indicates that the I4.0 capabilities don't interact to strengthen each to achieve IC. The overall $R^2 = 0.480$ which explains approximately 48% of the variance in IC. However, the CI4C showed a significant and positive relationship to IC in table 58, which means they combine to create an additive effect.

In summary, Digitalisation is a key predictor of IC on its own, however, the two-way complementary that combines Digitalisation with a Decentralised Service Orientated capability will result in less innovation and should be avoided. The industry should be considered since the result suggests that the banking and non-banking sectors are associated with lower levels of innovation. Lastly, the full complementary capability I4CC is insignificant and will not influence IC however CI4C positively influences IC and is a positive predictor of IC.

Based on Table 61, the impact of various control variables, individual effects, and interaction combinations of I4.0 capabilities on the Value Outcomes can be observed. The table presents a comprehensive analysis of the effects of these variables on Value Outcomes

*Table 63. I4.0 Complementary capability interaction testing – H3: Value Outcomes*

| **Restricted model Control Regressed against dependent variables (hypotheses testing)** | **Controls Variables plus complementary dimensions of Industry 4.0 Complementary capability regressed Value Outcomes H3- Value Outcomes (VO)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 |
| | Industry 4.0 Capabilities | Digitalisation X Integration | Digitalisation X Real -Time | Digitalisation X Decentralisation _ Service Orientation | Digitalisation X Modularisation | Digitalisation X Virtualisation | Digitalisation X Human Resource Skills | Integration X Real-time X Decentralisation X Service Orientation X Modularisation X Virtualisation X Human Skills X Digitalisation |
| *Control Variables* | | | | | | | | |
| Organisational Size | -0,196 | -0,146 | -0,146 | -0,156 | -0,164+ | -0,163 | -0,169 | -0,171 | -0,153 |
| Organisation Industry | 0,091 | 0,024 | 0,011 | 0,009 | -0,028 | -0,026 | -0,088 | -0,082 | -0,088 |
| Organisational Age | 0,073 | 0,058 | 0,076 | 0,096 | 0,076 | 0,072 | 0,059 | 0,061 | 0,036 |
| *Independent Variables* | | | | | | | | |
| Integration | | -0,010 | -0,020 | -0,022 | -0,024 | -0,028 | -0,058 | -0,050 | -0,105 |
| RT | | 0,117 | 0,112 | 0,125 | 0,126 | 0,126 | 0,174 | 0,171 | 0,174 |
| Decentralisation and Service Orientation | | 0,027 | 0,021 | 0,017 | 0,086 | 0,081 | 0,204 | 0,196 | 0,225 |
| Modularisation | | 0,253+ | 0,259+ | **0,276*** | **0,319*** | **0,323*** | **0,385**** | **0,381**** | **0,375**** |
| Virtualisation | | -0,100 | -0,112 | -0,135 | -0,154 | -0,159 | -0,216 | -0,211 | -0,226 |
| Human Resource Skills | | 0,134 | 0,157 | 0,122 | 0,002 | 0,004 | -0,117 | -0,108 | -0,143 |
| Digitalisation | | **0,412**** | **0,408**** | **0,437**** | **0,444**** | **0,456**** | **0,438**** | **0,430**** | **0,422**** |
| *Complementary Dimensions* | | | | | | | | |
| | | | | | | | | |
| Digitalisation X Integration | | | -0,088 | -0,019 | 0,122 | 0,101 | 0,099 | 0,103 | 0,164 |
| Digitalisation X Real -Time | | | | -0,111 | -0,017 | -0,004 | -0,066 | -0,067 | -0,069 |
| Digitalisation X Decentralisation_ Service Orientation | | | | | **-0,310*** | **-0,323*** | **-0,510**** | **-0,502**** | **-0,504**** |
| Digitalisation X Modularisation | | | | | | 0,035 | 0,010 | 0,028 | -0,005 |
| Digitalisation X Virtualisation | | | | | | | **0,368**** | **0,363**** | **0,411**** |
| Digitalisation X Human Resource Skills | | | | | | | | -0,030 | 0,024 |
| Integration X Real-time X Decentralization X Service Orientation X Modularisation X Virtualisation X Human Skills X Digitalisation | | | | | | | | | 0,157 |
| $R^2$ | 0,049 | 0,497** | 0,504** | 0,511** | 0,557** | 0,558** | 0,628** | 0,628** | 0,637** |
| Adjusted $R^2$ | 0,007 | 0,416** | 0,415** | 0,413** | 0,459** | 0,451** | 0,530** | 0,522** | 0,525** |

+ p<0.1; * p<0.05; ** p<0.01

Table 61 results indicate no significance on the control variables. Model 1 indicates the I4.0 capabilities were then included indicating a significant increase in $R^2$. Digitalisation shows a positive significant beta coefficient of 0.412 (p = <0.01) and on its own is a significant predictor of VO. The overall $R^2$ = 0.497 which explains approximately 50% of the variance in VO. Models 2 to 7 show the inclusion of the two-way interactions between Digitalisation and the remaining constructs. Digitalisation on its own is consistently significant in all the models and is a significant predictor of VO. This is indicated by the positive significant beta coefficient of 0.408 (p < 0.01), 0.437 (p < 0.01), 0.444 (p < 0.01), 0.456 (p < 0.01), 0.438 (p < 0.01), 0.430 (p < 0.01) and 0.422 (p < 0.01) in Model 2, 3, 4, 5, 6, 7, and 8 respectively. Modularity is also a significant predictor of VO which is indicated by the positive significant beta coefficients 0.276 (p < 0.05), 0.319 (p < 0.05), 0.323 (p < 0.05), 0.385 (p < 0.01), 0.381

(p < 0.01) and 0.375 (p < 0.01) in Model 3, 4, 5, 6,7 and 8 respectively. However, the two-way complementary (Digitalisation * Decentralisation_ Service Orientation) shows negative statistically significant beta coefficients of -0.310 (p < 0.05), -0.323 (p < 0.05), -0.510 (p < 0.01), -0.502 (p < 0.01) and -0.504 (p < 0.01) in Model 4, 5, 6, 7, and 8 respectively. This finding suggests that Digitalisation may be less effective in driving value when combined with a significant component of a Decentralised Service Orientated capability, thus higher levels of Digitalisation and D_SO imply an organisation is less likely to derive value. The two-way complementary (Digitalisation *Virtualisation) shows a positive significant beta coefficient of 0.368 (p = <0.01), 0.363 (p = <0.01), and 0.411 (p = <0.01) in Models 6, 7, and 8 respectively and is a significant predictor of VO. This indicates that each Digitalisation and Virtualisation do interact and strengthen each other to positively influence VO. Lastly, the complementary dimension, I4CC in Model 8 was included however there was no statistical significance in generating VO thus hypothesis 3 is rejected. That indicates that the I4.0 capabilities don't interact to strengthen each to achieve VO. However, the CI4C showed a significant and positive relationship to VO in table 58, which means they combine to create an additive effect.

In summary, Modularity, Digitalisation, and the two-way complementary (Digitalisation *Virtualisation) are positive predictors of Value Outcomes and should be considered within organisations to achieve value however combining Digitalisation with a Decentralised Service Orientated capability will result in less value creation. The full complementary capability I4CC is insignificant and will not yield value creation however, the additive effect CI4C positively influences VO and is a positive predictor of VO.

## 5.7 Conclusion

This section covers the data collection design process and methodology adopted to primarily collect data for hypothesis testing. The data analysis followed a process of rigor by providing descriptive information, then following intensive reliability and validity analysis, followed by hypothesis testing. The results were analysed, showing statistical significance in I4CC's complementary effects on FP, supporting hypothesis 1. The additive effect was also tested which was found to support FP for synergistic and additive effects. In addition, one of the two-way interaction variables did show significance in influencing FP. Hypothesis 2 testing the effect on IC was not supported by the I4.0 Complementary capability on Innovation Capabilities. Furthermore, the additive effect was also tested which was found to support IC. However, the two-way complementary (Digitalisation and Decentralisation_ServiceOrientation) and the control variable namely, Organisation Industry showed significant but negative effects on IC. Lastly, hypotheses 3 and 4 were combined into a single hypothesis that aim to measure VO. The results indicated no support of I4CC on VO. However, Modularity, Digitalisation, and the two-way complementary (Digitalisation*Virtualisation) show a positive statistical significance on VO. Lastly, the two-

way complementary (Digitalisation * Decentralisation_ServiceOrientation) showed significant but negative effects on VC.

*Table 64. Hypothesis findings*

| **Hypothesis** | **Description** | **Outcome** |
|---|---|---|
| *Hypothesis 1* | A complementary system of Industry 4.0 capabilities will have a significant effect on the Firm Performance of financial organisations | Supported |
| *Hypothesis 2* | A complementary system of Industry 4.0 capabilities will have a significant effect on the Innovation Capability of financial organisations | Rejected |
| *Hypothesis 3* | A complementary system of Industry 4.0 capabilities will have a significant effect on the Value Outcomes of financial organisations | Rejected |

Chapter 6 will discuss the results in greater detail, assessing each hypothesis and providing insights and discussions.

# CHAPTER 6 – DISCUSSION AND IMPLICATIONS

The results from the previous section will be discussed in detail in this chapter. Each hypothesis will be discussed along with the control variables.

## 6.1 Discussion

Drawing on the Industry 4.0 literature review conducted in this study, the key Industry 4.0 capabilities were identified within financial services (Havle and Üçler, 2018; Kamble, Gunasekaran and Gawankar, 2018; Mohamed, 2018). These capabilities are necessary to be in place within financial services to create an overall I4.0 complementary capability.

Human resource skills capability addresses the skills, competencies, and leadership that an organisation's personnel should possess to implement and operate within the new technological field (Piccarozzi, Aquilani, and Gatti, 2018; Horváth and Szabó, 2019). Digitalisation is a strategic approach to creating innovative business models by incorporating cutting-edge digital technologies into products, services, processes, and people to create significant value (Annarelli et al., 2021; Yvonne Lederer Antonucci, Fortune, and Kirchmer, 2021). DPs are considered to be capabilities that add value to the I4.0 ecosystem (Dikhanbayeva *et al.*, 2020) and consist of Integration, Virtualisation, Decentralisation, Real-time capability, Modularity, and Service Orientation. Integration proposes structural and digital changes internal and external to an organisation to establish an interconnected value chain (Pereira and Romero, 2017; Dalenogare et al., 2018). Virtualisation is a technological process that transforms physical world data into a virtual form (Lambropoulos, Mitropoulos, and Douligeris, 2021). Decentralisation refers to the ability of people and machines that allow systems to autonomously make decisions without relying on a centralised decision-making body and is achieved through the use of various technologies (Ferreira, Armellini, and De Santa-Eulalia, 2020). Real-time capability is the combination of interactive processing, full networking, and integration of the functional areas utilising real-time data enabling automation of tasks and improving the efficiency of its operations (Cundius and Alt, 2013). Thus Service Orientation refers to the combination of people, processes, business models, and intelligent systems to design and create a product-service system to deliver precisely what a customer wants (Dikhanbayeva *et al.*, 2020; Münch *et al.*, 2022a). The concept of modularity refers to the process of decomposing a product or system into re-combinable modules that are created from multiple components that can be adapted to meet different requirements and needs (Kamble, Gunasekaran, and Gawankar, 2018; Ferreira, Armellini and De Santa-Eulalia, 2020).

Based on the RBV of the firm (Nevo and Wade, 2011; Schryen, 2013) the combination of these capabilities was then suggested to create a complementary capability in such a way that its exhibits Value, Rarity, and Inimitability, Non-substitutability referred to as VRIN

(Nevo and Wade, 2011). The I4.0 complementary capability (I4CC) was thus created and theorised to determine the relationship and the extent to which it influences performance outcomes being Firm Performance, Innovation capabilities, and Value Outcomes. As part of the reliability and validity testing, the PCA analysis indicated that Decentralisation and Service orientation clustered into a single component and could not be distinguished separately and thus were combined into a single variable. Upon reviewing the measures and literature (Ghobakhloo, 2018; Kamble, Gunasekaran and Gawankar, 2018; Dikhanbayeva *et al.*, 2020) of both variables, the research indicated that decentralised structures are consistent with service-orientated architecture which may explain the single-component loading. Innovation capability (IC), Improved Value Chain (VC), Servitisation Outcomes (SO), Operational performance (OC), and Competitive performance (CP) were identified as the dependent outcomes. The PCA analysis indicated OP and CP clustered into a single component and were combined into the overall variable of FP. Similarly, VC and SO clustered into a single component and could not be distinguished separately and thus were combined into a single variable called Value Outcomes (VO). Servitisation is defined as the process where value-added services are bundled as a total offering with products and services to deliver customised solutions that are designed to meet specific customer needs increasing customer satisfaction (Martín-Peña, Sánchez-López, and Díaz-Garrido, 2019; Jang, Bae, and Kim, 2020; Münch *et al.*, 2022) thus SO also measures the customer value outcomes to some extent. VC involves digitising and integrating the entire product or service lifecycle (Ghobakhloo, 2020) thus optimising the entire value chain through collaboration among suppliers and customers, utilising real-time information, as well as vertically integrating systems and structures within the organisation (Dalenogare *et al.*, 2018; Calış Duman and Akdemir, 2021). Upon reviewing the measures of both variables, VC measures indicated conceptual overlap that is consistent with SO since the outcomes of an optimised value chain also measure customer outcomes to some degree. This may explain the single-component loading thus resulting in the combination of Hypothesis 3 and 4 into a single Hypothesis 3. The effects of the I4CC, IC, and VO were tested and are discussed further next.

### 6.1.1 Hypothesis 1

Hypothesis 1 was established to test that I4CC may have a significant effect on an organisation's ability to yield Firm Performance (FP). This was done using the RBV theoretical framework. FP was initially categorised as consisting of OP and CP. OP was measured using 5 items renamed FP1 to FP5. Competitive performance was measured using 5 items now renamed FP6 to FP9 however item 10 was dropped in the reliability and validity testing. The questionnaire items are below:

*Table 65. Firm performance Questionnaire Items*

| Item | Survey Question |
|---|---|
| **FP1** | "The Industry 4.0 complementary capability helps the organisation or business area to reduce costs." |
| **FP2** | "The Industry 4.0 complementary capability helps the organisation or business area to increase revenue." |
| **FP3** | "The Industry 4.0 complementary capability built improves quality of operations." |
| **FP4** | "The Industry 4.0 complementary capability enables the organisation or business area to reduce lead time for products or services delivered." |
| **FP5** | "The Industry 4.0 complementary capability improves the reliability of operations." |
| **FP6** | "The Industry 4.0 complementary capability provides the organisation or business area with a competitive advantage." |
| **FP7** | "The Industry 4.0 complementary capability has expanded our market share consistently." |
| **FP8** | "The Industry 4.0 complementary capability helps us to improve financial profitability." |
| **FP9** | "The Industry 4.0 complementary capability provides the ability to introduce new products or services more quickly than competitors." |
| **FP10** | "The Industry 4.0 complementary capability enables the organisation or business area to respond more quickly to change." |

Nevo and Wade (2011) and Wade and Hulland (2004) argue that the resource-based view (RBV) is founded on the concept that resources can work together synergistically to create economic and strategic potential. This potential is derived from the five properties of RBV: value, rarity, inimitability, non-substitutability, and immobility. By leveraging different combinations of resources and capabilities, organisations can achieve a competitive advantage that is difficult to imitate. To evaluate the impact of I4.0 capabilities, their complementary effects were examined by developing a product of each capability. This product was then used to measure the influence of the interactions between I4.0 capabilities on FP. To test the complementary effects, a hierarchical regression was conducted, involving eight models. The findings revealed a significant relationship between I4CC interactions and FP, providing support for hypothesis 1. As a result, an organisation that creates the I4CC should expect to see synergistic effects on achieving FP, in addition to the individual I4.0 capability's direct effect. That is, if an organisation can leverage its resources and capabilities consisting of the I4.0 capabilities, and combine in a way that exhibits VRIN, then they are at a greater advantage and more likely to achieve high levels of FP. Digitalisation at the individual level is indicated to be a significant predictor of FP which suggests that an organisation that implements Digitalisation as a capability will achieve higher levels of FP.

The outcome is consistent with previous studies that have found digitalisation to be a positive predictor of FP (Martín-Peña, Sánchez-López and Díaz-Garrido, 2019; Salvi *et al.*, 2021; Fernández-Portillo *et al.*, 2022). Two-way interactions using Digitalisation as the primary determinant (Martín-Peña, Sánchez-López and Díaz-Garrido, 2019; Büşra and Çallı, 2021; Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020; Manser Payne, Dahl and Peltier, 2021; Münch *et al.*, 2022b; Niemand *et al.*, 2020; Fernández-Portillo *et al.*, 2022) were also incorporated into the model to identify possible impacting relationships. The findings also revealed a significant relationship between the two-way complementary (Digitalisation *Virtualisation). This two-way complementary suggests that the joint effect of Digitalisation and Virtualisation is important for understanding FP. The significance of the interaction term is consistent with the idea that the impact of Digitalisation on FP may be moderated by the degree of Virtualisation thus an organisation should consider increasing the levels of Virtualisation capability to achieve greater levels of Digitalisation such that FP is attained. As a result, an organisation that integrates Digitalisation and Virtualisation as a 2- way complementary should expect to see synergistic effects on achieving FP, in addition to the direct effect of the individual I4.0 capability. The additive multiple regression was also conducted to assess the impact of a composite I4.0 capability (CI4C) on FP, that is the sum of the individual I4.0 capabilities. This was tested using the additive effect, showing a strong positive and statistically significant relationship with FP. This suggests that I4.0 capabilities possess additive properties. As a result, an organisation that integrates various I4.0 capabilities should expect to see cumulative effects on achieving FP, beyond the direct impact of each individual I4.0 capability.

In summary, organisation can leverage the above findings to find the adequate fit that is suited to their needs in achieving FP. If an organisation finds costs and resources a challenge, they could start by implementing Digitalisation and at a later stage incorporate a virtual capability to get higher levels of FP. On the other hand, a larger more established organisation can investigate and implement all the I4.0 capabilities into a complementary capability to achieve the best levels of FP. Finally, organisations can also use the additive effect of I4 capabilities to achieve increased levels of FP.

### 6.1.2 Hypothesis 2

Hypothesis 2 was established to test that a complementary system of I4.0 capabilities will have a significant effect on an organisation to develop innovation capabilities (IC). This was done using the RBV theoretical framework. IC is the ability and competencies of the organisation to absorb, adapt and transform technologies into management and operational routines that will yield organisation profits based on the innovative activities implemented (Calantone, Cavusgil, and Zhao, 2002; Zawislak et al., 2012). The operational definition is the organisation's capacity to foster innovation by creating products and services that generate profits and provide a competitive advantage. The questionnaire items in table 64 were used,

however, IC1 and IC2 were removed in the reliability and validity testing due to cross-loading. The questionnaire items are below:

*Table 66. Innovation Capability Questionnaire Items*

| Item | Survey Question |
|---|---|
| **IC1** | "The Industry 4.0 complementary capability enables the organisation or business area to provide innovative products or services." |
| **IC2** | "The Industry 4.0 complementary capability enables the organisation or business area to use innovations which use technologies that have an impact on or cause significant changes in the whole industry." |
| **IC3** | "A majority of our organisation or business area's innovations use new technologies that permit quantum leaps in performance through the implementation of the Industry 4.0 complementary capability." |
| **IC4** | "The majority of our innovations offer our customers a unique advantage over competitors' products through the implementation of the Industry 4.0 complementary capability." |

Nevo and Wade (2011) and Wade and Hulland (2004) argue that the resource-based view (RBV) is founded on the concept that resources can work together synergistically to create economic and strategic potential. This potential is derived from the five properties of RBV: value, rarity, inimitability, non-substitutability, and immobility. By leveraging different combinations of resources and capabilities, organisations can achieve a competitive advantage that is difficult to imitate. To evaluate the impact of I4.0 capabilities, their complementary effects were examined by developing a product of each capability. This product was then used to measure the influence of the interactions between I4.0 capabilities on IC. To test the complementary effects, a hierarchical regression was conducted, involving eight models. The findings revealed there was no statistical significance in the relationship between I4CC interactions and IC and thus hypothesis 2 was rejected. Digitalisation at the individual level is indicated to be a significant predictor of IC which suggests that an organisation that implements Digitalisation as a capability will achieve higher levels of IC. The outcome is consistent with previous studies that have found digitalisation to be a positive contributor to IC (Niemand *et al.*, 2020; Fernández-Portillo *et al.*, 2022). Two-way interactions using Digitalisation as the primary determinant (Martín-Peña, Sánchez-López and Díaz-Garrido, 2019; Büşra and Çallı, 2021; Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020; Manser Payne, Dahl and Peltier, 2021; Münch *et al.*, 2022b; Niemand *et al.*, 2020; Fernández-Portillo *et al.*, 2022) were also incorporated into the model to identify possible impacting relationships. The findings revealed a significant negative relationship between the two-way complementary capability (Digitalisation * Decentralisation_ Service Orientation). This means, suggests that the interaction between Digitalisation and D_SO may hinder innovation performance. This could be due to various factors unknown to this study. As a result, an organisation seeking to create ongoing innovations should avoid creating the two-way complementary capability using Digitalisation with decentralised service orientated

capabilities, since it will not yield innovation capabilities. However, this finding creates room for question since one of the anticipated key determinants to drive innovation according to the literature is to develop a service-orientated architecture and systems using decentralised decisions coupled with digitalisation. (Manser Payne, Dahl and Peltier, 2021; Münch *et al.*, 2022a). Furthermore, an empirical study by Martín-Peña et al.( 2019) focused on the effects of Digitalisation and Servitisation on FP. According to the study, there is a positive correlation between the level of Servitisation and the level of Digitalisation. The study categorises Servitisation as a business innovation, and therefore, the effects of digitalisation and service-oriented capabilities on the creation of innovations need to be further examined. There are no possible explanations indicating the outcome however as part of future studies, this could be a gap to explore the nature of the contributing factors. Another negative and significant relationship between Industry and IC was uncovered. It indicates that organisations within financial services are less innovative in comparison to organisation in other industries and thus may face more challenges or barriers in creating innovations. Possible contributing factors could be the lack of necessary resources, skills, or knowledge to innovate effectively compared to organisations operating in other industries however this finding should be explored further in future studies. The additive multiple regression was also conducted to assess the impact of a composite I4.0 capability (CI4C) on IC, that is the sum of the individual I4.0 capabilities. This was tested using the additive effect, showing a strong positive and statistically significant relationship with IC. This suggests that I4.0 capabilities possess additive properties. As a result, an organisation that integrates various I4.0 capabilities should expect to see cumulative effects on achieving IC, beyond the direct impact of each I4.0 individual capability.

In summary, organisation can leverage the above findings to find the adequate fit that is suited to their needs in achieving IC. If an organisation seeks to increase its innovative capabilities, it should consider implementing Digitalisation. It is also important that the negative relationships identified are considered by organisations and decision-makers. Finally, organisations can also use the additive effect of I4 capabilities to achieve increased levels of FP.

### 6.1.3 Hypothesis 3

Hypothesis 3 was established to test that a complementary system of I4.0 capabilities will have a significant effect on an organisation to create customer-centric value outcomes. This was done using the RBV theoretical framework. VO was synthesised to measure the outcomes of having a customer-centric capability with value-added services bundled as a total offering with products and services to deliver customised solutions that are designed to meet specific customer needs increasing customer satisfaction (Martín-Peña, Sánchez-López, and Díaz-Garrido, 2019; Jang, Bae, and Kim, 2020; Münch *et al.*, 2022). The operational definition was revised as the ability of an organisation to increase the value of products and services to the customers. The questionnaire items used are below however

SO1, SO2, and VC3 were removed from reliability and validity testing due to cross-loading leaving 5 remaining items classified into VO. The questionnaire items are below:

*Table 67. Value Outcomes Questionnaire Items*

| Item | Survey Question |
|---|---|
| **SO1** | "The Industry 4.0 complementary capability enables the organisation to offer products or services that are customised for each individual customer." |
| **SO2** | "The Industry 4.0 complementary capability enables the organisation to offer a reasonable price and ensure cost savings for customers." |
| **SO3** | "Customer needs are satisfied through products and services provided by the Industry 4.0 complementary capability." |
| **SO4** | "The Industry 4.0 complementary capability enables consistent support to be provided during the use of the product and service." |
| **SO5** | "The Industry 4.0 complementary capability enables the organisation or business area to better understand customer problems and requests." |
| **VC1** | "The Industry 4.0 complementary capability enables the organisation or business area to provide reliable high-quality products or services." |
| **VC2** | "The Industry 4.0 complementary capability allows for the ability to make rapid design changes." |
| **VC3** | "The Industry 4.0 complementary capability improved the decision-making process." |

Nevo and Wade (2011) and Wade and Hulland (2004) argue that the resource-based view (RBV) is founded on the concept that resources can work together synergistically to create economic and strategic potential. This potential is derived from the five properties of RBV: value, rarity, inimitability, non-substitutability, and immobility. By leveraging different combinations of resources and capabilities, organisations can achieve a competitive advantage that is difficult to imitate. To evaluate the impact of I4 capabilities, their complementary effects were examined by developing a product of each capability. This product was then used to measure the influence of the interactions between I4.0 capabilities on Value outcomes. To test the complementary effects, a hierarchical regression was conducted, involving eight models. The findings revealed no statistical significance in the relationship between I4CC interactions and VO and thus hypothesis 3 was rejected.

Digitalisation at an individual level is consistently indicated to be a significant predictor of VO which suggests that an organisation that implements Digitalisation as a capability will achieve higher levels of customer-centric value outcomes. The outcome is consistent with previous studies that have found digitalisation to be a significant contributor to VO (Martín-Peña, Sánchez-López and Díaz-Garrido, 2019; Abou-Foul, Ruiz-Alba and Soares, 2020; Antonucci, Fortune and Kirchmer, 2021). Two-way interactions using Digitalisation as the primary determinant (Martín-Peña, Sánchez-López and Díaz-Garrido, 2019; Büşra and Çallı, 2021; Martínez-Caro, Cegarra-Navarro and Alfonso-Ruiz, 2020; Manser Payne, Dahl and

Peltier, 2021; Münch *et al.*, 2022b; Niemand *et al.*, 2020; Fernández-Portillo *et al.*, 2022) were also incorporated into the model to identify possible impacting relationships. The findings also revealed a significant relationship between the two-way complementary (Digitalisation *Virtualisation). This two-way complementary suggests that the joint effect of Digitalisation and Virtualisation is important for understanding VO. The significance of the interaction term is consistent with the idea that the impact of Digitalisation on VO may be moderated by the degree of Virtualisation thus an organisation should consider increasing the levels of Virtualisation capability to achieve greater levels of Digitalisation such that VO is attained. As a result, an organisation that integrates Digitalisation and Virtualisation as a 2- way complementary should expect to see synergistic effects on achieving VO, in addition to the individual I4.0 capability's direct effect. The findings also revealed a significant negative relationship between the two-way complementary capability (Digitalisation * Decentralisation_ Service Orientation). This suggests that the interaction between Digitalisation and D_SO may hinder achieving customer-centric value outcomes. This could be due to various factors unknown to this study. As a result, an organisation that seeks to create value should avoid developing the two-way complementary capability using Digitalisation with decentralised service orientated capabilities, since it will not yield the value outcomes expected. However, this finding creates room for question since one of the anticipated key determinants to drive customer-centric value according to literature is to develop a service-orientated architecture associated with delivering customer value and systems using decentralised decisions coupled with digitalisation (Manser Payne, Dahl and Peltier, 2021; Münch *et al.*, 2022a). Furthermore, an empirical study by Martín-Peña et al.( 2019) and Abou-Foul et al. (2020) focused on the effects of Digitalisation and Servitisation on FP. According to the study, there is a positive correlation between the level of Servitisation and the level of Digitalisation. The studies suggest Servitisation is associated with customer-centric business models thus the effects of digitalisation and service-oriented capabilities on creating customer-centric value need to be further examined. There are no possible explanations indicating the outcome however as part of future studies, this could be a gap to explore the nature of the contributing factors.

The additive multiple regression was also conducted to assess the impact of a composite I4.0 capability (CI4C) on VO, that is the sum of the individual I4.0 capabilities. This was tested using the additive effect, showing a strong positive and statistically significant relationship with VO. This suggests that I4.0 capabilities possess additive properties. As a result, an organisation that integrates various I4.0 capabilities should expect to see cumulative effects on achieving VO, beyond the direct impact of each individual I4.0 capability.

In summary, organisation can leverage the above findings to find the adequate fit that is suited to their needs in achieving VO. If an organisation finds costs and resources a challenge, they could start by implementing Digitalisation and at a later stage incorporate a virtual capability to get higher levels of VO. It is also important that the negative relationships

identified are considered by organisations and decision-makers. Finally, organisations can also use the additive effect of I4 capabilities to achieve increased levels of FP.

### 6.1.4 Conclusion

In this section, the study's findings were examined in detail concerning the three hypotheses that were initially presented. The data analysis results were used to develop a new conceptual model, which is presented on page 131. The results indicate that if an organisation is seeking Firm Performance, then the I4.0 complementary capability or Digitalisation or the combination of Digitalisation and Virtualisation can be implemented. The additive or cumulative effect of all I4.0 capabilities can also be used by organisations since it does yield Firm performance. If an organisation seeks to increase its Innovative Capabilities, it should consider implementing Digitalisation or the additive effect of all I4.0 capabilities. From a control perspective, Industry indicated a negative relationship indicating financial services are less likely to be innovative. Decentralised service-oriented capabilities also suggest it would result in organisations not being innovative. Organisations seeking customer-centric value should be implementing Digitalisation as a capability or the combination of Digitalisation and Virtualisation or the additive effect of all I4.0 capabilities. Decentralised service-oriented capabilities should be avoided as it hinders the creation of customer value.

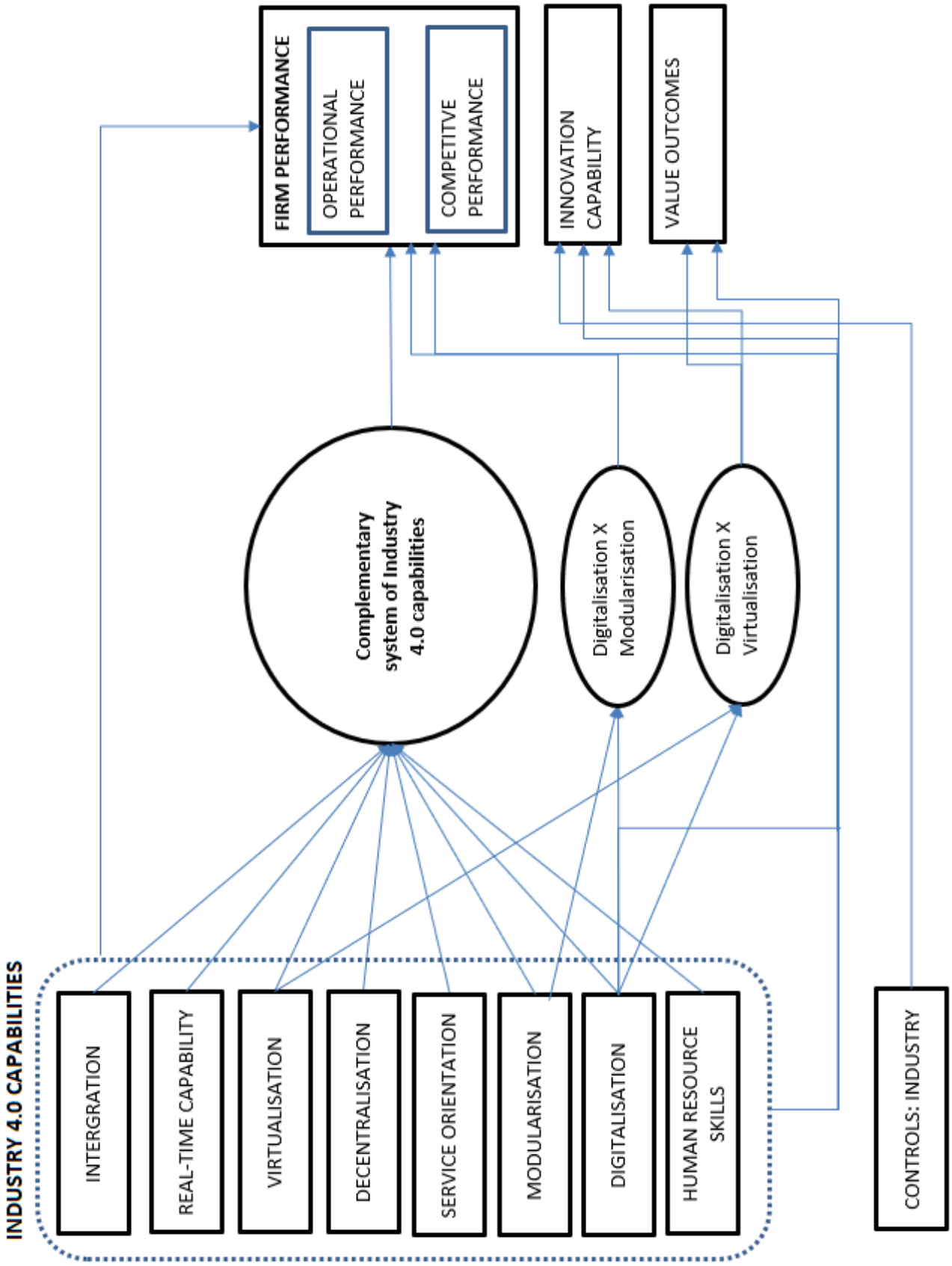


Figure 18. Revised Conceptual Model

# CHAPTER 7 – CONCLUSION

The research paper focused on exploring the impact of I4.0 complementary capabilities on Firm Performance. To conduct this study, a systematic literature review was conducted to determine existing literature and determine possible gaps. A survey was administered to collect data, resulting in 73 responses. The survey data was screened catering for missing and outlier data which was followed by providing descriptive statistics. Reliability and validity analysis was performed resulting in multiple variables being reviewed and removed. This impacted the hypotheses resulting in revising hypothesis 1 and hypothesis 3 and 4 into a single hypothesis. The analysis of the data used different regression techniques such as simple, multivariate, and hierarchical regression to test the final three hypotheses. The results showed that hypothesis 1 was supported, indicating that I4.0 complementary capabilities have a positive impact on Firm Performance. However, hypotheses 2 and 3 were rejected. Two-way interactions and the additive effect were investigated indicating specific I4 capabilities and two-way complementary capabilities showing significant effects on Firm Performance, Innovation Capability, and Value Outcomes. Control variables such as Industry, Size, and Age were found to be insignificant in predicting Firm Performance and Value Outcomes. However, the control variables were found to have a significant negative effect on Innovation Capability. The findings were further discussed in chapter 6. The limitations and contributions of the study are discussed in this chapter, along with suggestions for future research. Overall, the study provides valuable insights into the effect of I4.0 Complementary Capabilities on Firm Performance, which can be used by organisations to improve their performance and competitiveness.

## 7.1 – Limitations

The study initially involved the use of web-based questionnaires, which were distributed through a link on a survey site. Due to the lack of responses, this approach was combined with a snowball approach to data gathering. The snowball approach refers to a methodology in which survey participants are selected based on specific target audience criteria and then asked to share the survey with others in their network who match the same profile. The result of the survey participation was underwhelming, although a total of 102 responses including the pilot were received, many incomplete surveys were removed resulting in 73 valid responses. As a result, hypotheses 3, and 4 were not supported as anticipated. The sample size of the study reduced its statistical power, which could prevent it from detecting significant results. Secondly, the I4.0 research model used selected capabilities derived from previous studies to evaluate the Firm's Performance and capabilities. However, these capabilities are limited to their relevance to the financial sector. There could be additional factors or capabilities that may be relevant but are out of the scope of this study. The control variables used were also limited and can be expanded further into additional variables that may impact performance outcomes. During the hypothesis testing several negative significant relationships were

identified. Specifically for the two-way complementary capability (Digitalisation * Decentralisation_ServiceOrientation) with a significant but negative effect in developing Innovation capabilities. A possible reason could be the item measure which can in future be revisited and assessed accordingly. Lastly, the RBV framework lacks practical specifics, focusing on organizational-level theory, omitting in-depth factors and practical utilisation guidance. Furthermore, the interaction variables identified were limited to Digitalisation. There could be more combinations of these capabilities that may result in Firm Performance that is not catered for in this study.

## 7.2 Study Contributions

### 7.2.1 Contribution and Implications for Research

The research study has contributed to noteworthy findings that have implications for researchers. Specifically, the study developed a model that analyses the relationship between an I4.0 complementary capability and Firm Performance. Additionally, the study initially identified three key performance outcomes of I4.0: Servitisation Outcomes, Innovation Capabilities, and Improved Value chain. Furthermore, the study investigated the effect of I4.0 capabilities on these outcomes on performance, thereby providing important insights into the factors underlying these relationships. By adopting a scientific and trusted methodology, a systematic literature review was administered, secondly, the Resource-Based View (RBV) of a firm was utilised to measure the outcomes. The Resource-Based View of the firm is a reliable and appropriate theoretical framework that enables researchers to determine performance outcomes. The key I4.0 capabilities were identified to provide a holistic overview to encompass I4.0 in financial services. These capabilities can further be studied by the researcher to expand the knowledge and contribute further to the literature arena. Lastly, based on the research this is the only study that attempts to operationalise an end-to-end complementary capability encapsulating I4.0 within financial services thus contributing to the body of knowledge within information systems. It opens the opportunity for further research based on the foundation laid in this study. Based on the outcome, there is a positive and significant relationship between I4.0 complementary capabilities and Firm Performance thus the RBV model is suitable. The additive effect was also included to expand on the knowledge of how it can be considered in future studies. Finally, also noted under the limitations of the study, the study suggested additional capabilities through interaction variables that could offer an opportunity for further research to determine the necessary complementary interactions required to achieve optimal performance outcomes. Researchers have the opportunity to identify and study the remaining two and three-way interactions among capabilities, beyond digitalisation, to determine their potential impact on firm performance.

### 7.2.2 Contribution and Implications for Practice

The I4.0 complementary capability offers practitioners a holistic perspective on its essential elements to support Firm Performance, while also identifying key determinants that businesses should consider for Innovation Capabilities and Value outcomes. The outcomes of I4.0 capabilities offer potential benefits that can be leveraged in practical settings.

By operationalizing and analysing the relationship among I4.0 capabilities, Firm Performance, Innovation Capabilities, and Value outcomes, organisations can gain a better understanding of how these dynamics impact their business. This understanding can enable businesses to incorporate findings into their adoption or improvement of I4.0 capabilities. These results may have implications for policymakers and industry leaders who seek to foster innovation, value, and competitiveness within the different sectors.

This study suggests that managers, policymakers, and decision-makers should pay attention to the I4.0 complementary capability, Digitalisation, and Virtualisation and understand the additive effect of I4.0 capabilities since they are key determinants in achieving Firm Performance. Drawing from the results, explicit recommendations can be suggested. If an organisation in financial services is underperforming compared to its competitors or has ineffective or inefficient operational processes, then for an organisation to achieve the greatest result, the additive effect of I4.0 capabilities is recommended followed by the full I4.0 complementary capability. Due to the high costs of implementation, this may not always be feasible. In that case, the organisation can consider combining Digitalisation and Virtualisation capabilities to achieve these goals. However these capabilities must be combined in such a way that they exhibit value, rarity, inimitability, and non-substitutability (VRIN) to be performance-yielding (Bharadwaj, 2000; Nevo and Wade, 2011).

Whilst building an Innovation Capability, practitioners should consider having the additive effect of I4.0 capabilities and alternatively consider a digital capability if there are cost and resource barriers. The I4.0 complementary capability is not recommended. Furthermore, they should pay attention to the industry context in which the organisation operates since financial services face more barriers to innovation. This may have a significant impact on the level of innovation achieved by the organisation. Digitalisation and a decentralised service-orientated business models could also hinder innovation capabilities and should be carefully evaluated. Strategists and decision-makers should consider improving their innovation capabilities by investing in innovation-related resources, developing new skills, and acquiring knowledge from external sources to overcome the barriers to innovation and remain competitive in the market. Lastly, organisations that are seeking growth and are looking at a customer-centric strategy should not consider implementing the I4.0 complementary capability but rather implement the additive effect of I4.0 capabilities. Creating a digital capability will also yield value less than the additive effect. The use of virtual technologies can also contribute to digitalisation in achieving significant levels of firm

performance thus a company that incorporates higher levels of virtual technologies with digitalisation will yield better customer value. Various I4.0 capabilities are likely to show additive effects on customer value, beyond the direct effect of individual I4.0 capabilities. All the above-stated positive predictors must be combined in such a way that they exhibit VRIN to be effective.

### 7.2.4 Suggestions for Future Research

The study's outcomes are deemed successful, but there are still constraints and opportunities for growth. Conducting the study with a more extensive pool of participants would enhance validity results and unveil additional substantial connections between dimensions, thereby increasing the findings dependability. Some capabilities on their own were found to be insignificant such as integration, Human resource skills, and across all outcomes. It is expected for Human resources to be a key contributor to performance outcomes thus this can be further explored. Further research may explain this phenomenon. Also, the control factor of industry and size can be investigated further to discover insights into recommendations for SMEs and larger companies.

Lastly, the study's limitations highlight the potential for additional research to explore the necessary complementary interactions that can lead to optimal performance outcomes in light of the identified underlying capabilities. Beyond digitalisation, researchers have the chance to examine the remaining two and three-way interactions between capabilities and determine their potential effect on Firm Performance.

### 7.2.5 Conclusion

The purpose of the study was to investigate a gap in the existing literature regarding the relationship between I4.0 capability and Firm Performance. To fill this gap, a total of 73 responses were collected and analysed. The study's findings indicated that I4.0 complementary capability had a positive and significant effect on Firm Performance. Furthermore, the study identified increased Innovation Capability and Value Outcomes. Although the I4.0 complementary capability had no significant effect on these outcomes, the study utilised the additive and two-way complementary capability to determine underlying significant predictors of Firm Performance, Innovation Capability, and Value Outcomes. This research has contributed to a better understanding of the dimensions of I4.0 capability and their impact on Firm Performance for both researchers and practitioners.

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# 9. APPENDICES

## 9.1 Appendix A: Construct Items

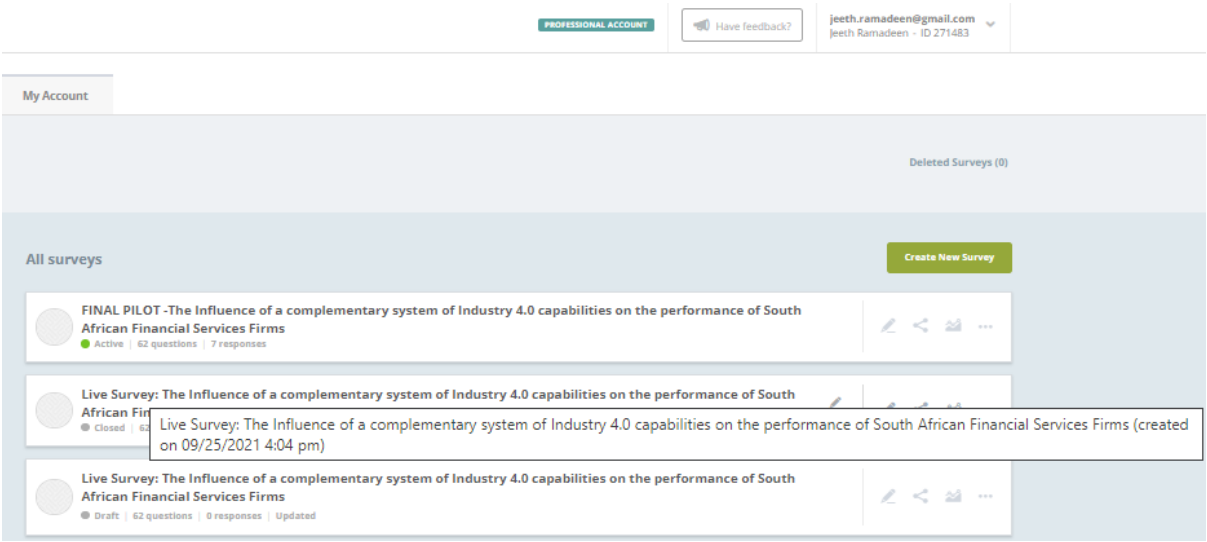
| Measure of | Item | Reference |
|---|---|---|
| Integration | "There is a business and Information Technology (IT) integration across different levels of the organisation or business area."<br>"There is system integration of similar functionality across different levels of our organisation or business area. For example, an internal system that links various branches of an organisation to share a single view of customer data."<br>"There are streamlined business processes with suppliers, distributors, and customers. For example, automation of the supply chain management."<br>"Our organisation can aggregate relevant information from business partners, service providers, and customers. For example, operating information or business customer performance."<br>"There is a compatibility of digital service applications with existing information systems."<br>"There is a compatibility of external enterprise applications with existing information systems."<br>"There is a degree of interoperability between the organisation stakeholders, business partners and customers." | (Sarantis, Charalabidis and Psarras, 2008; Majeed and Rashid, 2010; Ranganathan, Teo and Dhaliwal, 2011; Marin-Garcia, Alfalla-Luque and Medina-López, 2013; Fan and Luo, 2014; Mikalef and Pateli, 2016) |
| Real-time capability | "There are development projects for real-time embedded systems in our organisation or business area."<br>"Data and other valuable resources are accessible in real-time from business partners, service providers, and customers."<br>"Our organisation measures product or service delivery in real-time." | (Yazici, 2014; Ghouri and Mani, 2019; Akesson *et al.*, 2021) |
| Decentralisation | "Decision making is done faster and is automated where possible."<br>"Decision making is enabled by data and analysis."<br>"Decision making is dispersed amongst empowered employees." | (Andersen and Segars, 2001; Juul Andersen, 2005; Futcher and Sunjka, 2018) |
| Service Orientation | “Our senior leaders are actively promoting a vision of the future that involves servitized offerings.”<br>“The organisation has invested in the necessary skills and capabilities to provide servitized offerings.”<br>“The product is designed appropriately for service by our organisation or business area.”<br>“There is a high level of implementation for expanding the service offering to your customers. (e.g., by investing in new service development)”<br>“There is a high level of implementation for designing products or services so that the after-sales service is easier to manage. (e.g., design for maintenance)” | (Sousa and da Silveira, 2017; Abou-Foul, Ruiz-Alba and Soares, 2020; Jang, Bae and Kim, 2020) |
| Modularity | “Information Technology (IT) systems are modular. “<br>“Our product or service uses a modularised design.”<br>“Our products or services can be customised by adding feature modules as requested.” | (Tu *et al.*, 2004; Cohen and Olsen, 2013) |

| | | |
|---|---|---|
| Virtualisation | "Our organisation or business area is able to become virtual"<br>"It is possible for my organisation or business area to become virtual. "<br>"Becoming virtual is within my organisation or business area's capabilities." | (Liu, Sia and Wei, 2008) |
| Digitalisation | "There is a high level of digitalisation in your organisation business model."<br>Our core processes are automated."<br>"We are using digital technologies (such as analytics, social media, mobile, and embedded devices) to understand our customers better."<br>"We market and sell our products and services through digital channels."<br>"We use digital channels to collaborate with business partners and to provide customer services."<br>"We use digital technologies to increase the performance or added value of our existing products and services."<br>"The digital products or services provided by our organisation meets customer needs." | (Abou-Foul, Ruiz-Alba and Soares, 2020; Niemand *et al.*, 2020) |
| Human Resources | "Leaders are be digitally fluent and knowledgeable in the organisation or business area."<br>"There is a culture in the organisation or business area that promotes flexibility, innovation and encourages risk-taking, and employees are empowered."<br>"Leaders have the ability to transform their organisations, and employees have the ability to implement digital initiatives."<br>"There is knowledge, management of software and interfaces that support Industry 4.0 capabilities within the organisation or business area."<br>"There is development of employee skills, capabilities and improvement processes with regard to Industry 4.0 technologies and capabilities." | (Bermúdez and Juárez, 2017; Futcher and Sunjka, 2018) |
| Servitisation outcomes | "The Industry 4.0 complementary capability enables the organisation to offer products or services that are customised for each individual customer."<br>"The Industry 4.0 complementary capability enables the organisation to offer a reasonable price and ensure cost savings for customers."<br>"Customer needs are satisfied through products and services provided by the Industry 4.0 complementary capability."<br>"The Industry 4.0 complementary capability enables consistent support to be provided during the use of the product and service."<br>"The Industry 4.0 complementary capability enables the organisation or business area to better understand customer problems and requests." | (Wang, Tang and Tang, 2001; Petrick, 2002; Korda and Snoj, 2010) |
| Innovation | "The Industry 4.0 complementary capability enables the organisation or business area to provide innovative products or services."<br>"The Industry 4.0 complementary capability enables the organisation or business area to use innovations which use technologies that have an impact on or cause significant changes in the whole industry."<br>"A majority of our organisation or business area's innovations use new technologies that permit quantum leaps in performance through the implementation of the Industry 4.0 complementary capability."<br>"The majority of our innovations offer our customers a unique advantage over competitors' products through the implementation of the Industry 4.0 complementary capability." | (Nagaraju, 2015) |

| | | |
|---|---|---|
| Improved value chain | "The Industry 4.0 complementary capability enables the organisation or business area to provide reliable high-quality products or services."<br>"The Industry 4.0 complementary capability allows for the ability to make rapid design changes."<br>"The Industry 4.0 complementary capability improved the decision-making process." | (Wang, Tang and Tang, 2001; Carlos Fandos Roig *et al.*, 2006; Dalenogare *et al.*, 2018; Salam, 2019) |
| Operational advantage | "The Industry 4.0 complementary capability helps the organisation or business area to reduce costs."<br>"The Industry 4.0 complementary capability helps the organisation or business area to increase revenue."<br>"The Industry 4.0 complementary capability built improves quality of operations"<br>"The Industry 4.0 complementary capability enables the organisation or business area to reduce lead time for products or services delivered."<br>"The Industry 4.0 complementary capability enables the organisation or business area to reduce lead time for products or services delivered." | (Nevo and Wade, 2011) |
| Competitive advantage | "The Industry 4.0 complementary capability provides the organisation or business area with a competitive advantage.:<br>"The Industry 4.0 complementary capability has expanded our market share consistently. "<br>"The Industry 4.0 complementary capability helps us to improve financial profitability."<br>"The Industry 4.0 complementary capability provides the ability to introduce new products or services more quickly than competitors."<br>"The Industry 4.0 complementary capability enables the organisation or business area to respond more quickly to change." | (Alkhalaf et al., 2012; Kim and Baek , 2018; Nevo and Wade, 2011) |

## 9.2 Appendix B: Research Instrument

https://www.surveyhero.com/user/surveys/506189/edit



SurveyHero

## Live Survey: The Influence of a complementary system of Industry 4.0 capabilities on the performance of South African Financial Services Firms

### The Influence of a complementary system of Industry 4.0 capabilities on the performance of South African Financial Services Firms

Participant Information Sheet

Dear Sir / Madam,

My name is Jeeth Ramadeen, and I am a Masters student in Information systems at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project. I am investigating, The Influence of a Complementary system of Industry 4.0 capabilities on the performance of South African Financial Services Firms, under the supervision of Neetu Ramsaroop. This research project aims to answer:

1- What are the critical Industry 4.0 capabilities that can be proposed in delivering firm performance within financial services?
2- What are the measurable benefits of Industry 4.0 that can result in generating firm performance within the financial services sector?

As part of this research study, I would like to invite you to answer an online questionnaire which should take approximately 15 minutes to complete.

There will be no personal costs if you choose to participate in this research study. You will not receive any direct benefits from participating in this study, and there are no disadvantages or penalties for not participating. You may withdraw at any given time and you may choose not to answer a question if you do not want to. The questionnaire will be completely confidential and anonymous. Personal identifying information is not required should you choose to participate.

Should you have any questions during or after this research, please contact me on the details listed below. This study will be written up as journal articles or papers for conferences. If you wish to receive a summary of the research article, I will be happy to send it to you upon request. The data collected from this research study will be stored in a password-protected computer and kept for 1 year. With your permission, the data collected from this research project may be used by other researchers. If you have any concerns or complaints regarding this study's ethical procedures, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrec-medical.researchoffice@wits.ac.za.

Yours sincerely,
Jeeth Ramadeen

Researcher:
Jeeth Ramadeen, 2180644@students.wits.ac.za
PROTOCOL NUMBER: CBUSE/1755

Supervisor:
Professor Neetu Ramsaroop, neetu.ramsaroop@wits.ac.za, 011 717 8154

**The Influence of a complementary system of Industry 4.0 capabilities on the performance of South African Financial Services Firms**

Project Background

**Please select which title best describes your role in the organisation? ***

- ◯ CEO
- ◯ CIO
- ◯ Department head
- ◯ IT Manager
- ◯ Strategy or Development Manager/ Lead
- ◯ Project Manager/ Scrum Master
- ◯ Other

**Please indicate the number of employees in the organisation or your business unit. ***

- ◯ 1-200
- ◯ 201-500
- ◯ 501-1000
- ◯ 1001- 5000
- ◯ 5001-10000
- ◯ 10001-40000
- ◯ >40001

**Please indicate the industry of the organisation or business unit. ***

- ◯ Retail and Commercial bank
- ◯ Digital Bank
- ◯ Investment Managment
- ◯ Insurance
- ◯ Legislation and Regulation
- ◯ Fintech
- ◯ Other

**How old is the organisation or business unit , in years? ***

- ◯ 0-5
- ◯ 6-10
- ◯ 11-15
- ◯ 16-20
- ◯ >21

**Industry 4.0**

Industry 4.0, also acknowledged as the Fourth Industrial Revolution or Digital Revolution is considered the next industrial stage. Industry 4.0 is defined as the integration of disruptive innovations, technologies, and people into the value creation processes of organizations. It will enable organisations to harness interconnected, intelligent, automated, digitized, and decentralised value chains that will drive for flexible business models, enhancing organizational agility in responding and adapting to dynamic business environments.

Industry 4.0 is based on the below principles:

- Integration
- Real-time capability
- Decentralisation
- Service Orientation
- Modularisation
- Virtualisation
- Digitalisation
- Human Resources

Each of the above principles will be defined within the survey.

**Complementary system of Industry 4.0 capabilities**

Complementarities are based on the combined effect of resources and capabilities to significantly affect the sum of the individual values. A complementary system of Industry 4.0 capabilities for this survey is be defined as:

- The ability of an organization to assemble, integrate and deploy Industry 4.0 principles, capabilities, skills, competencies, and design strategies in a different and dynamic frame, and to create other capabilities, processes, tools, and combinations of them, to ensure proper strategy implementation involving the entire organisation or business area.

**Firm Performance**

Firm performance for the purpose of this survey constitutes Operational Performance and Competitive Performance.

- Operational performance represents the organization or business unit performance measured in cost reduction, increased quality, flexibility, reliability, and faster delivery.

- Competitive performance can be conceptualized as the degree to which an organization or business unit can produce and sell products and services that outperform its domestic competitors. It primarily represents performance measured in customer satisfaction, innovation, profitability, and competitive advantage.

**Contribution of the research**

Research has shown that high and significant investments are required for implementing capabilities related to Industry 4.0 within financial services. They vary from infrastructure, design, implementation, and people investment; however, a firm's return on investment and value creation is not fully realized. There is also a lack of knowledge within the domain, and implementation success rates are low. It is anticipated that this study would provide professional audiences and academics a robust view of Industry 4.0 and its fundamental capabilities in realizing the possible benefits and achieving a competitive advantage for financial services within South Africa. Secondly, Industry 4.0 is a reasonably new subject of study for which research is lacking. This research may contribute to adding new knowledge to the research domain.

**Survey Structure**

This survey aims to determine the influence of a complementary system of Industry 4.0 capabilities on firm performance on financial services firms within South Africa. The survey consists of 5 pages with 58 questions in total. The survey makes use of a 7-point scale, 1:Strongly disagree, 2: Disagree, 3: Slightly disagree, 4: Neither agree or disagree, 5: somewhat agree, 6: Agree, 7: Strongly agree. The questions are structured per principle with the definition provided under the respective sections.

## Section A: The Industry 4.0 Complementary capability

Please answer the following questions concerning your organisations or business area implementation of Industry 4.0 capabilities.

**Integration**

Integration proposes structural and digital changes internal or external to an organisation or business area to establish an interconnected and interoperable value chain. It incorporates the management of physical objects, the establishment of networks between information systems, and expansion across the entire product or service lifecycle.

**There is a business and Information Technology (IT) integration across different levels of the organisation or business area. ***

Integration

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There is system integration of similar functionality across different levels of our organisation or business area.**
**For example an internal system that links various branches of an organisation to share a single view of customer data. ***

Integration

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There are streamlined business processes with suppliers, distributors, and customers.**
**For example automation of the supply chain management. ***

Integration

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Our organisation can aggregate relevant information from business partners, service providers, and customers.**
**For example operating information or business customer performance. ***

Integration

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There is a compatibility of digital service applications with existing information systems.**
***

Integration

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There is a compatibility of external enterprise applications with existing information systems. ***

Integration

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There is a degree of interoperability between the organisation stakeholders, business partners and customers. ***

Integration

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Real-time capability**

Real-time capabilities allow organisations and devices to share real-time information and make optimized decisions regarding current or future operations.

**There are development projects for real-time embedded systems in our organisation or business area. ***

Real-Time Capability

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Data and other valuable resources are accessible in real-time from business partners, service providers, and customers. ***

Real-Time Capability

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Our organisation measures product or service delivery in real-time. ***

Real-Time Capability

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Virtualisation**

Virtualisation involves developing a digitally replicated version of the physical world. Virtualisation uses software that simulates hardware functionality in order to create a virtual system and serves to monitor processes through simulation.

**Our organisation or business area is able to become virtual. ***

Virtualisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**It is possible for my organisation or business area to become virtual. ***

Virtualisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Becoming virtual is within my organisation or business area's capabilities. ***

Virtualisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Human Resource Skills**

The human enablers constitute skills and competencies from employees that potentialise the effective implementation of Industry 4.0 principles and capabilities.

**Leaders are be digitally fluent and knowledgable in the organisation or business area. ***

Human Resources

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There is a culture in the organisation or business area that promotes flexibility, innovation and encourage risk-taking,and employees are empowered. ***

Human Resources

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Leaders have the ability to transform their organisations, and employees have the ability to implement digital initiatives. ***

Human Resources

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There is knowledge, management of software and interfaces that support Industry 4.0 capabilities within the organisation or business area. ***

Human Resources

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**There is development of employee skills, capabilities and improvement processes with regard to Industry 4.0 technologies and capabilities. ***

Human Resources

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Digitalisation**

Those capabilities or resources that a business will need to operate in a digital environment, i.e., involves the digitisation and integration of the entire value chain of the lifecycle of products.

**There is a high level of digitalisation in your organisation business model. ***

Digitalisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Our core processes are automated. ***

Digitalisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**We are using digital technologies (such as analytics, social media, mobile, and embedded devices) to understand our customers better. ***

Digitalisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**We market and sell our products and services through digital channels. ***

Digitalisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**We use digital channels to collaborate with business partners and to provide customer services. ***

Digitalisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**We use digital technologies to increase the performance or added value of our existing products and services. ***

Digitalisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The digital products or services provided by our organisation meets customer needs. ***

Digitalisation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

## Section B: Benefits of Industry 4.0 Complementary capability

Complementarities are based on the combined effect of resources and capabilities to significantly affect the sum of the individual values.
The Industry 4.0 Complementary capability is the ability of an organisation to assemble, integrate and deploy the Industry 4.0 principles being, Integration, Real-time capability, Decentralisation, Service Orientation, Virtualisation, Digitalisation, and Human Resource skills as previously indicated.
This section of the survey measures the possible benefits of such a complementary capability.

Please answer the following questions concerning your organisation or business area implementation of Industry 4.0 complimentary capability.

**The Industry 4.0 complementary capability enables the organisation to offer products or services that are customised for each individual customer. ***

Servitization outcomes

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables the organisation to offer a reasonable price and ensure cost savings for customers. ***

Servitization outcomes

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Customer needs are satisfied through products and services provided by the Industry 4.0 complementary capability. ***

Servitization outcomes

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables consistent support to be provided during the use of the product and service. ***

Servitization outcomes

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables the organisation or business area to better understand customer problems and requests. ***

Servitization outcomes

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables the organisation or business area to provide reliable high-quality products or services. ***

Improved Value Chain

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability allows for the ability to make rapid design changes. ***

Improved Value Chain

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability improved the decision-making process. ***

Improved Value Chain

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables the organisation or business area to provide innovative products or services. ***

Innovation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables the organisation or business area to use innovations which use technologies that have an impact on or cause significant changes in the whole industry. ***

Innovation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**A majority of our organisation or business area's innovations use new technologies that permit quantum leaps in performance through the implementation of the Industry 4.0 complementary capability. ***

Innovation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The majority of our innovations offer our customers a unique advantage over competitors' products through the implementation of the Industry 4.0 complementary capability. ***

Innovation

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

## Section C: Firm Performance

Please answer the following questions concerning your organisations or business area implementation of Industry 4.0 capabilities. Performance can be organisational or business area level.

**The Industry 4.0 complementary capability helps the organisation or business area to reduce costs. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability helps the organisation or business area to increase revenue. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability built improves quality of operations. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables the organisation or business area to reduce lead time for products or services delivered. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability improves the reliability of operations. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability provides the organisation or business area with a competitive advantage. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability has expanded our market share consistently. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability helps us to improve financial profitability. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability provides the ability to introduce new products or services more quickly than competitors. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**The Industry 4.0 complementary capability enables the organisation or business area to respond more quickly to change. ***

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

## 9.2 Appendix C: Ethics Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

**SCHOOL OF BUSINESS SCIENCES ETHICS COMMITTEE**
**CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)**

| | |
|---|---|
| **CLEARANCE CERTIFICATE** | **PROTOCOL NUMBER: CBUSE/1755** |
| **PROJECT TITLE** | The Influence of a Complementary System of Industry 4.0 Capabilities On the Performance of South African Financial Services Firms |
| **INVESTIGATOR** | Mr Jeeth Ramadeen |
| **SCHOOL/DEPARTMENT OF INVESTIGATOR** | School of Business Sciences |
| **DATE CONSIDERED** | 29 October 2020 |
| **DECISION OF THE COMMITTEE** | Approved unconditionally |
| **RISK LEVEL** | LOW RISK |
| **EXPIRY DATE** | 31 December 2022 |

**ISSUE DATE OF CERTIFICATE** 2 November 2020 **CHAIRPERSON** _____
(Neetu Ramsaroop)

cc: Supervisor: Neetu Ramsaroop

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**DECLARATION OF INVESTIGATOR**

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

_____ _____/_____/_____
**Signature** **Date**

**PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES**

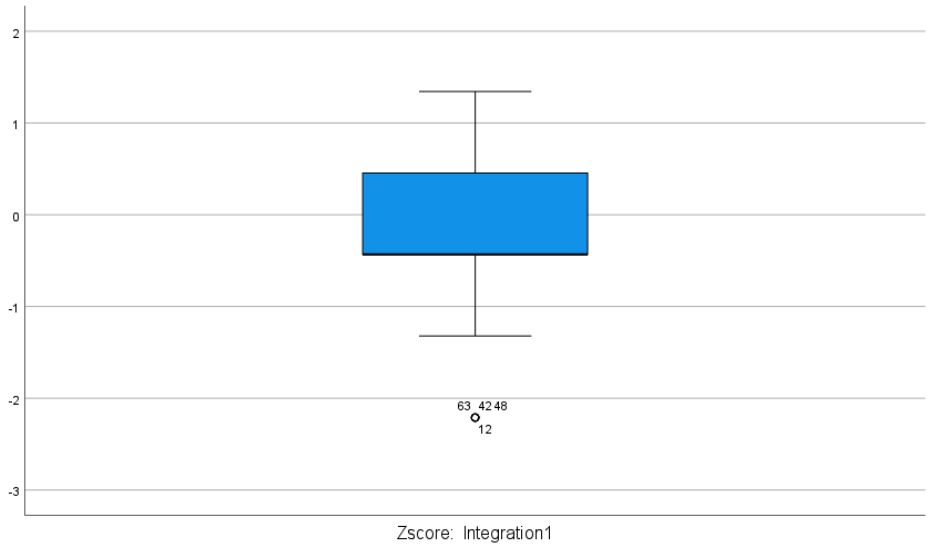
## 9.3 Appendix D: Missing Data Statistics

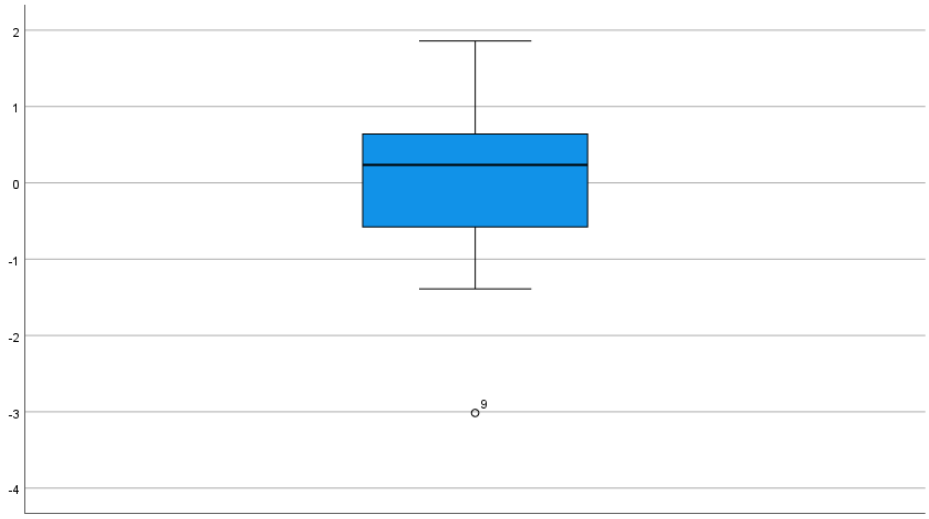
| Statistics | | |
|---|---|---|
| | N | |
| | Valid | Missing |
| Please select which title best describes your role in the organisation? | 95 | 0 |
| Please indicate the number of employees in the organisation or your business unit. | 95 | 0 |
| Please indicate the industry of the organisation or business unit. | 95 | 0 |
| How old is the organisation or business unit, in years? | 95 | 0 |
| "There is a business and Information Technology (IT) integration across different levels of the organisation or business area." | 85 | 10 |
| "There is system integration of similar functionality across different levels of our organisation or business area. For example, an internal system that links various branches of an organisation to share a single view of customer data." | 85 | 10 |
| "There are streamlined business processes with suppliers, distributors, and customers. For example, automation of the supply chain management." | 85 | 10 |
| "Our organisation can aggregate relevant information from business partners, service providers, and customers. For example, operating information or business customer performance." | 85 | 10 |
| "There is a compatibility of digital service applications with existing information systems." | 85 | 10 |
| "There is a compatibility of external enterprise applications with existing information systems." | 85 | 10 |
| "There is a degree of interoperability between the organisation stakeholders, business partners and customers." | 85 | 10 |
| "There are development projects for real-time embedded systems in our organisation or business area." | 85 | 10 |
| "Data and other valuable resources are accessible in real-time from business partners, service providers, and customers." | 85 | 10 |
| "Our organisation measures product or service delivery in real-time." | 85 | 10 |
| "Decision making is done faster and is automated where possible." | 81 | 14 |
| "Decision making is enabled by data and analysis." | 81 | 14 |
| "Decision making is dispersed amongst empowered employees." | 81 | 14 |
| "Our senior leaders are actively promoting a vision of the future that involves servitised offerings." | 81 | 14 |
| "The organisation has invested in the necessary skills and capabilities to provide servitised offerings." | 81 | 14 |
| "The product is designed appropriately for service by our organisation or business area." | 81 | 14 |
| "There is a high level of implementation for expanding the service offering to your customers. (e.g., by investing in new service development)" | 81 | 14 |
| "There is a high level of implementation for designing products or services so that the after-sales service is easier to manage. (e.g., design for maintenance)" | 81 | 14 |
| "Information Technology (IT) systems are modular." | 81 | 14 |
| "Our product or service uses a modularised design." | 81 | 14 |

| | | |
|---|---|---|
| “Our products or services can be customised by adding feature modules as requested.” | 81 | 14 |
| “Our organisation or business area is able to become virtual.” | 81 | 14 |
| “It is possible for my organisation or business area to become virtual.” | 81 | 14 |
| “Becoming virtual is within my organisation or business area's capabilities.” | 81 | 14 |
| “Leaders are be digitally fluent and knowledgeable in the organisation or business area.” | 81 | 14 |
| “There is a culture in the organisation or business area that promotes flexibility, innovation and encourage risk-taking, and employees are empowered.” | 81 | 14 |
| “Leaders have the ability to transform their organisations, and employees have the ability to implement digital initiatives.” | 81 | 14 |
| “There is knowledge, management of software and interfaces that support Industry 4.0 capabilities within the organisation or business area.” | 81 | 14 |
| “There is development of employee skills, capabilities and improvement processes with regard to Industry 4.0 technologies and capabilities.” | 81 | 14 |
| “There is a high level of digitalisation in your organisation business model.” | 81 | 14 |
| “Our core processes are automated.” | 81 | 14 |
| “We are using digital technologies (such as analytics, social media, mobile, and embedded devices) to understand our customers better.” | 81 | 14 |
| “We market and sell our products and services through digital channels.” | 81 | 14 |
| “We use digital channels to collaborate with business partners and to provide customer services.” | 81 | 14 |
| “We use digital technologies to increase the performance or added value of our existing products and services.” | 81 | 14 |
| “The digital products or services provided by our organisation meets customer needs.” | 78 | 17 |
| “The Industry 4.0 complementary capability enables the organisation to offer products or services that are customised for each individual customer.” | 78 | 17 |
| “The Industry 4.0 complementary capability enables the organisation to offer a reasonable price and ensure cost savings for customers.” | 78 | 17 |
| “Customer needs are satisfied through products and services provided by the Industry 4.0 complementary capability.” | 78 | 17 |
| “The Industry 4.0 complementary capability enables consistent support to be provided during the use of the product and service.” | 78 | 17 |
| “The Industry 4.0 complementary capability enables the organisation or business area to better understand customer problems and requests.” | 78 | 17 |
| “The Industry 4.0 complementary capability enables the organisation or business area to provide reliable high-quality products or services.” | 78 | 17 |
| “The Industry 4.0 complementary capability allows for the ability to make rapid design changes.” | 78 | 17 |
| “The Industry 4.0 complementary capability improved the decision-making process.” | 78 | 17 |
| “The Industry 4.0 complementary capability enables the organisation or business area to provide innovative products or services.” | 78 | 17 |
| “The Industry 4.0 complementary capability enables the organisation or business area to use innovations which use technologies that have an impact on or cause significant changes in the whole industry.” | 78 | 17 |
| “A majority of our organisation or business area's innovations use new technologies that permit quantum leaps in performance through the implementation of the Industry 4.0 complementary capability.” | 78 | 17 |

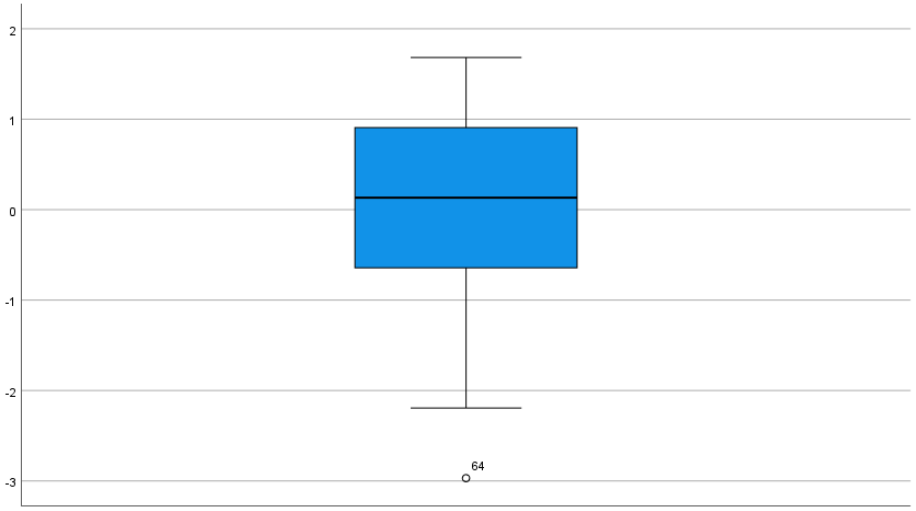
| | | |
|---|---|---|
| "The majority of our innovations offer our customers a unique advantage over competitors' products through the implementation of the Industry 4.0 complementary capability." | 78 | 17 |
| "The Industry 4.0 complementary capability helps the organisation or business area to reduce costs." | 75 | 20 |
| "The Industry 4.0 complementary capability helps the organisation or business area to increase revenue." | 76 | 19 |
| "The Industry 4.0 complementary capability built improves quality of operations." | 76 | 19 |
| "The Industry 4.0 complementary capability enables the organisation or business area to reduce lead time for products or services delivered." | 76 | 19 |
| "The Industry 4.0 complementary capability improves the reliability of operations." | 76 | 19 |
| "The Industry 4.0 complementary capability provides the organisation or business area with a competitive advantage." | 76 | 19 |
| "The Industry 4.0 complementary capability has expanded our market share consistently. " | 76 | 19 |
| "The Industry 4.0 complementary capability helps us to improve financial profitability." | 76 | 19 |
| "The Industry 4.0 complementary capability provides the ability to introduce new products or services more quickly than competitors." | 74 | 21 |
| "The Industry 4.0 complementary capability enables the organisation or business area to respond more quickly to change." | 74 | 21 |

## 9.4 Appendix E: Outlier Analysis






Zscore: Integration3

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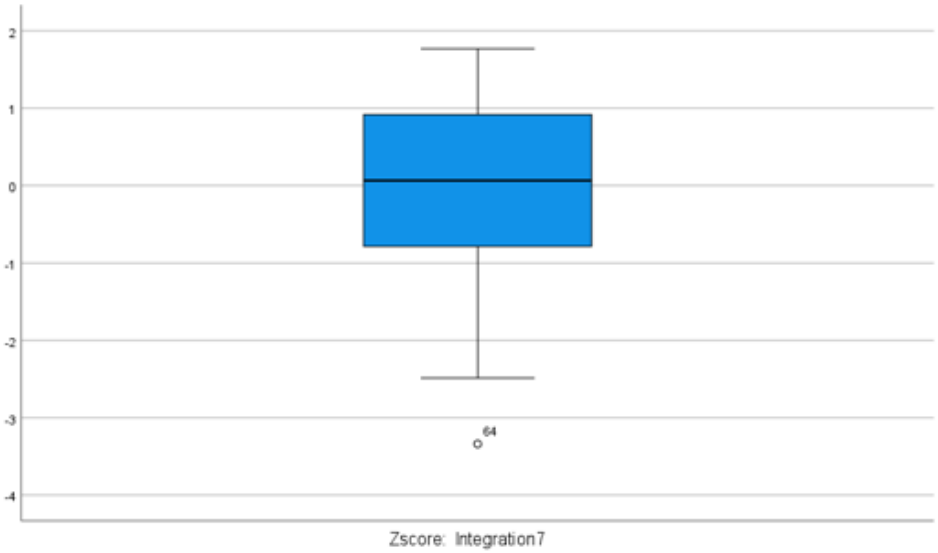
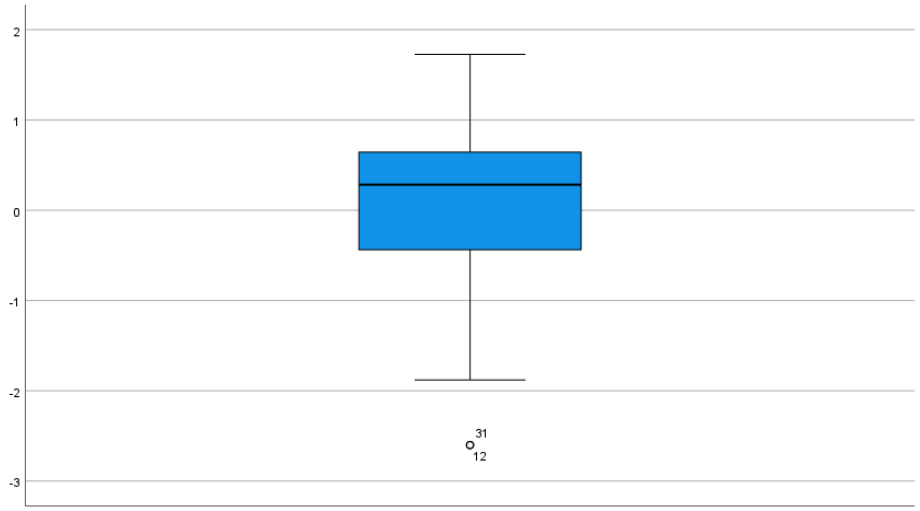
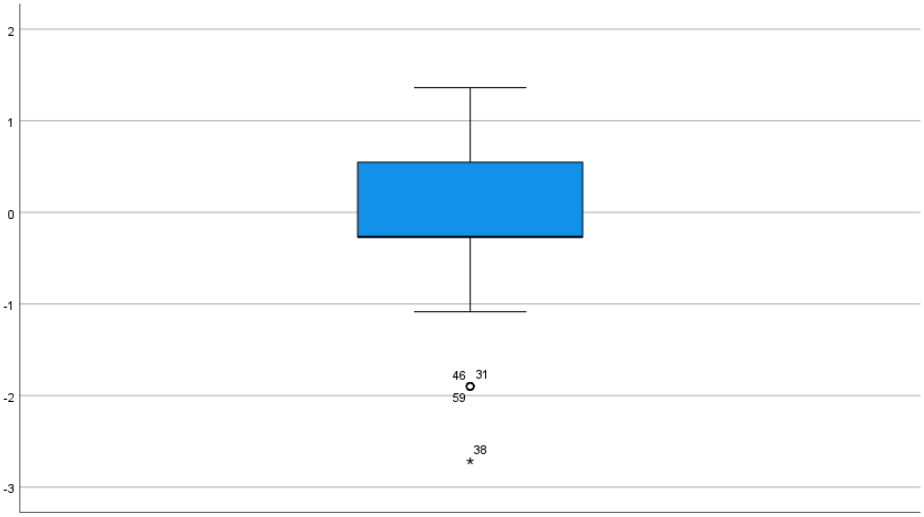


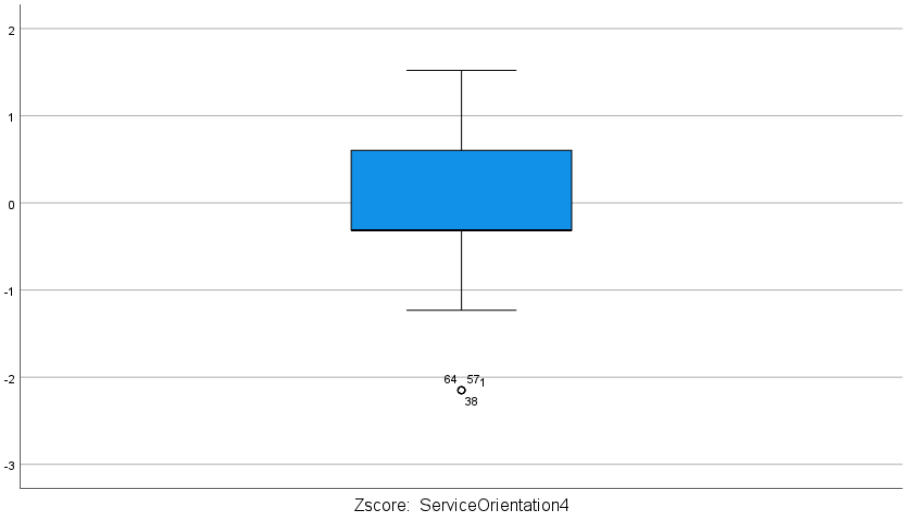

Zscore: Integration7



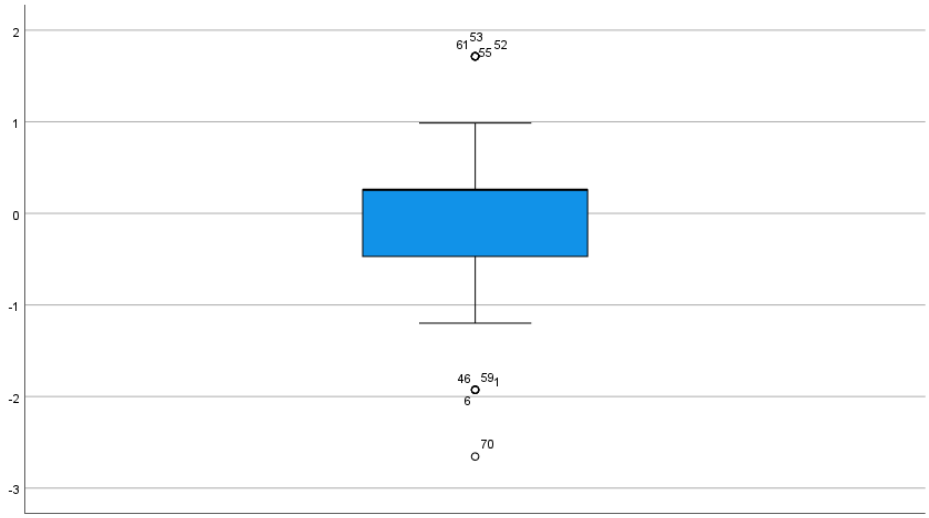

Zscore: RT2



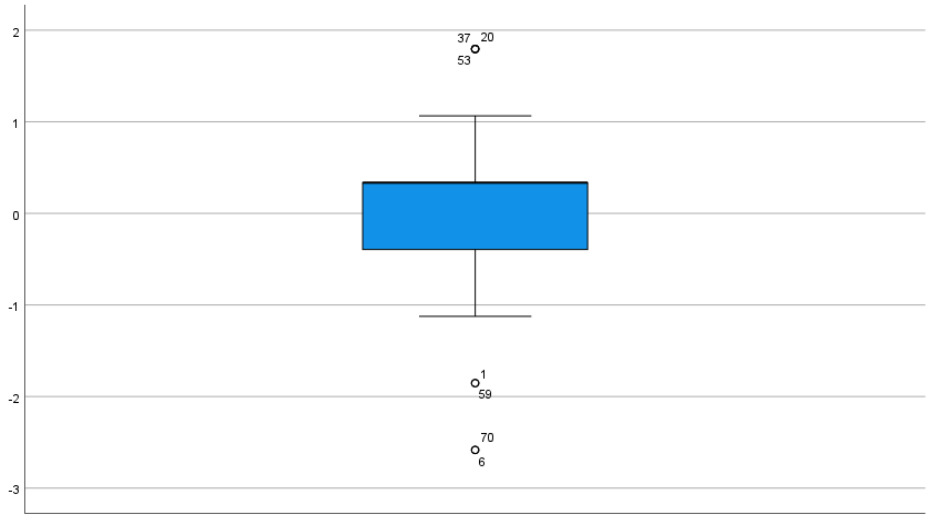

Zscore: ServiceOrientation1



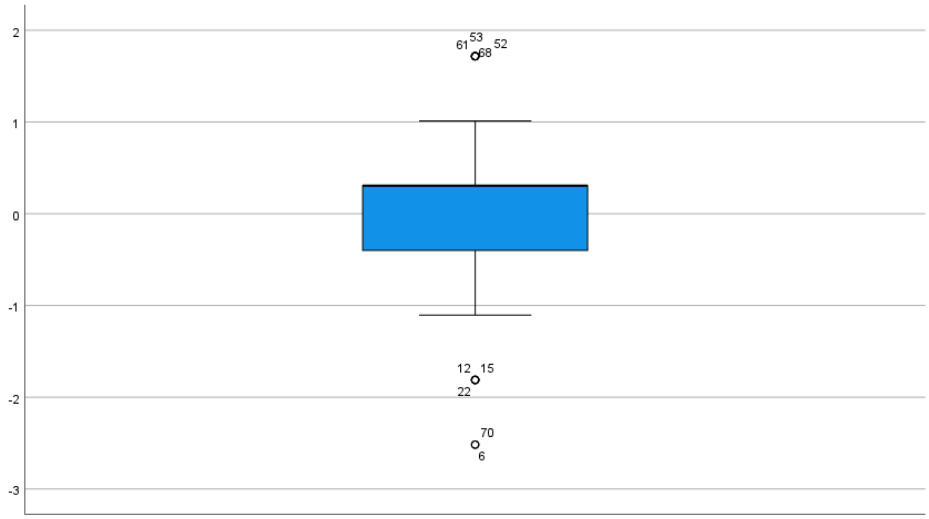

Zscore: ServiceOrientation4



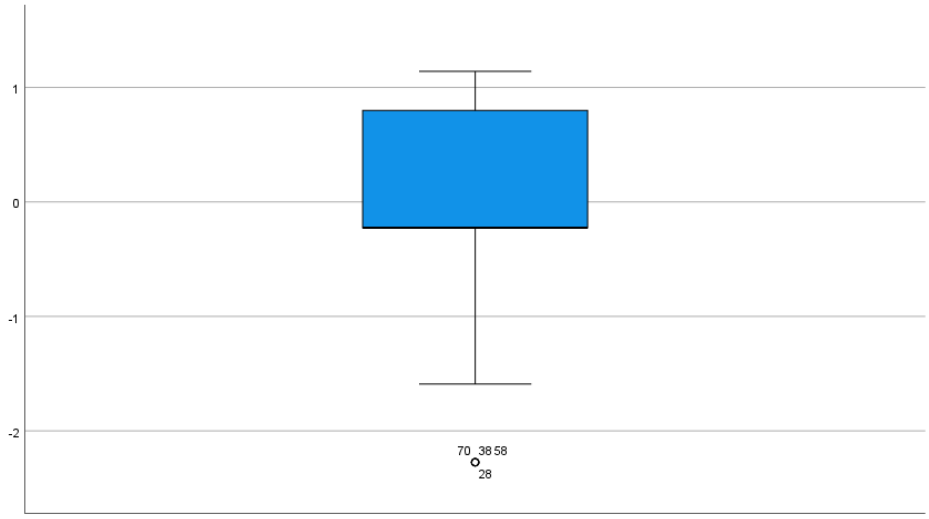

Zscore: Modularisation1



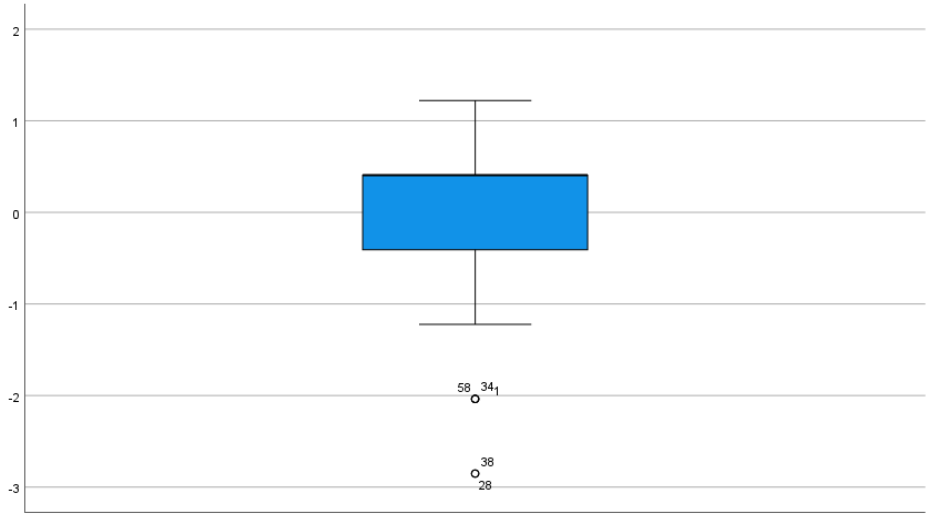

Zscore: Modularisation2



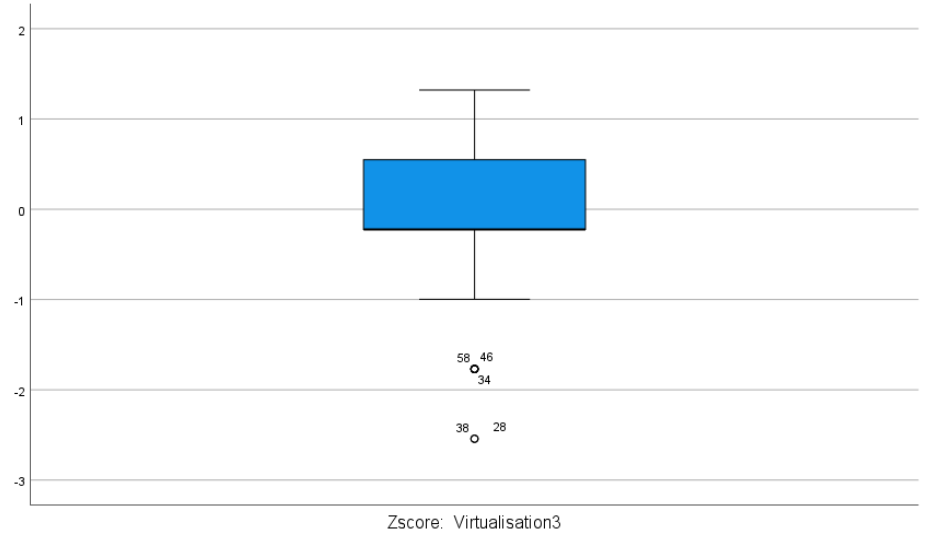

Zscore: Modularisation3



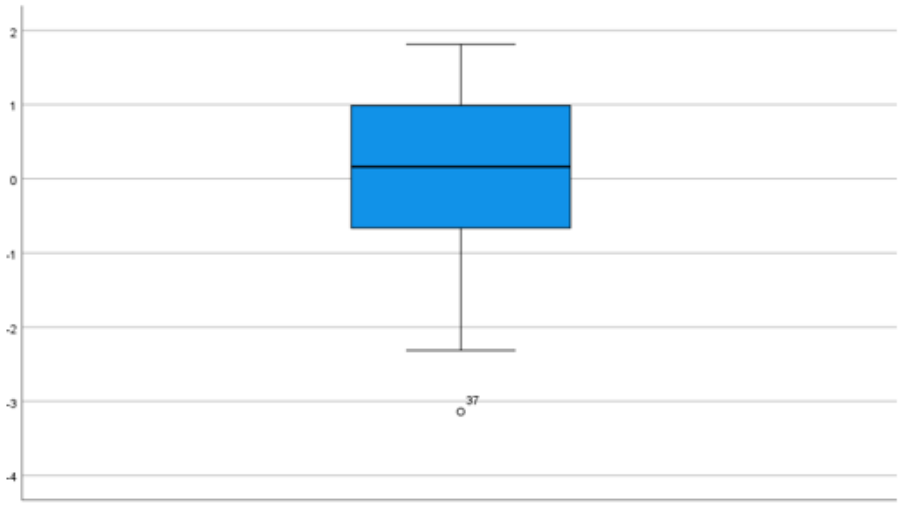

Zscore: Virtualisation1



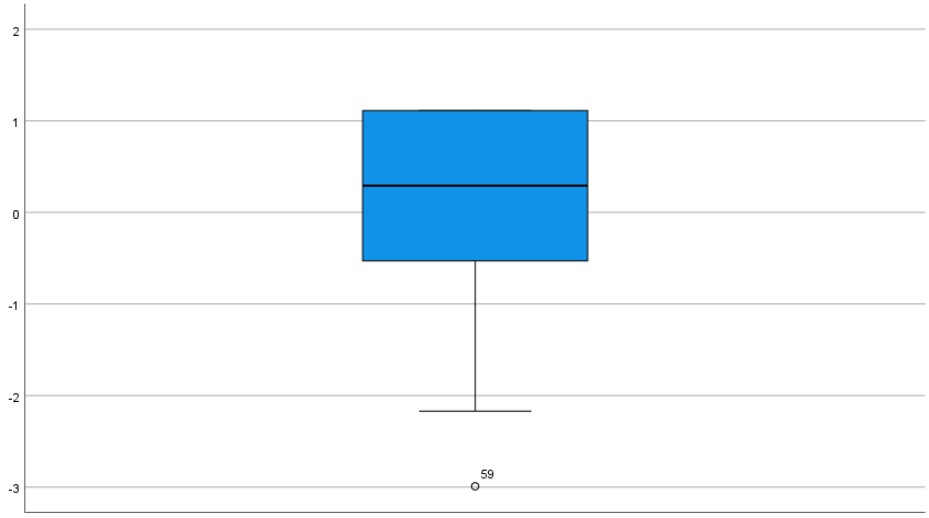

Zscore: Virtualisation2



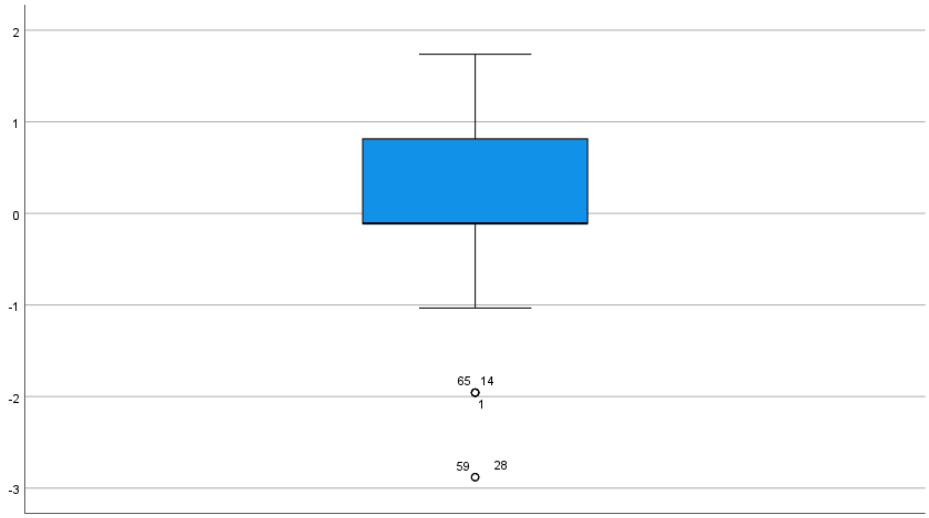

Zscore: Virtualisation3



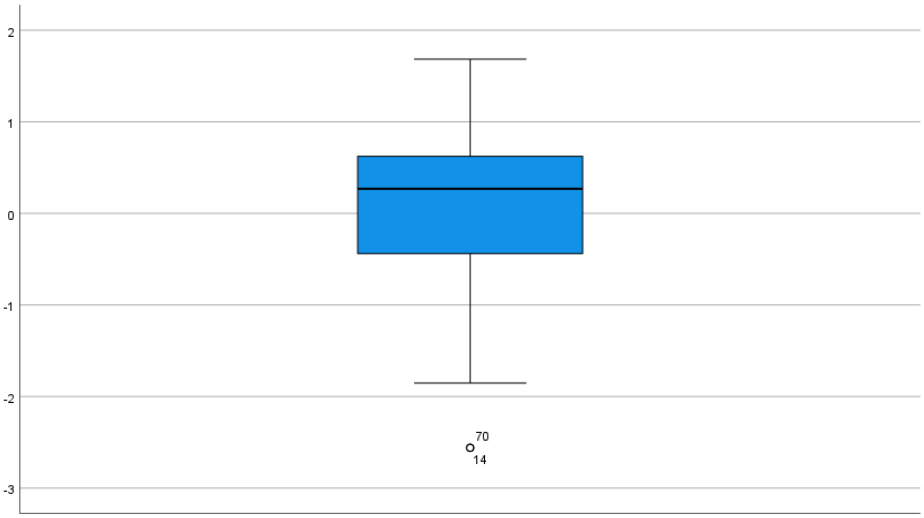

Zscore: HRS5



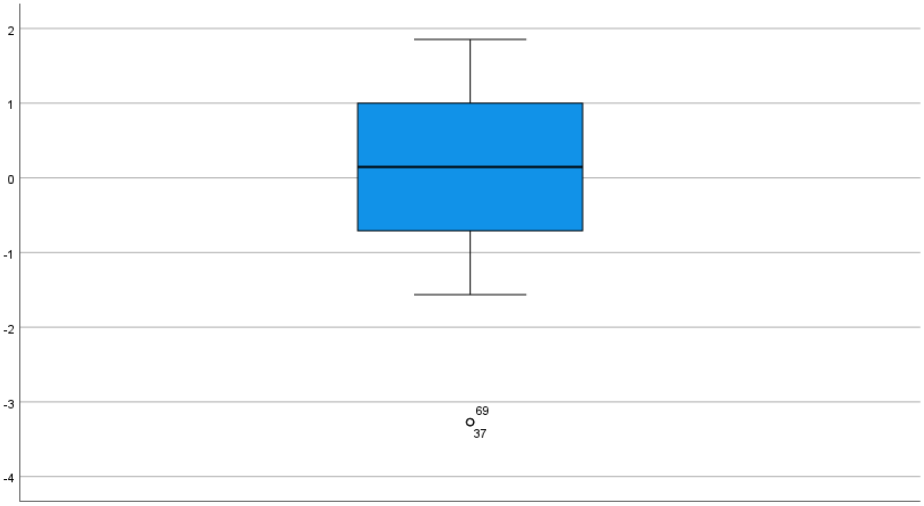

Zscore: Digitalisation6



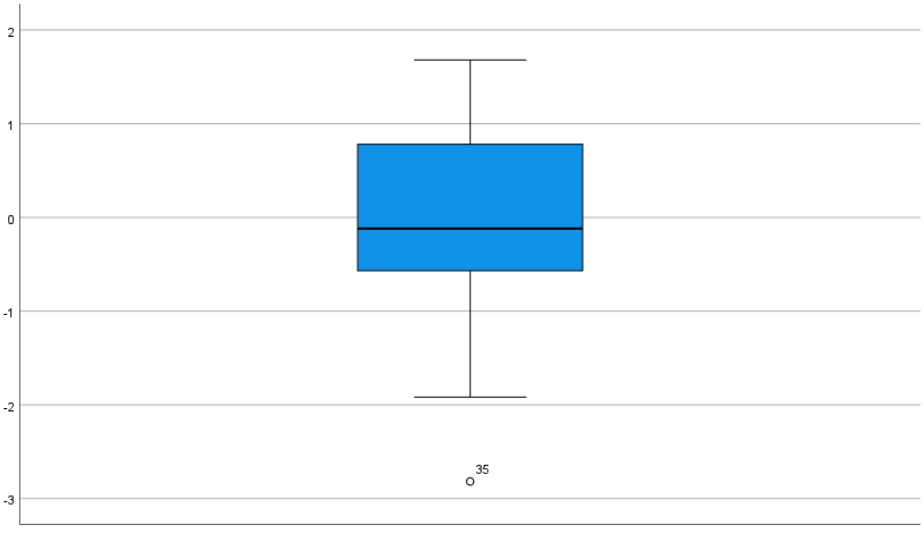

Zscore: Digitalisation7




Zscore: SO1




Zscore: SO2

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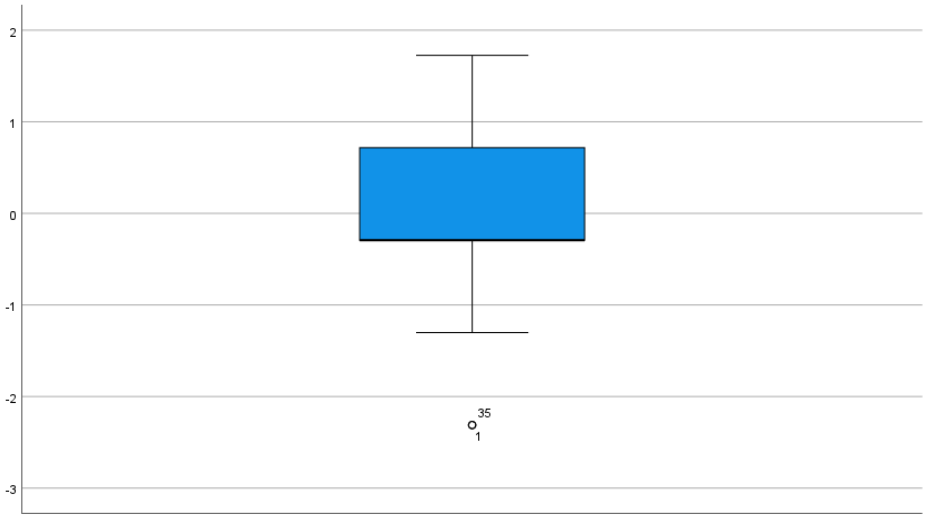


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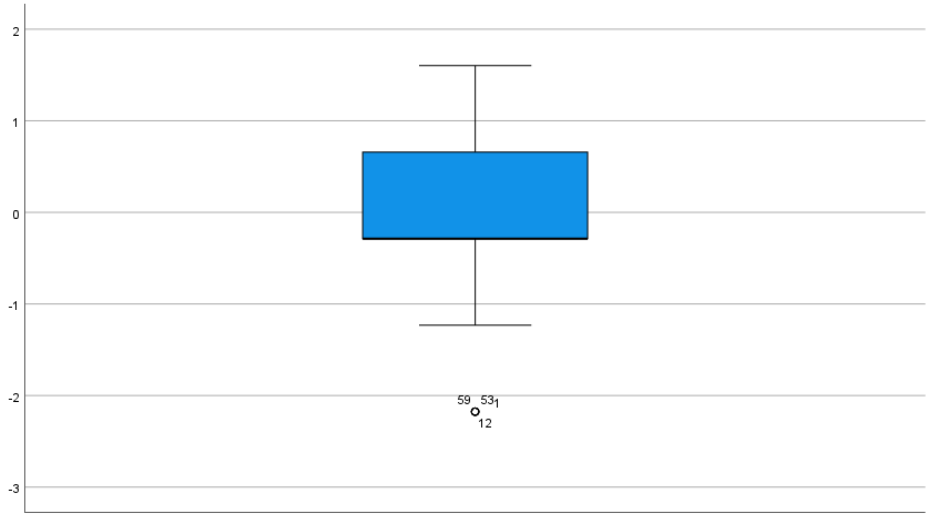


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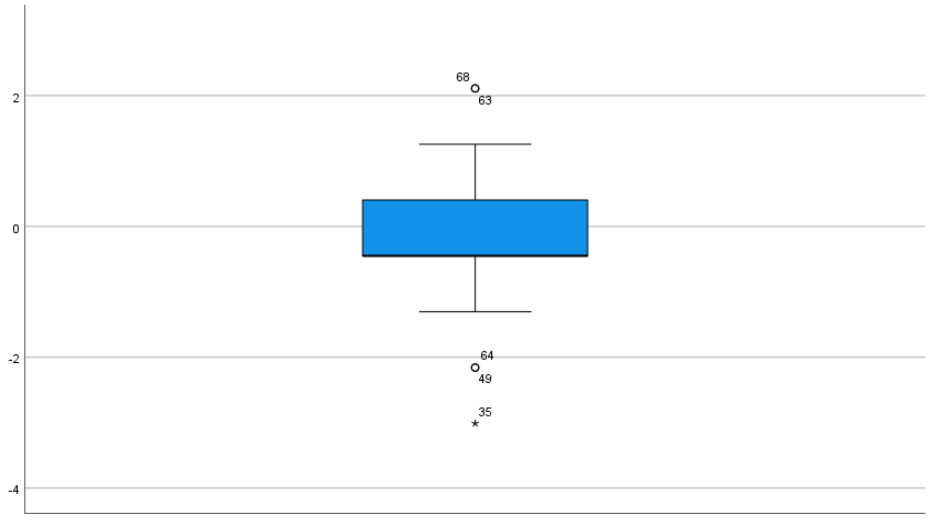


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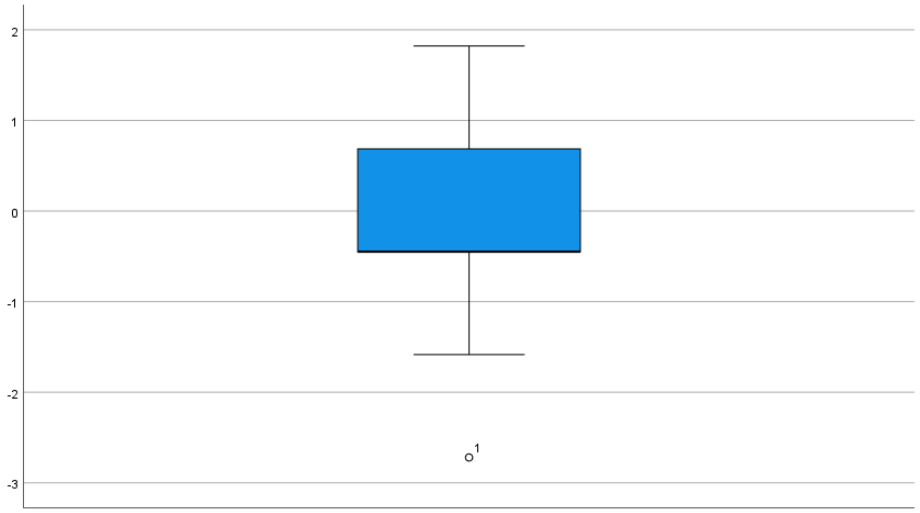
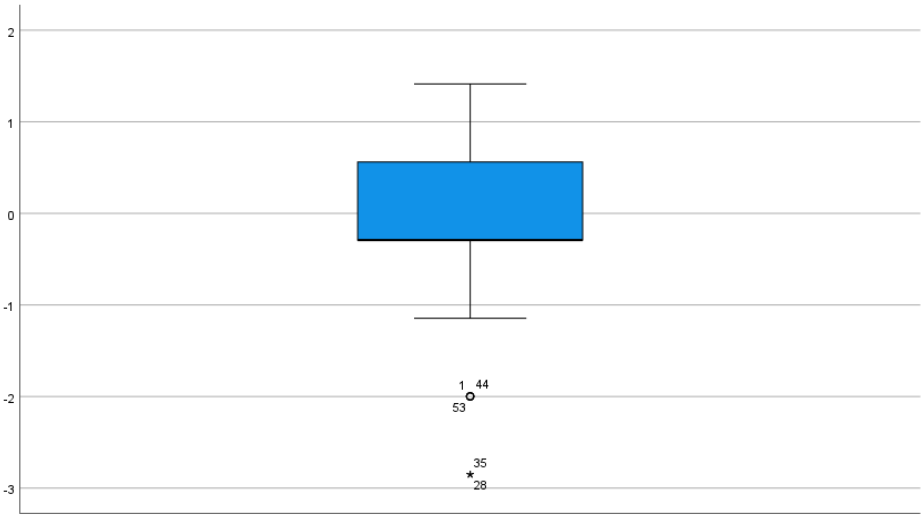



Zscore: OP3

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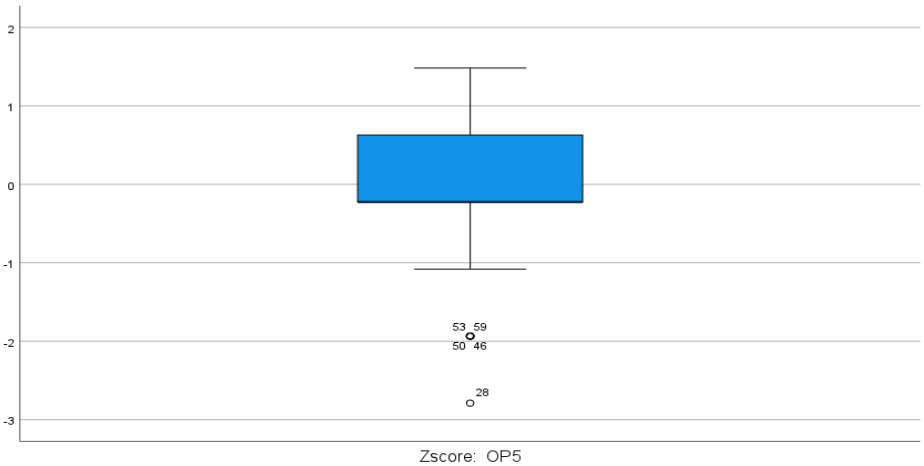


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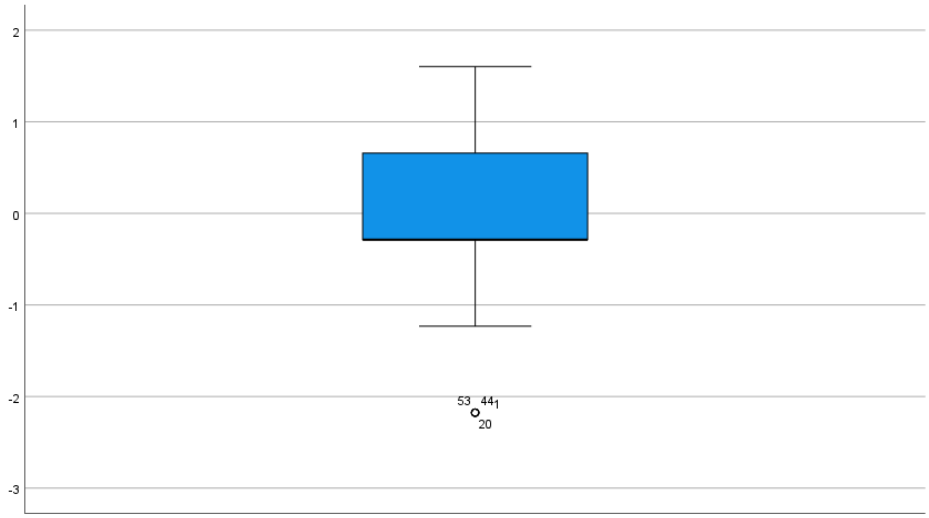


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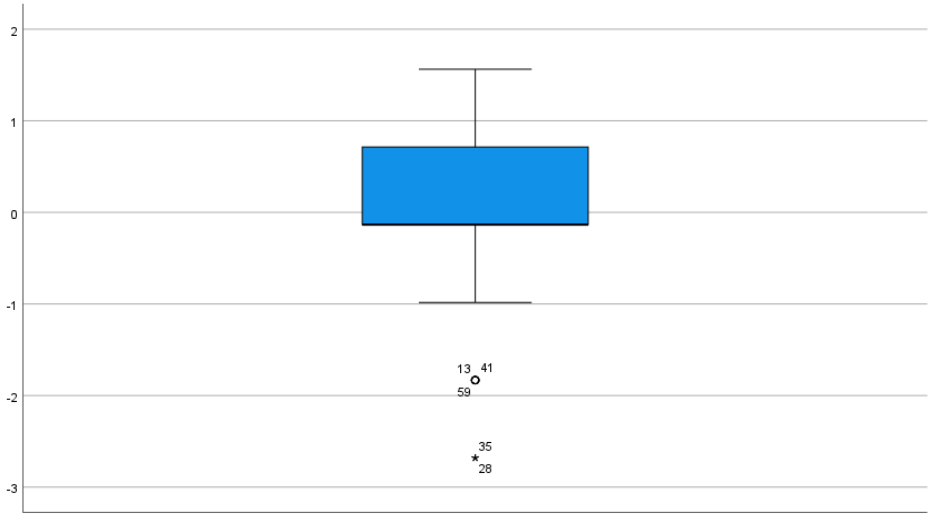



Zscore: CP5

## 9.5 Appendix F: Multiple Regression assumptions

**Collinearity**

Tolerance values are above 0.2 and 1. The VIFs are below 5, hence, the collinearity of the independent variables is not a concern and is deemed satisfactory and are retained.

**Coefficients[a]**

| Model | | Collinearity Statistics | |
|---|---|---|---|
| | | Tolerance | VIF |
| 1 | Composite_Integration | .545 | 1.835 |
| | Composite_RT | .586 | 1.707 |
| | Composite_D_SO | .401 | 2.492 |
| | Composite_Modularisation | .515 | 1.942 |
| | Composite_Virtualisation | .637 | 1.569 |
| | Composite_HRS | .422 | 2.369 |
| | Composite_Digitalisation | .568 | 1.762 |

a. Dependent Variable: Composite_FP

Figure 19.Coefficients of I4.0 Complementary Capability

**Assumption of Linear Relationships, Normality of Residual Distribution and Heteroscedasticity**

The linear relationship test involved a P-P Plot scatterplot of standardised residuals (ZRESID) and standardised predicted values (ZPRED). The ideal scatterplot should show a block or spherical shape. A curved pattern in the residual elements indicates the need to consider non-linearities. The scatterplot does not show a curve shape therefore a linear relationship is present.

Secondly the test for Heteroscedasticity i.e., assumption of constant error variance) is indicative if the predicted values don't follow the standardised residuals and the plot fans out. In the case of Figure 20 does not exhibit a fan shape, indicating no violation of Heteroscedasticity

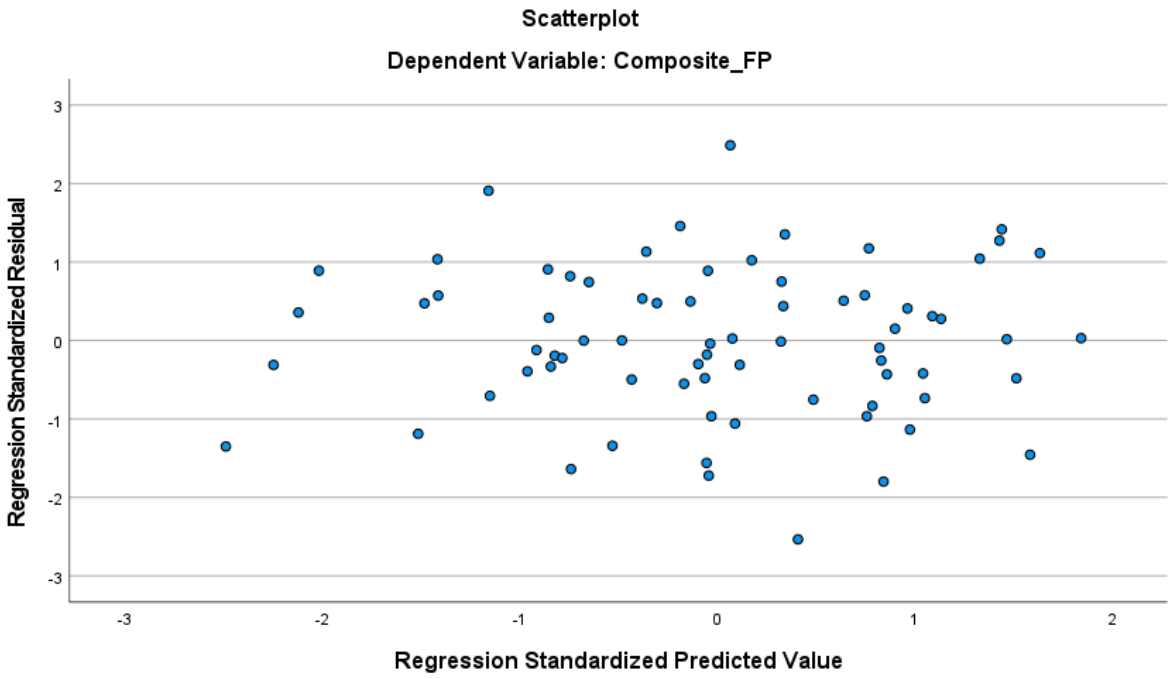



Figure 20. Normality of the Residual Distribution of I4.0 Complementary capability and Servitisation outcomes

The P-P Plot assessed residual distribution normality. The closely clustered points around the line suggest normal distribution of residuals.

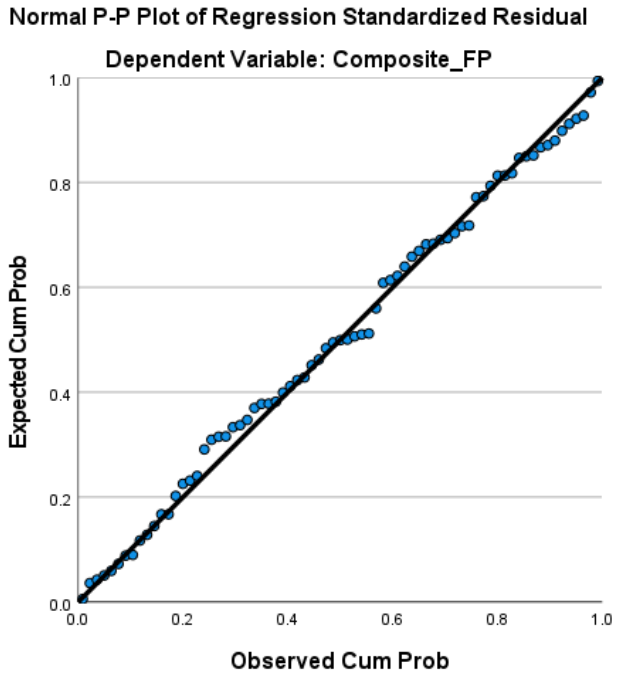



Figure 21. Normality of the Residual Distribution of I4.0 Complementary capability and Servitisation outcomes

## 9.5 Appendix G: Permission letter

**RESEARCH APPROVAL LETTER**

| | |
|---|---|
| **Date** | 27 September 2021 |
| **Validity of Research Approval** | September 2021 to 31 January 2022 |
| **Name of Researcher** | Jeeth Ramadeen |
| **Contact details** | Jeeth.ramadeen@absa.africa<br>071 681 7298 |
| **Research Topic** | The Influence of a Complementary System of Industry 4.0 Capabilities On the Performance of South African Financial Services Firms |

**Re: Approval in respect of request to conduct research**

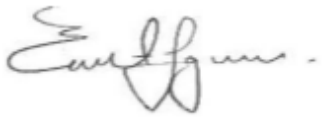
This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with respect in respect of the study indicated above. An informed consent letter must be furnished to the participants to enlist their participation in this academic research study and requesting their permission for same. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the research participants.

The following conditions apply to research within Absa. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be contravened.

- The target population for the research should be employees who have been with Absa for longer than 12 months – no new employees should be sampled.
- Any sensitive information provided by the interviewees regarding the Bank's specific processes/strategies should be treated as confidential. Approval to use such information should be sought from the Bank.
- Bank employees shall not share confidential Absa information that may be market sensitive.
- Outcomes will not be published, any requirements to publish should be approved by the Brand team.
- Information gathered during the interview process may not be validated and thus might not reflect the Bank's position.
- During the interviews no personal information pertaining to other employees or the Bank's clients shall be shared without the relevant consent being obtained.
- Data should not be used for competitor strategic intent.
- Ensure Absa data protection and confidentiality requirements are adhered to.

Absa Group Limited Reg No 1986/003934/06

- Respective business area line manager permission is required where there will be engagement with individuals during working hours to avoid disruption to BAU activities. Otherwise, the research can be conducted in an employee's free time.



Erin Ferguson Ormond
Head of People & Culture: Corporate Functions