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The determinants of Procurement 4.0 technology adoption by South African manufacturing firms

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"A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the Degree of Master of Management in the field of Digital Business."

Johannesburg, 2022

DECLARATION

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

Name: Karishma Singh Signature: 

Signed at …**Linden, Johannesburg**……

On the …22nd…….. day of ……February…… 2022.

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ABSTRACT

This study sought to identify the key digital procurement technologies utilised by South African manufacturing firms and the level of adoption of those technologies and examine the barriers to digitally transforming the procurement function and the suggestions to overcome them. This quantitative study utilised an online survey to collect data from a randomly selected sample of 102 participants in procurement or related functions from different sectors of the manufacturing industry in South Africa. The survey was designed to collect data related to the level of digital technology adoption and factors influencing procurement 4.0 technology adoption, measured on a five-point Likert scale. The results showed that CC, IoT and BDA were the most adopted technologies, whilst BCT was observed to have the lowest adoption level. The results highlighted three prominent barriers to adoption: lack of a clear digital strategy, poor observability and low levels of technology competence. The study unearthed that these adoption barriers differed between developed and emerging markets due to specific environmental and organisational factors, such as national or corporate policies to support the transition to procurement 4.0 adoption. The study recommended that managers focus on organisational learning of the available enabling technologies, developing concise digital procurement strategies, and hiring key talent to lead digital transformation initiatives. This research contributed to the growing body of knowledge on procurement 4.0 from an emerging market context, where most literature focused on developed markets. Future studies could focus on assessing the level of adoption in each sub-sector of manufacturing.

Key words – *Procurement 4.0, Industry 4.0, Digital procurement, Digital adoption*.

LIST OF ACRONYMS

AI	Artificial Intelligence
BI	Business Intelligence
BDA	Big Data Analytics
BT	Blockchain technology
CC	Cloud computing
CPS	Cyber-Physical System
EDI	Electronic Data Interchange
IoT	Internet of Things
IT	Information Technology
ML	Machine Learning

CHAPTER 1. INTRODUCTION

1.1 Purpose of the study

The purpose of this report is to examine the procurement 4.0 technologies being adopted to amplify the procurement function of supply chains in South African manufacturing firms and to determine the potential barriers and enablers to digital tool adoption. This research aims to determine the level of adoption of procurement 4.0 technologies in South African manufacturing firms and provide a framework for grasping the context under which procurement digitalization is more or less effective.

1.2 Background of the study

As digital disruption invades and challenges all industries, companies must rapidly adapt to changing consumer behaviour, growing service expectations, and increasing competitive pressure. As industry dynamics change, digitisation continues to facilitate the growing need for inter-organisational interactions and partnerships essential for survival in the digital age. A steady trend toward individualisation and customisation is driving constant growth and changes in product portfolios. Furthermore, online-enabled visibility and easy access to an array of online stores, pricing, and a large variety of goods to choose from have been driving competition of supply chains (McKinsey & Company, 2016).

The response to digital disruption by corporations has largely been to digitally transform key areas or functions of the business, of which most of those are customer-facing. To date, support functions like supply chain, specifically procurement, have not been first on the transformation agenda globally (Accenture, 2017).

The term “supply chain” can be described as “the network between companies and their vendors built for the manufacture and distribution of a specific product” (Büyüközkan & Göçer, 2018, p. 8). This traditional supply chain is characterised by an organisational design that is functionally and geographically siloed and typically utilizes a mixture of electronic and analogue processes and documents, leading to sub-optimal performance of a firm (Büyüközkan & Göçer, 2018).

Supply Chain Management 4.0 (SCM 4.0), Digital Supply Chain Management (DSCM), or Smart Supply Chains are terms that have been used interchangeably to describe a firm’s capability of internal and external information processing and information sharing; a superior collaboration that results in enhanced supply chain performance in terms of reliability, agility, and effectiveness (Bhargava et al., 2013).

Procurement plays a pivotal role in traditional and digital supply chains and was the focus of this research study. The traditional role of the procurement function, previously referred to as “supply management” or “sourcing”, focuses on material acquisition and later became a more strategic function with the goal of cost reduction and improving profitability through supplier relationship management (Giunipero & Brand, 1996).

“Procurement 4.0”, “digital procurement”, or Industry 4.0 are synonymous terms that can be defined as smart systems with the capability to auto-detect demand for materials, auto-generate an order and transmit the order to suppliers without human intervention (Bienhaus & Haddud, 2018). According to Jerome et al. (2021), research on procurement 4.0 is in its infancy, and studies are theoretical and exploratory (Jerome et al., 2021). This empirical study aims to extend the knowledge base of Procurement 4.0, the digital tools adopted by procurement functions, the factors that impact digital tool adoption in an emerging market context, the level of digital tool adoption, and provide a framework to enhance digital tool development adoption in procurement functions.

The phrase “Procurement 4.0” concerning the application of Industry 4.0 technologies resulted in an article (Bienhaus & Haddud, 2018) that focused on the effect of digitization on the procurement function and the barriers to digitizing procurement and how to overcome them. Bienhaus and Haddud (2018) surveyed professional procurement participants worldwide, with 28.7% of study participants working in the aerospace, automotive, and industrial manufacturing industry and 23.9% of participants located in Africa. The majority of study participants were located in Europe (41.7%), America, the Middle East and, Asia-pacific (Bienhaus & Haddud, 2018). This paper aims to address the research gaps related to procurement digitization in an emerging country, South Africa, in the manufacturing industry.

1.3 Research problem

Industry 4.0 invades business ecosystems, from manufactured products to how they are delivered and returned. Industry 4.0 (I4.0) is considered novel to emerging economies

like South Africa. Although businesses are aware they need to become more agile and efficient to survive the digital age, most companies have focused on transforming customer-facing functions like marketing and customer services but paid less attention and investment to the transformation of the field of procurement (Accenture, 2017). Most firms have gravitated towards “digitization” first by investing and embracing e-Procurement systems and tools as a way of replicating physical processes digitally (Seyedghorban et al., 2020). Firms need to move towards “digitalization” and eventually “digital integration” of the procurement function to fully realize the benefits of emerging technologies. Recent research indicates slow and low uptake of I4.0 technologies in procurement (Handfield et al., 2019). PWC South Africa (2016) highlights the findings from a worldwide Industry 4.0 survey that revealed that 27% of manufacturing companies gauged their level of digitisation as high. This is expected to increase to 64% between 2016 and 2021. This research suggested that manufacturing executives in South Africa are digitising what they consider crucial functions or processes (PWC South Africa, 2016). The research further indicated that the focus of South Africa manufacturing leaders is to drive revenue growth and improve operational efficiency levels by implementing novel digital technologies (PWC South Africa, 2016). It is observed that due to the underdeveloped nature of South African industrial firms IT infrastructure, they have the advantage to overcome barriers to technology adoption much faster than firms from developed nations, which have to overcome the challenges of legacy issues, outdated systems and processes (PWC South Africa, 2016). In 2016, South Africa's level of digitization stood at 27%, which was close to the global average of 33%. Asia-Pacific resulted in a 36% level of digitisation. PWC South Africa (2016) highlights that the most

notable challenge for building digital operations in South African industrial firms is the absence of digital culture and insufficient training, followed by an absence of appropriate digital skills and high investment and implementation costs.

There is a need to appreciate the determinants impacting the adoption and implementation of Procurement 4.0 technologies in emerging vs developed markets to identify the similarities and differences (Bienhaus & Haddud, 2018). This paper aimed to highlight the key determinants to Procurement 4.0 initiative adoption by taking the South African manufacturing industry perspective.

1.4 Research questions

Research question 1

What are the key digital technologies adopted in the procurement function by South African Manufacturing firms?

Research question 2

What is the current level of adoption of digital technologies in procurement functions of South African Manufacturing firms?

Research question 3

What are the determinants impacting the level of adoption of digital technologies in procurement functions of South African manufacturing firms?

Research question 4

What could be done to enhance the level of adoption of procurement 4.0 technologies in South African manufacturing firms?

1.5 Significance of the study

The key constructs of this research paper include the barriers and enablers to Procurement 4.0 adoption and the level adoption of I4.0 technologies in procurement functions of South African manufacturing firms.

Bienhaus and Haddud (2018) and Raj et al. (2019) explored the factors that influenced digitization and provided suggestions to manage them. Raj et al. (2019) evaluated Procurement 4.0 digital tools adoption barriers in the Indian industrial sector and compared the findings to a developing country (France). Raj et al. (2019) found that an immature digital strategy coupled with resource constraints is the most notable barrier in emerging and developing countries. Bienhaus and Haddud (2018) supported this view and showed three key barriers related to resource capacity, lack of a clear digital strategy and management uncertainties and fears. The absence of digital mastery and expertise is seen as a key challenge by most authors as it impacts the ability for firms to collaborate with digital tool providers and users lack understanding of the technology, which negatively impacts the usage rate (Breunig, 2016; Hung, 2018). Geissbauer et al. (2015) suggest that unskilled employees are another significant barrier to realizing the benefits of digital procurement technologies (Geissbauer et al., 2015).

The above statements highlight that the study participants felt their organisations are not ready for digital transformations. While these studies are useful for highlighting the barriers to digitization and digitalization for firms worldwide, it could be possible that a different set of key barriers and enablers would arise if the study were to be conducted in a developed country only. This study does not compare the results by region and hence does not reveal the differences or similarities in the findings.

SCM 4.0, which encompasses Procurement 4.0, is a relatively new field of research with 176 articles published between 1994 and 2020, with the bulk of the research papers (85,23%) published between 2016 and 2020 (Zekhnini et al., 2021). According to Zekhnini et al. (2021), supply chain digitization is well researched in the established markets compared to emerging markets; a majority of the research has been conducted in the US, UK, France, China, and Germany. Further to this, Bienhaus and Haddud (2018) state that there is a higher degree of digitization in developed countries, as these markets have mature integrated IT infrastructure, higher level of internet access, higher resource capacity, and more skilled human capital.

This research paper elaborated on the body of knowledge on procurement digitization and the specific barriers and enablers to adopting Procurement 4.0 technologies in a South African context. This research paper determined the factors and technology adoption constructs that influence the digital procurement technology adoption process in the emerging market context, specifically South Africa. This research provided supply chain practitioners and managers with a digital procurement technology implementation plan that assists with the management and coordination of the successful implementation of key novel procurement technologies.

1.6 Delimitations of the study

This study centred on determining the digital procurement technologies adopted in South African manufacturing firms and investigated the key determinants influencing the adoption of novel industry 4.0 technologies. The technology adoption constructs that influence the adoption process were drawn from prior studies and examined to create a robust research instrument to assess the factors influencing procurement 4.0 adoption in an emerging market context. Finally, this research paper developed a comprehensive implementation framework to facilitate the adoption of novel digital procurement technologies in a South African context, focusing on the manufacturing sector.

This study excluded the investigation of the impact of Procurement 4.0 technologies on overall supply chain or procurement function performance. This study excluded the procurement 4.0 process adaptation and only focuses on technology adoption.

1.7 Definition of terms

“Industry 4.0”: Commonly referred to as the fourth industrial revolution (4IR), this can be defined as the current trend in process automation and data exchange driven by modern information and communication technology. It is characterised by industrial automation, data networks, intelligent production systems, cyber-physical systems, 3D printing, and remote operations.

Digital technology adoption: or “digital readiness is defined as an organisation's ability to use and embrace novel digital technologies” (Kosmol et al., 2019, p. 11).

Digital procurement practices: relates to the usability of digital procurement technological tools, both individually or with other technologies (Srai & Lorentz, 2018, p. 15).

Advanced digital technologies: "include BDA, CC, IoT, additive manufacturing, mobile applications, social networks, artificial intelligence, autonomous robots, and BCT to enhance procurement processes" (Srai & Lorentz, 2018).

"Procurement 4.0": synonymous with the term "digital procurement", can be defined as "smart systems with the capability to auto-detect demand for materials, auto-generate an order and transmit the order to ecosystem partners (i.e., suppliers) in an automated fashion" (Bienhaus & Haddud, 2018).

1.8 Assumptions

- It was assumed that digital procurement literature review articles cited in this paper that highlight the "most discussed" technologies are not synonymous with the term "most adopted" or "most implemented" technology.
- The survey respondents are assumed to reflect standard responses and experiences.

1.9 Chapter Outline

This research paper investigates the key digital procurement technologies adopted in South African manufacturing firms and determines the current level of adoption of these technologies. Further, this research aims to determine the factors that influence the

technology adoption process and the level of adoption in South African manufacturing firms. Finally, a holistic conceptual framework is developed to assist practitioners, and procurement managers navigate the barriers to technology adoption. The rest of the study is organised as follows: Section 2 is a literature review of current digital procurement technologies and hypotheses. Section 3 presents the research methodology adopted by the study. Section 4 presents the results of the study. The discussion is described in section 5, and section 6 provides the conclusion, limitations and future research suggestions.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The transformation journey from being digitised, to digitalised, to being digitally integrated is now the path most recently travelled, revolutionising companies' operational and administrative processes worldwide. 4IR, otherwise known as Industry 4.0, combines novel digital technologies such as blockchain, artificial intelligence, 3D printing and big data analytics. Increasing competitive pressures and changing customer behaviour and expectations have driven businesses to employ disruptive technologies to innovate and maintain competitiveness with the newly developed business models and concepts created due to this technology. Supply chain complexity has grown in alignment with the increasing scale of businesses, diverse product portfolios, and vast geographical locations to serve (Kamble et al., 2019). Manufacturers worldwide are faced with the challenge of constantly offering customised products to compete, which has had a knock-on effect on sensing demand, planning production, and order management. Internal process integration within an organisation is not enough to overcome these challenges that require inter-organisational information systems to synchronize operations of all trading partners (Williamson et al., 2004). Advanced digital technologies can transform the way manufacturers interact with their supply networks globally, and leading firms have achieved operational efficiencies and significant cost savings from employing these technologies in the field of procurement. Digital procurement is thought to be in the nascent stage, and this sentiment is supported by a pilot study carried out in Europe that the vast majority of participating companies were still to implement advanced

technologies (Pellengahr et al., 2016, p. 15). It is imperative to understand the organisational, environmental, and technological factors that influence the technology adoption process to facilitate implementation.

A literature review was conducted to identify the key procurement 4.0 technologies most utilized in firms today and the barriers and enablers that impact the level of adoption of these digital technologies. The literature review focused on journal articles from prominent journals in supply chain management, production research, purchasing management, supply management, and operations management. Since the study of the field of digital procurement is in its nascent stage, the literature review search was limited to papers published in the last 15 years (i.e., since 2006). To identify a wide scope of journal articles, the following databases were used to search for relevant works:

i. Elsevier
ii. Emerald
iii. Scopus
iv. Google Scholar

The search terms in titles, keywords, and abstracts used were “digital procurement” and “procurement 4.0” to identify relevant publications on digital procurement technologies. To find relevant publications on the adoption of procurement 4.0 technologies, the search terms in titles, keywords, and abstracts used were “procurement 4.0”, “digital technology adoption”, and “manufacturing supply chains”.

2.2 Digital procurement technologies (Procurement 4.0)

“Procurement 4.0”, “digital procurement”, Industry 4.0, or supply chain 4.0 are synonymous terms that can be defined as smart systems with the capability to auto-detect demand for materials, auto-generate an order and transmit it to a supplier in an automated fashion (Bienhaus & Haddud, 2018).

Digital procurement practices utilise enabling and advanced digital technologies to enhance and automate procurement processes, mostly for burden reduction (Kosmol et al., 2019). These digital technologies or tools include big data analytics (BDA), cloud computing (CC), the Internet of Things (IoT), additive manufacturing, mobile applications, social networks, artificial intelligence (AI), autonomous robots, and blockchain technology (BCT) to strengthen purchasing processes (Srai & Lorentz, 2018). These advanced disruptive technologies are adopted to automate transactions and information flows instead of basic technologies in e-procurement aimed at using the internet to ‘digitize’ purchasing activities (i.e., e-ordering, e-sourcing, e-tendering, etc.) (Bag et al., 2020).

2.3 Key digital technologies in procurement

A literature review article focused on digital supply chain management by Zekhnini et al. (2021) states that the key enabling technologies include IoT, CC, BDA, AR, AI and blockchain (Zekhnini et al., 2021). The most discussed technologies include BDA with 30 published articles, followed by blockchain, AI and IoT with 25, 16 and 14 articles, respectively (Zekhnini et al., 2021). According to another supply chain digitization literature review by Büyüközkan and Göçer (2018), the focus of the literature has been

primarily on its enablers such as BDA with 25-30 publications, IoT with 15-20 publications and, CC with 15 publications (Büyüközkan & Göçer, 2018). Zekhnini et al. (2021) state that the technologies considered highly impactful on the procurement function performance are BDA, IoT, blockchain, and cybersecurity. Bienhaus and Haddud (2018) survey results highlight that the essential digital tools for procurement include CC, sensor technology (RFID), BDA, and cybersecurity. These technologies are considered essential as they promote end-to-end collaboration, ensure “many-to-many” communication to speed up transactions, and allow real-time information flow (Bienhaus & Haddud, 2018). Rejeb et al. (2018) discussed the following new emerging procurement technologies that can be deployed to support and streamline communication and information sharing between firms and their suppliers: BDA, robotics, IoT, BT and smart contracts (Rejeb et al., 2018). The papers by Zekhnini et al. (2021), Bienhaus & Haddud (2018), and Rejeb et al. (2018) support the findings that BDA, IoT, and BT are essential key digital procurement technologies that are required to support communication and information flow inter-organisationally.

Zekhnini et al. (2021) and Büyüközkan and Göçer (2018) highlight the most discussed technologies in a DSC context but not the most frequently adopted or implemented technologies. It is assumed that the term “most discussed” is not synonymous with “most adopted” technologies. The bulk of SCM 4.0 research conducted is in developed markets rather than emerging markets, which may impact the generalisability of the findings for the emerging market context (Zekhnini et al., 2021).

Srai and Lorentz (2018) categorize digital procurement technologies into two areas: basic and advanced digital technologies (Srai & Lorentz, 2018). Rudimentary digital tools are largely characterized by the use of e-procurement tools and the internet to digitize existing purchasing processes (i.e., buying products and services electronically, via the internet) (Ronchi et al., 2010). Advanced digital tools include IoT, CC, BDA, and additive manufacturing (Srai & Lorentz, 2018). Advanced technologies are used for burden reduction (i.e., intelligent automation of processes using RPA and IoT technologies to automate procure to pay or smart maintenance). Advanced technologies are further utilised to improve internal processes with the implementation of BDA and AI and to develop AI-based category management, real-time spend analytics capabilities, and smart contract management (Nicoletti, 2018).

According to Ehie and Ferreira (2019), three broad categories are used to describe the types of digital technologies, namely, “digital technology enablers, digital system integrators and application technologies” (Ehie & Ferreira, 2019, p. 1). Digital technology enablers such as BDA, IoT, and CC provide the foundation for the digital transformation of industrial production (Gurria, 2017). Digital system integrators include simulations, AI, and cyber-physical systems. The application technologies enhance productivity using 3D printing, additive manufacturing, CPS and autonomous machines (Gurria, 2017). Ehie and Ferreira (2019) suggested that companies should first establish a foundation using digital enablers, followed by tools earmarked for system integration and, ultimately, the application technologies (Ehie & Ferreira, 2019).

For this research, the two aforementioned digital technology categorisation methods will be adapted and combined to provide a more comprehensive structure to classifying technologies adopted at participant firms. Figure 1 below is a representation of this adaptation of the literature (i.e., adaption of categorization by Ehie & Ferreira, 2019; Srai & Lorentz, 2018)

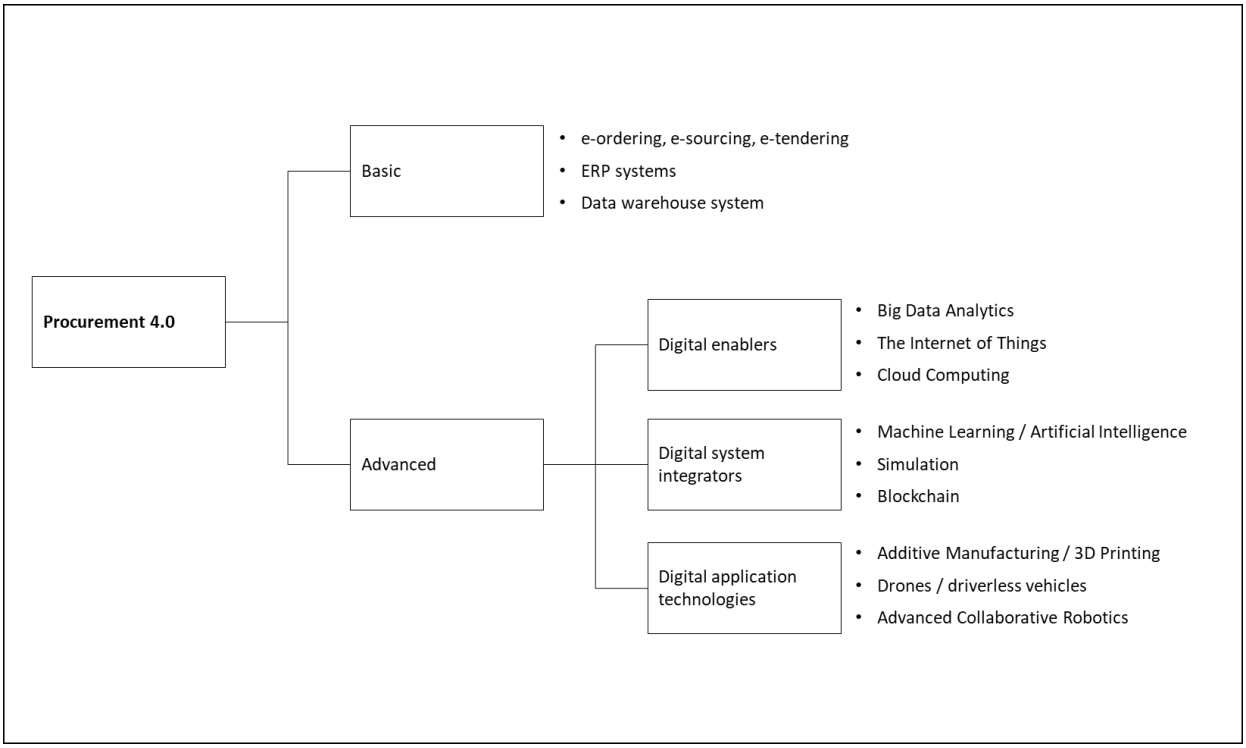


Figure 1: Procurement 4.0 technology categories
Source: Ehie et al. (2018)

2.3.1 *Big Data Analytics (BDA)*

Big data can be described as large amounts of unstructured data a firm creates that is stored in siloes within functions, departments, or divisions. Big data includes many technologies that help firms manage, structure, and use data in various ways to extract

valuable insights to improve the speed and accuracy of decision-making (Nguyen et al., 2017). BDA can improve organisational, overall supply chain, and procurement function performance (Dubey et al., 2019). BDA can improve an organisation's relationship with its suppliers and help purchase and supply managers monitor and track supplier performance (Kamble et al., 2018). BDA has the potential to improve sourcing and production costs, heighten customer satisfaction, transform the procurement function into one that is agile and adaptable to changes in the environment (Dubey et al., 2019). As the data-driven supply chain trend rises, the expectation of adoption of BDA is thought to be high, but a report in 2016 showed that as little as 17% of companies globally had adopted BDA in one or more of their supply chain activities (Kang et al., 2016). The low level of adoption is mainly due to the lack of knowledge of how to implement the technology, poor data quality or understanding of how it can be used, data security issues and low level of acceptance by employees (Nguyen et al., 2017). Upon examining the distribution of BDA literature by supply chain function, 11% of BDA literature pertains to the procurement function, whilst the bulk of the research relates to logistics and manufacturing functions. Of 13/88 papers related to the field of procurement, the focus on supplier selection, sourcing cost improvements, and sourcing risk management was balanced (Nguyen et al., 2017).

2.3.2 *The Internet of Things (IoT)*

The IoT can be described as a widespread network of interconnected objects (e.g., mobile phones), made up of “sensors, actuators, and data communication technology” built into physical objects (Rejeb et al., 2018). IoT is a network of sensors, software and physical

objects. IoT devices such as RFID tags, GPS, wireless sensor networks assist in identifying physical objects, allow for track and trace and help coordinate and control objects using the internet (Rejeb et al., 2018). IoT provides the platform to assimilate the physical and computer-based system's worlds hence deeming the object “sensed” and “self-controlled” (Kang et al., 2016). Bienhaus and Haddud (2018) place RFID and smart sensor technology as vital tools to support transparency and traceability in the field of procurement, as well as a digital enabler. Kang et al. (2016) and Vass et al. (2018) view IoT as a platform for digital system integration (Vass et al., 2018). This is considered a different perspective from Ehie and Ferreira (2019), and Bienhaus and Haddud (2018), who view IoT as a digital enabler.

2.3.3 *Blockchain Technology (BT)*

The blockchain is a “peer-to-peer transaction platform” that alleviates the need for a mediator to verify the transaction details. Blockchain comprises cryptography, distributed ledger technology, and smart contacts. Blockchain’ decentralised, distributed ledger creates a trusted network to exchange value, information, or assets across transaction entity nodes (i.e., computer nodes of transaction participants), and the process is confirmed through cryptography (Rejeb et al., 2018). BT’s potential use in procurement is to bring about digital trust by closing the gap between product delivery and account settlement (Kamble et al., 2019). BT aims to close the pay gap by integrating actual product delivery and a final payment of the account in smart contracts that can be accessed by all transaction participants and integrated with banks and logistics partners (Kamble et al., 2019). Smart contracts act as a rule book for transactions.

2.4 Procurement 4.0 level of technology adoption

Procurement 4.0 adoption has been seen as revolutionary as it transforms the management of supply networks by enhancing trust, transparency, and visibility between supply chain partners (Lorentz et al., 2021). This has led to the recent uptake of these technologies in procurement functions today as part of exploratory and experimental projects to decipher the benefits (Gualandris et al., 2018). Lorentz et al. (2021) findings show that procurement digitalisation has not been widely adopted and implemented, most especially in its advanced forms, namely, AI, BDA, and blockchain (Handfield et al., 2019; Lorentz et al., 2021). Another study conducted to understand the use of blockchain in procurement found that 40.5% of participants had a dampened awareness of BT and increased their knowledge base on the benefits, applications, and appropriate use cases of BCT. Further to this, 42.5% of respondents felt their companies had an intention to implement BCT in the following year (Austin, 2017). Kang et al. (2016) and Austin (2017) share the view that advanced technologies are in their infancy, and the adoption level is low but increasing.

IoT adoption studies in the procurement function are minimal, and the retail industry's uptake has been exaggerated (Handfield et al., 2019; Vass et al., 2018). As organizations experiment, pilot, implement and ramp up on investment and training to embed these technologies into their businesses, practitioners need to truly understand the factors that impact the adoption process and the post-adoption stages of usage and impact (Zhu et al., 2006). The vast majority of literature focuses on the adoption decision and on measures such as “intention to adopt”, “technology adoption process”, and a binary view of adoption (i.e., adopted vs not adopted) (Kosmol et al., 2019). While it is valuable to

acknowledge the technology adoption process, it is imperative to recognize post-adoption in terms of the adoption level (i.e., usage) and impact of technology on the process and performance.

Zouari et al. (2021) developed a framework to determine the level of digital tool adoption in a supply-chain context and a framework to measure the construct developed by the study called “digital maturity degree” (DMD). The positive effect of DMD on digital tool adoption is shown in this study (Colli et al., 2019). The DMD construct comprises five dimensions: “governance, connectivity, technology, value creation and competencies” (Zouari et al., 2021).

2.5 Determinants of digital procurement technology adoption

The technology-organisation-environmental (TOE) framework is an important theoretical framework to categorise contextual factors for analysis. The TOE framework is made up of three categories that affect the use of novel technologies: technological, organizational, and environmental (Kosmol et al., 2019). The prior studies analysed in this research paper that have utilised the TOE framework show that the specific factors assigned to each category differ (Chen et al., 2015).

2.5.1 *Organisational factors impacting technology adoption*

Organisational readiness is a major influencing factor in the technology adoption process as it encompasses people, process, and financial indicators of a firm that influence experimentation, initial adoption, and eventually usage of technology (Chen et al., 2015).

2.5.1.1 *Lack of top management support (lack of a clear digital strategy)*

Leadership executives and senior management support play a critical role in creating the digital vision, culture and strategy to guide digital transformation efforts that influence the culture and attitude of employees toward adopting the change in processes, ways of working, and the usage of new technologies (Bienhaus & Haddud, 2018; Chen et al., 2015; Li et al., 2017). A lack of digital strategy was noted as the most prominent barrier to digital technology adoption in both developed and emerging countries in the manufacturing sector (Raj et al., 2019). Senior management plays a critical part in crafting and disseminating a digital strategy and allocating human resources to support technology implementation (Kosmol et al., 2019). An Innovation Readiness Index notes that German medium-sized firms' senior management dismiss the use of cloud computing, exhibiting reservations to technology adoption due to uncertainty, fear, lack of awareness and a lack of a clear strategy (Schröder, 2016).

2.5.1.2 *Limited financial resources*

Firms intending to implement digital procurement technologies would need to increase their annual capital investment budgets by 50% for the next five years (Geissbauer et al., 2015). This notion is supported by Kache and Seuring (2017) as funding is required to hire, upskill and train people, manage the change, implement the technology, maintain the technology and adjust the processes. Limited financial resources and high investment costs of novel technologies are viewed as inhibitors to digital tool adoption (Kosmol et al., 2019; Rejeb et al., 2018). Top management can allocate the necessary financial and

personnel resources to build digital procurement practices. Prior research suggests that adequate funding is needed to implement novel digital technologies (Chen et al., 2015).

2.5.1.3 *Inflexible organisational structure, small firm size (low turnover)*

Past studies have proven the positive impact of strong organisational governance and technology competence on the adoption of digital technologies in the supply chain. It is shown that firms with a higher turnover experience a higher level of adoption, possibly due to increased funds available to invest in digital technologies. Firm size represents other aspects of a firm, such as organisational structure, decision-making ability, and resource availability to affect technology adoption (Zhu et al., 2006). Smaller firms with structural inertia are seen to be more agile, need less frequent internal communication, harmonization, control, and possibly little effort to gain consensus, hence thought to have a higher level of adoption than larger firms with higher turnover (Zhu et al., 2006). Mid-sized firms in Germany often lack a clear and comprehensive digital strategy to integrate data from internal and external sources. Networking of numerous disparate IT systems is required to aid real-time data exchange cross-functionally and inter-organisationally. SMEs lack the skilled resources to assess the technological maturity of the new solutions and their potential business applications and benefits (Schröder, 2016).

2.5.1.4 *Lack of internal knowledge and skills and poor digital mind-set*

Past studies highlight that highly skilled IT personnel are crucial to the implementation of advanced technologies and that digital procurement practice skills differ greatly from those of a procurement manager (i.e., analytical and strategic vs operational) (Kosmol et al., 2019). Firms realise that they lack the digital skills to fully benefit from digital procurement technologies (Breunig, 2016). Rejeb et al. (2018) highlight that resource scarcity is a prominent inhibitor of technology adoption. Smaller firms may experience difficulties managing a technology implementation due to inappropriate skills and a lack of resources with the necessary skills to manage the change (Geissbauer et al., 2015).

2.5.1.5 *Low "digital maturity degree" (DMD)*

The "digital maturity degree" (DMD) variable is shown to have a consequential impact on the uptake of digital supply chain tools (Zouari et al., 2021). A low digital maturity degree is among the biggest challenges faced in digital supply chain tool adoption projects (Raj et al., 2019). Digital awareness and engagement are sub-factors of the "governance" dimension in the DMD model and are seen as a prerequisite that enables the acquisition and usage of digital technologies (Zouari et al., 2021).

2.5.2 *Technological factors impacting technology adoption*

Technological readiness or technology competence is made up of two components; infrastructure and IT human resource skills to implement novel digital technologies (Zhu et al., 2006).

2.5.2.1 *Lack of IT infrastructure*

IT infrastructure is highlighted in the literature as a key challenge for digital procurement adoption as all firms have different tools, technologies, and systems, implemented at different times and with different levels of integration (Kache & Seuring, 2017). Some technologies that rely on digital tools require specialised infrastructure to be built and maintained (Rejeb et al., 2018). New digital technologies that enable inter-and intra-organisational communication, such as electronic data exchange (EDI) and CC, establish a base for procurement digitalisation to flourish.

2.5.2.2 *Lack of IT and digital human resource skills*

To build, implement, and maintain digital procurement platforms, the know-how and expertise needed (Kamble et al., 2019) to be maintained by employees to facilitate adoption and sustained use (Rejeb et al., 2018).

2.5.2.3 *Technological maturity*

Rejeb et al. (2018) and Arunachalam et al. (2018) maintain that technological immaturity is a crucial inhibiting factor of technology adoption, especially when these technologies are in their proof of concept stage of their development. Rogers (2010) states that in the early stage of technology maturity, when the use cases are not clearly defined and when there is low availability of commercialised tools and a low level of innovation diffusion, the drivers to technology adoption are determined by the firm's actions (Lorentz et al., 2021). This is further supported by the notion that poorly tested technologies that are deployed

do not possess the data security and privacy standards to support a successful implementation (Lee & Lee, 2015).

2.5.3 *Environmental factors impacting technology adoption*

2.5.3.1 *Lack of standards and regulations*

Raj et al. (2019) suggested the need to improve internal company standards and external government regulations to accelerate the adoption and coercive pressure of digital technologies in emerging countries. The absence of national standards and policies is perceived as a key factor influencing firms' ability to participate in value-creation activities (Schröder, 2016). As advancing technologies continually change, regulatory and legislators need to keep up to understand what they are regulating and ensure they safeguard their customers' interests (Schwab, 2017).

2.5.3.2 *Supplier or partner readiness*

Advanced digital procurement is characterised by the relationship between firms, and therefore a firm wishing to implement Industry 4.0 technologies will be influenced by competitive pressures of competing firms and dependant on the readiness of partners or suppliers (Kosmol et al., 2019; Srai & Lorentz, 2018; Zhu et al., 2006).

2.6 Frameworks to support and enhance adoption of digital procurement practices

2.6.1 *The "Supply Chain Practice View on Digital Procurement" (SCPV) theoretical framework*

Kosmol et al. (2019) developed a conceptual framework that can be applied to digital procurement, called the SCPV. The SCPV model describes three components: 1) "*Digital procurement readiness" (technological and organisational readiness)* as inputs on the buyer and supplier side that aims to act as explanatory contextual factors for why firms adopt digital technologies or not; 2) *"digital procurement practices"* to explain the use of advanced technological tools within and between organisations; 3) "*performance"*, of both the individual technology or practice and the performance of the firm concerning all practices implemented as the output of the model (Kosmol et al., 2019). The SCPV model draws attention to the factors that influence technology adoption and explains why these factors are significant.

2.6.2 *Digital readiness matrix*

The digital readiness matrix, developed by Kosmol et al. (2019), describes the *corridor of co-evolution*, which is the notion that there is a mutual dependency on the buyer and supplier side digital readiness. The co-evolution suggests that with a parallel development of digital maturity, both parties, the supplier and buyer adopt the same technology categories at the same pace and simultaneously, facilitating the conditions for the adoption of both sides of the dyad.

2.6.3 *A conceptual framework on the effect of Additive Manufacturing adoption on SCM operations*

Oettmeier and Hofmann (2016) utilised a structure to explore the effect of Additive Manufacturing (AM) technology on manufacturing tasks and analysed how manufacturing tasks have changed due to AM technology usage. Technology maturity and internal factors (i.e., the firm's experience with the technology) are significant explanatory factors that affect the change to manufacturing processes due to AM technology adoption (Oettmeier & Hofmann, 2016). These findings are aligned with those of Lorentz et al. (2021) described in innovation diffusion theory, which suggests that a driving factor of technology adoption rate is understanding the level of technology development and the proven benefits of the technology.

2.6.4 *A digitalization maturity model for digital procurement*

Seyedghorban et al. (2020) designed a digital maturity model with three stages and underlying constructs to transform procurement function from digitised to digitalise to digitally integrate. The model aims to provide a roadmap for transforming a procurement function from administrative and clerical to strategic and value-adding. Each stage of the digital maturity level is defined and characterised by a series of constructs that relate to organisational readiness and skill profile, technology readiness in terms of IT infrastructure and technology use, primary technology purpose, and, finally, the performance of the organisation and the procurement function (Seyedghorban et al., 2020). The paper further highlights that understanding the barriers and enablers to progress from one digital maturity stage to another is imperative to transition from basic

to advanced and integrated technologies. This maturity model can be utilised to guide the measurement of the construct “adoption rate”.

2.7 ANALYTICAL FRAMEWORK

2.7.1 *Theoretical Framework*

Technology creates the opportunity to improve business efficiencies, pave the way for organisations and their functions to move their goals from operational to strategic and accelerate innovation. Nevertheless, technology needs to be adopted and used by individuals (i.e., employee-level user acceptance), organisations (i.e., management support), and, eventually, the industry to make an impact on business performance (Kosmol et al., 2019). The definition of technology adoption can be described as the “stage of selecting technology for use by individuals and organisations” or the “willingness within a group of users to employ technology for their benefit” (Kamble et al., 2019, p. 5). Three adoption theories exist, namely, the theory of planned behaviour (TPB), the technology acceptance model (TAM), and the technology readiness index (TRI).

Technology adoption is measured in a binary fashion (i.e., a digital procurement practice is either adopted or not adopted), and future studies could assess adoption more granularly (i.e., adoption rate) (Kosmol et al., 2019). The literature on technology adoption largely focuses on assessing the technology adoption process and the factors that influence or predict technology adoption and are not used to determine the adoption level or rate of adoption. The concept of the “performance-practice link” vs the “readiness-practice link” is introduced by Kosmol et al. (2019), stating that for the “performance-

practice link", KPIs measure the performance of digital initiatives play a role in determining the adoption rate of technology. According to Kosmol et al. (2019), a noteworthy industry trend is the absence of systematic performance measures to assess the success of digital procurement practice implementation (i.e., measurement of production lead time reduction with implementation of additive manufacturing).

2.7.2 *Technology adoption models*

2.7.2.1 *Technology acceptance model (TAM)*

The TAM examines the technology adoption process by assessing users' views on the usefulness and how easy the technology is to use. The TAM is the dominant model and is an approved instrument to predict technology use (Kamble et al., 2019). This model is not relevant to this study as the aim is to evaluate the level of technology adoption and not the "intent to use".

2.7.2.2 *Theory of planned behaviour (TPB)*

The TPB is derived from the theory of reasoned action (TRA), which combines several theories of attitude (Kamble et al., 2019). TRA proposed that people are motivated if they develop a good attitude towards a subject or expect this behaviour from others. The TPB is widely used to predict the level of usage of IT products and assess the acceptance of such technologies (Pattansheti et al., 2016). This model is not relevant to this study as the aim is to determine the level of technology adoption and not the "intent to use".

2.7.2.3 *Technology readiness index (TRI)*

The TRI is a construct described as an individual's or organisation's propensity to use and embrace technological assets (Kosmol et al., 2019). Knowledge sharing impacts ERP implementation and highlights that technological readiness is perceived as a major determinant in adopting technology (Li et al., 2017). According to Kamble et al. (2019), the TRI measures one's overall perception of technology and comprises four sub-themes: "optimism, innovativeness, discomfort and insecurity". The optimism and innovativeness sub-dimensions are considered motivators to adoption, and discomfort and insecurity are considered inhibitors. Past studies show how innovativeness and insecurity impact the intent to adopt a new technology significantly. In past studies, TRI and TAM have been used to foresee the "intent to use" a technology (Pattansheti et al., 2016). This model is not relevant to this study as the aim is to evaluate the level of technology adoption and not the "intent to use".

2.7.2.4 *Innovation diffusion theory (DOI)*

Innovation diffusion theory is conceptualised in a paper by Lorentz et al. (2021) and is characterised by its enabling factors: the knowledge of proven solutions, the high level of awareness regarding technology applications and their benefits, and the technology maturity. The constructs of DOI are as follows:1) relative advantage, 2) compatibility, 3) cost, 4) security concern 5) trialability (Zhu et al., 2006). Relative advantage is how innovation can bring about enhanced performance for a firm. Compatibility measures if the innovation is consistent with existing IT applications, software and processes. Complexity measures if the technology is hard to use; Observability measures how well

the outcome of innovation is known to others, and trialability is the measurement of experimentation with the technology (Zhu et al., 2006). Of the above constructs, relative advantage and observability are prominent barriers to technology adoption. Innovation diffusion theory suggests that technology adoption happens in environments where data about the return on investment from the use of a digital tool or technology becomes measurable and accessible (Lorentz et al., 2021). This model is deemed useful in determining the level of technology adoption.

2.7.3 *Conceptual Framework*

The relationship between the constructs used in this study needed to be tested. Thus, a conceptual framework was developed, as illustrated in figure 2 below. The conceptual framework addressed digital procurement technology adoption determinants and was informed by the study's research objectives, problems, and questions. A proposed integrative model is shown in Figure 2 that specifies two types of factors – digital procurement innovation characteristics (H1–H2: relative advantage, observability) and TOE contextual factors (H3–H7: technology readiness or competence, resource scarcity, clear digital strategy, organization size, turnover, industry standards, and government regulations) – as determinants of digital procurement technology adoption in the South African emerging market context as the outcome variable.

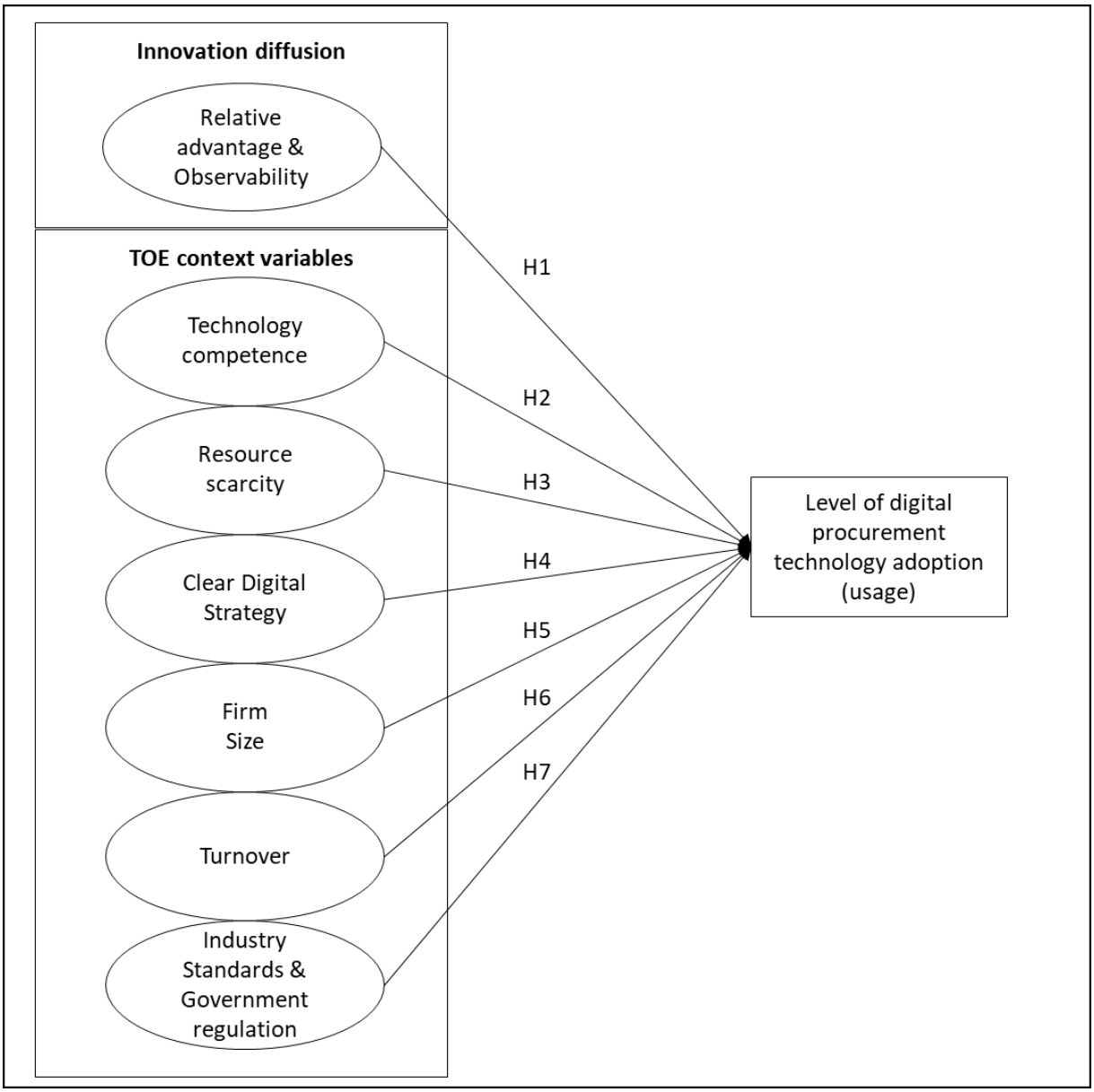


Figure 2: Conceptual framework to enhance digital procurement technology adoption

Source: Author's own construct

2.7.4 *Hypothesis development*

2.7.4.1 *Relative advantage and observability and digital procurement technology adoption*

Relative advantage and observability are prominent barriers to technology adoption (Arunachalam et al., 2017; Lorentz et al., 2021; Rejeb et al., 2018). Innovation diffusion theory proposes that technology adoption is enhanced when the benefit vs cost of technology implementation is well known, understood and measurable (Lorentz et al., 2021). Arunachalam et al. (2018) and Rejeb et al. (2018) maintain that technological immaturity is a major inhibitor of technology adoption, especially when these technologies are in their proof of concept stage of their development (Rejeb et al., 2018). Rogers (2010) states that in the early stage of technology maturity, when the use cases are not clearly defined and when there is poor access to commercial tools and a low level of innovation diffusion, the drivers to technology adoption are determined by the firm (Lorentz et al., 2021). Based on this, the following hypothesis is thus proposed:

H1: Relative advantage and observability positively influence the level of digital procurement technology adoption.

2.7.4.2 *Technology competence and digital procurement technology adoption*

IT infrastructure is highlighted in the literature as a key challenge for digital procurement adoption as all firms have different tools, technologies, and systems, implemented at different times and with different levels of integration (Kache & Seuring, 2017). Some

technologies that rely on digital tools require specialised infrastructure to be built and maintained (Rejeb et al., 2018). New digital technologies that enable inter-and intra-organisational communication, such as EDI and CC, establish a platform for building digital procurement technologies. To build, implement, and maintain digital procurement platforms, the know-how and expertise needed (Kamble et al., 2019) to be maintained by employees to facilitate adoption and sustained use (Rejeb et al., 2018). Based on the relative importance placed on IT infrastructure and IT skills, the following hypothesis is thus proposed:

H2: Technology competence positively influences the level of digital procurement technology adoption.

2.7.4.3 *Resource scarcity and digital procurement technology adoption*

Bienhaus and Haddud (2018) and Kosmol et al. (2019) highlight that IT human resources are vital to adopting advanced technologies. Further, the study by Kosmol et al. (2019) notes that digital procurement practice skills differ greatly from those of a procurement manager (i.e., analytical and strategic vs operational). This is further supported by Rejeb et al. (2018), which specifies that as new technology gets implemented, specialised resources are required to implement the technology and maintain the adoption (Rejeb et al., 2018). Based on the emphasis placed on having the appropriate amount of resource capacity and the necessary digital skills, the following hypothesis is thus proposed:

H3: Resource scarcity negatively influences the level of digital procurement technology adoption.

2.7.4.4 *Clear digital strategy and digital procurement technology adoption*

Leadership executives and senior management support and guidance play a critical role in creating the digital vision, culture and strategy to guide digital transformation efforts that influence the attitude of employees toward adopting the change in processes, ways of working, and the usage of new technologies (Bienhaus & Haddud, 2018; Chen et al., 2015; Li et al., 2017). An unclear digital strategy and resource scarcity are considered the most prominent barriers to digital technology adoption in both developed and emerging countries in the manufacturing sector (Raj et al., 2019). Senior management is instrumental in developing and disseminating a digital strategy and allocating human resources to support technology implementation. Based on this, the following hypothesis is thus proposed:

H4: A clear digital strategy positively influences the level of digital procurement technology adoption.

2.7.4.5 *Firm size and digital procurement technology adoption*

Firm size, often studied in the innovation literature, is an important internal factor influencing technology use (Zouari et al., 2021). In the IT literature, past studies found a correlation between the size of the firm and technology adoption (Zouari et al., 2021). There are opposing opinions regarding how the size of a firm impacts resource availability and structural flexibility. It is thought that smaller firms are more agile and can respond and adapt to new technologies faster. Smaller firms require less communication and less

effort to influence, train, and on-board. Based on the opposing views, the following hypothesis is thus proposed:

H5: Firm size positively influences the level of digital procurement technology adoption.

2.7.4.6 *Turnover and digital procurement technology adoption*

Zouari et al. (2021) proved that the level of firms "digital maturity" positively impacts digital technologies adoption in the supply chain for firms with a higher turnover than with firms with a lower turnover. Firm size represents other aspects of a firm, such as organisational structure, decision-making ability, and resource availability to affect technology adoption (Zhu et al., 2006). Smaller firms with structural inertia are seen to be more agile, need less discussion or deliberation, and less effort to gain consensus, and hence thought to have a higher level of adoption than larger firms with higher turnover (Zhu et al., 2006). Digital technology implementations involve a significant increase in investment (Geissbauer et al., 2015) and support the above findings. The following hypotheses are thus proposed:

H6: Large turnover positively influences the level of digital procurement technology adoption.

2.7.4.7 *Standards and government regulations and digital procurement technology adoption*

Comprehensive government regulation governing the use of novel technologies could accelerate Industry 4.0 adoption in emerging economies. Ambiguous standards and regulations are seen as a key influencing factor that impairs firms' ability to participate in value-creation activities (Raj et al., 2019; Schröder, 2016). As advancing technologies continually change, regulators and legislators need to understand what they are regulating and ensure they safeguard the customer's interests (Schwab, 2017).

H7: A lack of standards and government regulations negatively influences the level of digital procurement technology adoption.

2.8 Conclusion

The literature on digital procurement technologies provides a series of categorisations of Industry 4.0 technologies that aim to help practitioners and researchers decide what to implement for specific use cases. The literature on the barriers to digital technology adoption alert practitioners to the challenges associated with technology adoption and helps develop a series of checks for the technology, organisation and environmental context that need to be done before the implementation.

Table 1: Consistency table, research question and propositions

RQ #	Research Question	Hypotheses
1	What are the key digital technologies adopted in the procurement function by South African Manufacturing firms?	H1: Key digital procurement technologies developed countries adopt differ from those in the South African emerging market context.
2	What is the current level of adoption of digital tools in procurement functions of South African Manufacturing firms?	H2: A low level of digital tool adoption (DTA) in SA manufacturing firms would be observed.
3	What are the determinants impacting the level of adoption of digital tools in procurement functions of South African Manufacturing firms?	H1 – H7: X positively or negatively influences the level of digital procurement technology adoption (usage). See above: Figure 2 (Conceptual Framework)
4	What could be done to enhance the level of adoption of procurement 4.0 technologies in South African manufacturing firms?	H4: A conceptual framework to guide and facilitate adoption and increase the level of adoption of digital procurement technologies in the South African manufacturing firm context.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Research approach

The literature review discussed the key digital procurement technologies adopted, the level of adoption of these technologies, and the determinants that influence the adoption of procurement 4.0 digital tools. The purpose of this quantitative study was to evaluate the theoretical relationships proposed above, to understand which contextual and innovation characteristic factors predominantly impact digital procurement technology adoption. Therefore the research questions addressed by this study are: What are the key digital procurement technologies adopted by SA manufacturing firms? What is the current level of adoption of these technologies? What are the determinants that influence Procurement 4.0 technology adoption? What can be done to enhance the adoption process and usage of these novel technologies in the South African manufacturing sector?

This study used a quantitative method to address the research questions. Quantitative research “provides a quantitative description of trends, attitudes, and opinions of a population, or tests for associations among variables of a population, by studying a sample of that population” (Creswell & Creswell, 2017, p. 207). The quantitative approach is deemed suitable for this research study because it will help address the study’s descriptive questions and questions that require evaluating the relationships between variables by using a survey (Creswell & Creswell, 2017). The most dominant research method used in digital supply chain literature is survey-type research (40.0 percent), as it is noted to be more useful in theory and/or hypotheses testing (Iddris, 2018). Digital

technology adoption has been studied quantitatively in the past, aided by online surveys used for data collection. Quantitative research was deemed appropriate to answer this study's research questions.

The assumptions for this approach were as follows:

- The respondents who participated in the survey resulted in a greater understanding of the factors influencing digital procurement technology adoption and contributed to measuring the current level of adoption of novel digital technologies.
- The quantitative approach provided a more significant understanding of the factors influencing digital procurement adoption in the South African manufacturing firm context.

3.2 Research design

This quantitative research involved the use of an online questionnaire for data collection. The online survey helped evaluate the relationships between explanatory variables in the study's conceptual model. The benefits of an online survey included cost-saving and time saving on overcoming disparate geographical locations (Schindler, 2019). A disadvantage of performing a quantitative survey-based study is the common method bias, defined as the variations in responses caused by the instrument rather than the respondent (Creswell & Creswell, 2017).

This cross-sectional study aimed to develop self-administered web-based questionnaires to generalise findings from a sample to the South African manufacturing firm population.

Personalised emails were sent to avoid non-response bias and achieve an acceptable response rate while assuring participants that results would be passed on to them (Frohlich, 2002). The inevitable non-response bias was assessed using the nonresponse bias impact assessment strategy (N-BIAS) procedure (Rogelberg & Stanton, 2007). This method compares the responses of the first 25% of respondents with the last 25% to detect any differences between their responses.

3.3 Data collection methods

Numerous data collection methods are appropriate for a quantitative research study, such as interviews, questionnaire observations, and documentary reviews. The questionnaire method was utilised in this study. The reason for selecting questionnaires included the cost-saving and time-saving benefits of overcoming disparate geographical locations (Schindler, 2019). Data was collected through online surveys with participants in the sample. Self-administered online surveys shared via an email with a link to the online form (i.e., Qualtrics) provided a highly structured interview experience without the need for an interviewer. Due to the current Covid 19 pandemic in South Africa, online surveys were deemed most appropriate. Survey participants were targeted by searching for eligible companies on online databases, such as the SA Manufacturing directory. Potential participating companies were earmarked, and HR departments were contacted regarding the study aim and requested consent to participate. Potential survey participants were sent a personalised email to provide written consent to participate before survey dissemination.

3.4 Population and sample

3.4.1 *Population*

The study's population was drawn from professionals from South African manufacturing firms from the middle management level to executives. The population size of South African manufacturing firms is not known, but it is noted that there were 342 companies listed on the Johannesburg Stock Exchange and an estimated 2.2 million SMEs, as suggested by the 2016 Bureau of Economic Research report (Small Business Institute, 2016). The study did not restrict participants of a specific race, gender, or age. All sub-sectors of manufacturing were considered for participation.

3.4.2 *Sample and sampling method*

Respondents were selected to participate if they were actively involved in managing a procurement function with a restriction concerning the industry, manufacturing firms in South Africa only. As the size of the population was not known, the systematic sampling method was used to ensure the equivalent of random sampling (Fowler, 2014). Companies were randomly selected from the database list compilation from the association's databases of the makers of automotive components, steel, engineering industries, automobile manufacturers, minerals, and any other available lists. Participants were chosen randomly on a list (Creswell & Creswell, 2017).

The study aimed to sample 100-120 respondents of the target population. A G-Power analysis (i.e., correlation bivariate normal model, alpha value of .05 and power of 0.85) was conducted to determine the appropriate sample size as the population size was

unknown. The analysis plan detected a significant association between variables(Creswell & Creswell, 2017). The G-Power analysis resulted in a total sample size of 96. The number of total respondents to the study was 102.

Respondents were contacted through various channels, including LinkedIn and emails. The researcher shared the intent of the study, participation information sheets, consent forms and the link to the survey. Surveys were sent to procurement managers in various institutions, with an expected response rate ranging from 6% to 16% that is deemed acceptable (Dillman, 2000; Zouari et al., 2021). The sample was set to contain respondents with significant involvement in procurement management and at least five years' experience in their respective roles. Respondents from small, medium and large manufacturing companies were encouraged to participate as a variation in firm size helps to understand the correlation to the outcome variables.

3.5 Research instruments

The research instrument was made up of three sections:

1) **General overview**: five open questions to understand the participants' role, level of experience, firm size, and turnover.
2) **Digital tools adoption survey**: to understand the current level of adoption of the key digital procurement technologies used in South African manufacturing firms. This instrument assists in answering research questions 1 and 2.

3) **Operational measurement scale:** for assessing the factors that potentially influence the level of digital technology adoption within the procurement function. This section assists in answering research questions 3 and 4.

As shown in Figure 2, the conceptual model has seven variables that can influence digital procurement technology adoption, which is the outcome variable. The seven variables are divided into 1) Innovation characteristics and 2) TOE context variables. Based on the literature review, a survey was created to measure the innovation characteristics and TOE context variables. Industry 4.0 technology adoption survey-based literature was reviewed and adapted to the digital procurement context to measure the constructs (Bienhaus & Haddud, 2018; Büyüközkan & Göçer, 2018; Colli et al., 2019; Iddris, 2018; Kosmol et al., 2019; Schumacher et al., 2016; Zhu et al., 2006; Zouari et al., 2021). The third section of the research instrument was measured by selecting the appropriate agreement level with eighteen statements on a five-point Likert scale, ranging from 1) strongly disagree, 2) disagree, 3) neutral, 4) agree, 5) strongly agree. Table 2 illustrates an extract of the research instrument used to measure the level of digital procurement technology adoption, with the accompanying guiding authors. Table 3 below demonstrates the constructs formulated to evaluate the correlation of contextual variables with the influence on technology adoption with the guiding authors.

Table 2: Contribution of digital tools to digital procurement capability

Digital tool	Digital Procurement Capabilities	Contribution to digital procurement	References
BDA	Visibility, Decision Aid	BDA can be used to improve sourcing risk management, category management, supplier selection, sourcing cost improvement. BDA improves the resilience and agility of the procurement function. BDA coupled with other IT results in real-time communication and information flow.	Olson (2015); Kache and Suering (2017); Rozados and Tjahjono (2014); Sanders (2014)
IoT	Accuracy, Collaboration, Efficiency, Traceability	IoT technologies facilitate information capture and sharing among partners. IoT can sense supply chain processes, improving interoperability and decision-making. IoT has enabled the development of smart infrastructure in procurement.	Bienhaus and Haddud (2018); Ben-Daya et al. (2017); Tu (2018); Vass et al. (2018)
BT	Efficiency, Collaboration, Visibility	BT can be used in enhancing traceability and transparency of the procurement function. Blockchain assists with the development of execution of digital contracts. BT can improve the procure-to-pay cycle create improved supply partner collaboration and visibility of transactions.	Saurabh & Dey (2021)
CC	Access, Efficiency, Decision Aid, Collaboration, Visibility	Cloud solutions, mobile applications, and cloud-based software solutions allow for a flexible work location. Cloud service platforms allow for global networking are based on real-time information sharing.	Bag et al. (2020); Schumacher et al. (2016), Jede and Teuteberg (2015)

Table 3: Operational measurement scale for assessing factors influencing digital technology adoption within the procurement function

Constructs	Item	Statement	Select References
Observability	OB1	1) My company (MC) measures the performance of processes before and after implementing digital procurement initiatives (DPI).	Kosmol et al. (2019); Lorentz et al. (2021); Zhu et al. (2006)
Technology competence	TC1 TC2 TC3	1) Existing IT infrastructure within my organisation can handle procurement digitalisation. 2) We have the appropriate skills to support procurement digitalisation of the function. 3) We obtain training for the procurement team to drive and support the digitalisation of the procurement function.	Bienhaus and Haddud (2018); Issa et al. (2018); Zouari, et al. (2021)
Resource Scarcity	RS1 RS2 RS3	1) My company relies on digital skills internally to drive digital initiatives. 2) Services providers and/or supply chain partners drive procurement digitalisation as they have the right skills. 3) Our current job functions, roles, and descriptions can be transferred to the new procurement roles.	Bienhaus and Haddud (2018); Schumacher et al. (2016); Zouari et al. (2021)
Digital strategy	DS1 DS2 DS3 DS4	1) MC has a clear digital strategy. 2) We have clearly outlined processes for managing the digital procurement initiatives (DPI). 3) MC has developed a plan for managing DPI 4) We have dedicated and appropriate intangible and tangible resources to support DPI.	Bienhaus and Haddud (2018); Büyüközkan and Göçer (2018); Zouari et al. (2021)
Firm size	FS1 FS2	1) MC has the appropriate number of employees to manage the Digital Procurement Plan (DPP) execution. 2) MC organisational structure allows for agility when executing on the DPP.	Zouari, et al. (2021); Zhu et al. (2006)
Turnover	TO1	1) MC turnover is sufficient to support the investment required for DPT adoption.	Zouari, et al. (2021); Zhu et al. (2006)
Industry standards & government regulation	SR1	1) MC has sufficient coordinated internal standards and policies on Industry 4.0 to facilitate the adoption and use of DPT. 2) My country has sufficient coordinated national policies on Industry 4.0 to facilitate the adoption and use of DPT.	Raj et al. (2019); Saurabh and Dey (2021)

3.6 Procedure for data collection

As previously mentioned, the procedure for data collection was a web-based survey (using Google Forms). Participants were approached via HR managers from selected firms and then sent a personalised email with the survey web link. Participants received four follow-up emails if no response was received over two months.

3.7 Data analysis and interpretation

Statistical Package for the Social Sciences (SPSS) version 27.0 was adopted to run various analyses for the study. Cronbach's alpha was used to measure the reliability of the model. The Cronbach's alpha values above 0.5 were deemed acceptable, as guided by Creswell and Creswell (2017). Descriptive statistics (frequencies, mean, median and standard deviations) described the sample characteristics. Normality and outlier tests were performed on the dependant variable (i.e., level of digital technology adoption) to check the distribution of the data and any outlier present.

A correlation and covariance matrix were conducted across all independent variables to check covariance and if the variables are strongly correlated with each other. Correlation coefficients with values above 0.5 indicated moderate correlation and were deemed acceptable (Faul et al., 2009).

The data collected from the surveys were analysed using the simple linear regression approach. Simple linear regression was deemed appropriate in this case as it is recommended when independent explanatory variables (i.e., TOE and innovation variables) predict the outcome of the response variable (i.e., level of technology

adoption). Linear regression attempts to model the linear relationship between the explanatory (independent) variables and response (dependent) variables (Creswell & Creswell, 2017).

3.8 Limitations of the study

The results might not generalise to other emerging markets with poor IT infrastructure and low GDP. Despite the possible lack of generalisability, the study was deemed critical in exploring the adoption of digital procurement in an emerging economy, especially as the global business environment scrambles towards digitised business systems.

3.9 Validity and reliability OR transferability and dependability

3.9.1 *External validity*

External validity issues emerge when researchers draw incorrect conclusions from the research data (Creswell & Creswell, 2017). To mitigate the art of external validity, the investigator ensured that appropriate and adequate definitions and measures of variables were provided as posited by Merriam (1988).

3.9.2 *Internal validity*

Internal validity is the participants' experiences that dampen the researcher's ability to draw correct inferences from the data about the population in an experiment (Creswell &

Creswell, 2017). To ensure internal validity, controls were put in place during data collection to avoid data manipulation and elimination.

3.9.3 *Reliability*

Cronbach's alpha is a measure of internal consistency (the degree to which a set of items in an instrument behaves the same way) and is considered a good measure of scale reliability. In this case, the most important form of reliability is the consistency and repeatability of the instrument (Creswell & Creswell, 2017). Cronbach's alpha was used to measure the reliability of the model. Cronbach's alpha values above 0.7 were deemed acceptable. Cronbach's Alpha results were 0.933, higher than the 0.7 cut off value and therefore deemed a reliable instrument.

3.9.4 *Demographic profile of respondents*

Respondents were selected to participate if they were actively involved in managing a procurement function with a restriction concerning the industry, manufacturing firms in South Africa only. The sample contains respondents with management responsibilities in the procurement function and at least five years' experience in their respective roles. Respondents from small, medium and large manufacturing companies were encouraged to participate as a variation in firm size helps to understand the correlation to the outcome variables. The study did not restrict participants of a specific race, gender, or age. All respondents worked for South African firms or multinational firms with registered South African entities.

3.10 Ethical considerations

This research followed all the stipulated ethical standards for research as instructed by Wits University. The anonymity of the respondents was ensured as limited personally identifiable information was collected from the survey itself (i.e., email addresses). No personally identifiable information was shared or re-used. Respondents were not forced to participate and were allowed to pull out of the study at any point. Data collected was only used for analysis in this research study. This research was conducted after approval by the ethics board of Wits University. Ethical clearance was obtained from the Wits research ethics committee (REC). Written permission was granted from the companies. All participants were provided with information sheets explaining the nature of the study. Participation was voluntary, and participants could withdraw at any stage during data collection. There were no risks or benefits associated with participating in the study, and all data remained anonymous. Written informed consent was obtained for all participants. Personal identifiers were removed, and data was aggregated in the final thesis, ensuring anonymity.

The raw data collected was be stored electronically in a password-protected database. The data collected was used for research or academic purposes only. All future use of the stored data will be subject to further Research Ethics Committee review and approval. If participants have concerns or questions about the research, they were provided with the contact details of the Wits REC administrator and the contact details of the researcher and supervisor. The handling of participants personal information followed the Protection of Personal Information Act (POPIA) and the POPIA code of Conduct for Research (Adams et al., 2021). Personal information was kept secure to maintain confidentiality

and integrity and prevent data breaches. No personal information was stored upon completion of this study.

3.11 Conclusion

This quantitative study collected data via an online survey from procurement professionals working within the procurement function of South African manufacturing firms. The survey was structured into three sections: 1) demographic profile of participants, 2) measures to assess the level of digital tool adoption, 3) operational measurement scale for assessing factors influencing digital technology adoption within the procurement function. The data was collected as per the POPIA act, and ethical clearance was obtained before data collection started.

CHAPTER 4. RESULTS

4.1 Introduction

Statistical analysis was conducted using SPSS version 27. Descriptive statistics were used to describe the sample. A correlation analysis was conducted to determine if relationships exist between the dependent variable (Adoption) and the independent variables (Observability, Technology Competence, Resource Scarcity, Digital Strategy, Firm Size, Turnover, Industry Standards and Regulations). Correlation analysis was used to determine the direction and strength of the correlation. A linear regression analysis was conducted to determine which independent variables contribute to the variability in the level of digital procurement technology adoption. Reliability statistics such as the Cronbach's Alpha analysis were carried out to measure scale reliability (i.e., ensuring the research instrument did measure the level of digital procurement technology adoption). Cronbach's Alpha results were 0.933, higher than the 0.7 cut off value and therefore deemed a reliable instrument.

4.2 Demographic profiling of respondents

Of the total of 102 respondents that completed the survey, all respondents were working for manufacturing firms in South Africa. As seen in Table 1, respondents that most commonly participated were: Procurement Executives & Specialists (64.7%), other (11.8%), Supply Chain Executives & Managers (10.8%), Executives (9.8%), and Subject Matter Advisors (2.9%). The participants listed in the other category were comprised of IT professionals, Process Engineers, and Manufacturing Leads with role descriptions that

involved enhancing the procurement processes, technologies and ways of working. The category called Executives were made up of CEOs of micro, small and medium enterprises that perform the activities of procurement professionals as they do not have dedicated functional teams.

Of the 102 respondents who completed the survey, all respondents indicated their manufacturing sectors, firm size in terms of the number of employees, and turnover category. The respondents most common manufacturing sectors were: Industrial (39.2%), which was made up of firms from the mining, chemical products, electrical, electronic machinery, iron, steel, metals, paper, furniture, textiles, garments, vehicles and automotive components industries. The Food and Beverage sector made up the third most prominent category of respondents' firms. The majority of respondent firms' had an annual turnover of greater than R170 million (85.3%) and more than 250 employees (71.6%).

Table 4: Characteristics of the sample

Characteristics	**%**	**n**
Total	100	102
Participants Role Title		
Executive	9.8	10
Other	11.8	12
Procurement Executives & Specialists	64.7	66
Subject Matter Advisor	2.9	3
Supply Chain Executives & Managers	10.8	11
Manufacturing Sector		
Food and Beverage	21.6	22
Industrial	39.2	40
Other	26.5	27
Pharmaceutical	12.7	13
Firm Size		
Micro Enterprise (less than 10 employees)	7.8	8
Small to Medium Enterprise (10 - 249 employees)	20.6	21
Large Enterprise (More than 250 employees)	71.6	73
Turnover		
Greater than R10 million and less than R170 million	14.7	15
Greater than R170 million	85.3	87

4.3 Results on the key digital technologies adopted in the procurement functions

Of the 102 respondents who completed the survey, all respondents indicated their level of adoption of the 4IR digital procurement technologies. The key technologies adopted by procurement functions of South African manufacturing firms are Cloud Computing (CC), Big Data Analytics (BDA), the Internet of Things (IoT) and Blockchain technology (BCT) in order of highest level of adoption to the lowest.

4.4 Assessing the adoption level of digital tools in procurement functions

CC emerged as the most adopted technology as 85.3% of respondents confirmed basic to advanced use of the technology. 81.4% of respondents used BDA, and it was the second most adopted technology. IoT adoption was 74.5% adopted, and BCT with the lowest level of adoption of 48%. The mean and SD of BDA and IoT adoption: 2.76 (1.252); 2.62 (1.313), shows that most respondents have basic to developing capabilities, but the high SD relative to the mean shows a wider distribution of the scores around the mean and therefore varying levels of adoption. The mean and SD of CC adoption: 3.04 (1.266) shows that most respondents have developing capabilities and the lower SD relative to the mean shows a narrower distribution of the scores around the mean and therefore less varied levels of adoption. The mean and SD of BCT adoption: 1.97 (1.198) showed that most respondents have not started or basic capabilities, and the high SD relative to the mean shows a wider distribution of the scores around the mean and

therefore a varied level of adoption as shown in Table 5: Characteristics of the outcome variables below.

Table 5: Characteristics of the outcome variables

Characteristics	%/ Mean (SD)	n
Total	100	102
BDA Adoption	2.76 (1.252)	
(1) not started	18.6	19
(2) basic	25.5	26
(3) developing	27.5	28
(4) intermediate	17.6	18
(5) advanced	10.8	11
IoT Adoption	2.62 (1.313)	
(1) not started	25.5	26
(2) basic	25.5	26
(3) developing	20.6	21
(4) intermediate	18.6	19
(5) advanced	9.8	10
BCT Adoption	1.97 (1.198)	
(1) not started	52.0	53
(2) basic	15.7	16
(3) developing	19.6	20
(4) intermediate	8.8	9
(5) advanced	3.9	4
CC Adoption	3.04 (1.266)	
(1) not started	14.7	15
(2) basic	19.6	20
(3) developing	26.5	27
(4) intermediate	25.5	26
(5) advanced	13.7	14
BDA Adoption Recoded		
Not Adopted	18.6	19
Adopted	81.4	83
IoT Adoption Recoded		
Not Adopted	26	25.5
Adopted	76	74.5
BCT Adoption Recoded		
Not Adopted	52.0	53
Adopted	48.0	49
CC Adoption Recoded		
Not Adopted	14.7	15
Adopted	85.3	87

4.5 Results on the determinants impacting the level of adoption of digital tools in procurement functions

A correlation analysis was conducted between dependant variables (Adoption) and the independent variables (Observability, Technology Competence, Resource Scarcity, Digital Strategy, Firm Size, Turnover Recoded, Industry Standards and Regulations) to determine which factors have a significant influence on digital procurement technology adoption. Table 6 illustrates the linear regression results between outcome variable (Adoption) and predictor variables. The variable, Adoption, showed a moderate positive correlation with Observability, Technology Competence, and Digital Strategy. There is a statistically significant correlation between Adoption and all the independent variables as the Significance 2 tailed values are all below 0.05. Correlation coefficients with values below 0.5 were interpreted as weak correlations deemed unacceptable.

Table 6: Linear regression between outcome variable (Adoption) and predictor variables

Predictors	B	Std. Error	Beta	t	p value	R Square	R
OB	.562	.080	.575	7.023	.000	0.330	0.575
TC	.653	.086	.604	7.585	.000	0.365	0.604
RS	.532	.118	.410	4.491	.000	0.168	0.410
DS	.705	.082	.652	8.588	.000	0.424	0.652
FS	.537	.097	.486	5.559	.000	0.236	0.486
TOR	.255	.086	.284	2.964	.004	0.081	0.284
SR	.528	.098	.473	5.371	.000	0.224	0.473

*Detailed computations are in Appendix F.

Furthermore, seven proposed hypotheses were tested using the Pearson correlation analysis. Table 7 summarises the hypotheses test results and the interpretations of the results, based on the correlation coefficients and p-values obtained.

Table 7: Summary Hypotheses results

Hypotheses	p-value	Interpretation of analysis
H1: Relative advantage and observability positively influence the level of digital procurement technology adoption.	***	Supported
H2: Technology competence positively influences the level of digital procurement technology adoption.	***	Supported
H3: Resource scarcity negatively influences the level of digital procurement technology adoption.	***	Supported
H4: A clear digital strategy positively influences the level of digital procurement technology adoption.	***	Supported
H5: Firm size positively influences the level of digital procurement technology adoption.	***	Supported
H6: Large turnover positively influences the level of digital procurement technology adoption.	0.004**	Supported
H7: A lack of standards and government regulations negatively influences the level of digital procurement technology adoption.	***	Supported
**, p = significant at p < 0.005; ***, p = significant at p < 0.001		

4.5.1 *Hypothesis 1: Relative advantage and observability positively influence the level of digital procurement technology adoption.*

The correlation analysis between adoption and observability showed a moderate positive correlation coefficient of 0.575. This means that firms that demonstrate observability (i.e., understand and measure the benefit vs cost of technology implementation) will positively influence the choice to adopt digital procurement technology. The linear regression analysis results in an R^2=0.33, meaning that observability accounts for 33% of the variation in the level of adoption of digital procurement technology. It can thus be inferred that as observability increases, digital procurement technology adoption will increase. The p-value is .000. H1 was therefore accepted at p<0.001.

4.5.2 *Hypothesis 2: Technology competence positively influences the level of digital procurement technology adoption.*

The correlation analysis between adoption and technology competence showed a moderate positive correlation coefficient of 0.604. This means that firms that exhibit a degree of technical competence (i.e., have resources with advanced IT skills and a mature IT infrastructure) will positively influence the choice to adopt and level of adoption of digital procurement technology. The linear regression analysis results in an R^2=0.36, meaning that technology competence accounts for 36% of the variation in the level of adoption of digital procurement technology. It can be inferred that as technology competence increases, digital procurement technology adoption will increase.

The p-value is .000, which is less than the significance value of .05; therefore, H2 was confirmed at $p<0.001$.

4.5.3 *Hypothesis 3: Resource scarcity negatively influences the level of digital procurement technology adoption.*

The correlation analysis between adoption and resource scarcity showed a weak positive correlation coefficient of 0.410. The correlation coefficient is below the 0.5 cut off and therefore deemed a non-significant relationship. The linear regression analysis results in an R^2=0.17, meaning that resource scarcity accounts for 17% of the variation in the level of adoption of digital procurement technology. It can be inferred that resource scarcity has minimum influence on the level of digital procurement technology adoption.

However, the p-value is .000. Therefore, H3 was confirmed.

4.5.4 *Hypothesis 4: A clear digital strategy positively influences the level of digital procurement technology adoption.*

The correlation analysis between adoption and a clear digital strategy showed a moderate positive correlation coefficient of 0.652. This means that firms with a clear digital strategy will positively influence the level of adoption of digital procurement technology. The linear regression analysis results in an R^2=0.42, meaning that having a clear digital strategy accounts for 42% of the variation in the level of adoption of digital procurement technology and, therefore, a significant predictor of the level of digital procurement adoption by South African manufacturing firms. It can be inferred that having a clear digital strategy, clear digital procurement plans and processes in place will positively influence the level of digital procurement technology adoption and increase it. The p-value is .000, therefore, we can accept H4 at $p<0.001$.

4.5.5 *Hypothesis 5: Large firm size positively influences the level of digital procurement technology adoption.*

The correlation analysis between adoption and firm size showed a weak positive correlation coefficient of 0.486. The correlation coefficient is below the 0.5 cut off and therefore deemed a non-significant relationship. The linear regression analysis results in an R^2=0.24, meaning that firm size accounts for 24% of the variation in the level of adoption of digital procurement technology. It can be inferred that the large firm size influences the level of digital procurement technology adoption. As illustrated in Table 8, 71.6% of the sample size was made up of large enterprises (with more than 250 employees), thus the results are skewed to reflect a high adoption rate in this category.

Small to medium enterprises (10 - 249 employees) make up 20.6% of the sample, and micro-enterprise (less than 10 employees) make up 7.8% of the sample, which will show moderate to low adoption rate results which could be due to the sample majority consisting of large enterprises. Further studies could be conducted with an equal number of participants in each firm size category to determine if large enterprises adopt technology more than the small, medium and micro-enterprises.

The p-value for this hypothesis is .000, therefore, we can accept H5.

Table 8: Firm size and adoption cross-tabulation

Firm Size	BDA adoption		n	Adoption %
	Not Adopted	Adopted	102	
Micro Enterprise (> 10 employees)	5	3	8	38%
SM Enterprise (10 - 249 employees)	2	19	21	90%
Large Enterprise (< 250 employees)	12	61	73	84%
	IoT adoption			
Micro Enterprise (> 10 employees)	4	4	8	50%
SM Enterprise (10 - 249 employees)	5	16	21	76%
Large Enterprise (< 250 employees)	17	56	73	77%
	BCT adoption			
	Not adopted	Adopted		
Micro Enterprise (> 10 employees)	5	3	8	38%
SM Enterprise (10 - 249 employees)	12	9	21	43%
Large Enterprise (< 250 employees)	36	37	73	51%
	CC adoption			
	Not Adopted	Adopted		
Micro Enterprise (> 10 employees)	2	6	8	75%
SM Enterprise (10 - 249 employees)	5	16	21	76%
Large Enterprise (< 250 employees)	8	65	73	89%

4.5.6 *Hypothesis 6: Large turnover positively influences the level of digital procurement technology adoption.*

The correlation analysis between adoption and turnover showed a weak positive correlation coefficient of 0.284. The correlation coefficient is below the 0.5 cut off and therefore deemed a non-significant relationship. The linear regression analysis results in an R^2=0.08, meaning that firm size accounts for 8% of the variation in the level of adoption

of digital procurement technology. The p-value is .004, which is less than the significance value of .05; therefore, H6 is accepted at $p<0.005$. Turnover does influence digital procurement technology adoption. It can be inferred that turnover has little influence on the level of digital procurement technology adoption. As 85.3% of the sample size was made up of enterprises with an annual turnover of greater than R170 million, the results are skewed to reflect a high adoption rate in this category.

As shown in Table 9, firms with greater than R10 million and less than R170 million make up 14.7% of the sample, which will show moderate to low adoption rate results which could be due to the sample majority consisting of large enterprises with high turnover. Further studies could be conducted with an equal number of participants in each turnover category to determine if high turnover enterprises adopt technology more than the lower turnover enterprises.

Table 9: Annual turnover and adoption cross-tabulation

Annual Turnover	BDA adoption		n	Adoption %
	Not Adopted	Adopted		
> R10 million < R170 million	7	8	15	53%
> R170 million	12	75	87	86%
	IoT adoption			
	Not Adopted	Adopted		
> R10 million < R170 million	7	8	15	53%
> R170 million	19	68	87	78%
	BCT adoption			
	Not adopted	Adopted		
> R10 million < R170 million	12	3	15	20%
> R170 million	41	46	87	53%
	CC adoption			
	Not Adopted	Adopted		
> R10 million < R170 million	5	10	15	67%
> R170 million	10	77	87	89%

4.5.7 *Hypothesis 7: A lack of standards and government regulations negatively influences the level of digital procurement technology adoption.*

The correlation analysis between adoption and a lack of standards and government regulations showed a weak positive correlation coefficient of 0.473. The correlation coefficient is below the 0.5 cut off and therefore deemed a non-significant relationship. The linear regression analysis results in an R^2=0.22, meaning that a lack of standards and government regulations accounts for 22% of the variation in the level of adoption of digital procurement technology. It can therefore be inferred that a lack of standards and government regulations influences the level of digital procurement technology adoption. H7 was supported at a p-value of .000.

4.6 Results on the enhancement of the level of adoption of procurement 4.0 technologies

The linear regression and Pearsons' correlation analysis show that the factors that positively and significantly impact technology adoption in the South African manufacturing firm context were observability, technology competence, and having a clear, executable digital strategy.

4.7 Summary of the results

The key technologies adopted by procurement functions of South African manufacturing firms are CC, BDA, IoT and BCT in order of highest level of adoption to the lowest. The linear regression and Pearsons' correlation analysis show that the factors that positively

and significantly impact technology adoption are observability, technology competence, and having a clear, executable digital strategy. A clear digital strategy was the most significant predictor of digital procurement adoption as it had the highest positive correlation coefficient and explained 42% of the variability in the linear regression model.

CHAPTER 5. DISCUSSION OF THE RESULTS

5.1 Introduction

This chapter discusses the results for each research question and each hypothesis in the context of the literature reviewed in chapter 2.

5.2 Discussions on the key digital technologies adopted in the procurement functions

The current digital supply chain management literature states that the key enabling technologies include IoT, CC, BDA, AR, AI, and blockchain (Zekhnini et al., 2021). The most discussed technologies include BDA, followed by blockchain, AI and IoT (Zekhnini et al., 2021). According to another Digital Supply Chain (DSC) literature review, the focus of DSC literature has been primarily on its enablers such as BDA with, IoT and, CC (Büyüközkan & Göçer, 2018). This research is aligned with the above as the key technologies adopted by procurement functions of South African manufacturing firms are Cloud Computing (CC), Big Data Analytics (BDA), the Internet of Things (IoT) and Blockchain technology (BCT) in order of highest level of adoption to the lowest. Furthermore, research by Busch (2016), supported by Bienhaus and Haddud (2018), supported the above results by showing that their study participants viewed procurement platforms with “many-to-many” communication capabilities, cloud-based solutions to enhance communication effectiveness and efficiency and RDIF (smart senor technology to support tracking and traceability) as key to enabling digital transformations in the procurement space (Busch, 2016).

5.3 Discussion on digital tools adoption levels in procurement functions

The four dependent variables (i.e., BDA adoption, IoT adoption, CC adoption, BCT adoption) used to measure the level of digital procurement adoption were measured on a five-point Likert scale, ranging from 1 to 5: (1) not started, (2) basic, (3) developing, (4) intermediate, and (5) advanced. Due to the limited number of respondents (i.e., 102 respondents), measures of central tendency and standard deviations resulted in data points spread widely from the mean. For descriptive and cross-tabulation analysis, the decision was taken to recode the dependent variables into two categories, “not adopted” = 1 and “adopted” =2-5. The four independent variables were also combined into one single numerical variable called “Adoption” by averaging the Likert-scale scores of each technology adoption to conduct a linear regression analysis. The dependent variables recoded into two categories, “not adopted” and “adopted”, as per Table 5: Characteristics of the outcome variables, was used to determine the adoption % of each 4IR technology.

Zekhnini et al. (2021) and Büyüközkan and Göçer (2018) highlight the most discussed technologies in a supply-chain context but not the most frequently adopted or implemented technologies. It is assumed that the term “most discussed” is not synonymous with “most adopted” technologies. This research paper shows that CC is observed to be the most adopted technology for SA manufacturing firms, followed by BDA, IoT, and BCT.

The bulk of industry 4.0 research conducted is in developed markets rather than emerging markets, which may impact the generalisability of the findings for the emerging market

context (Zekhnini et al., 2021). The results of this research project reveal that the trend of adoption in emerging markets is in line with that of the developed markets with digital enabling technologies (i.e. CC, IoT, BDA) being adopted before digital system integrators (i.e., BCT) or digital application technologies. However, many other research papers highlight the emergence of other digital technologies such as cybersecurity and social media (Bag et al., 2020; Bienhaus & Haddud, 2018).

5.4 Discussion on the determinants impacting the level of adoption of digital tools in procurement functions

There is a correlation analysis between dependant variables (Adoption, computed variable with mean adoption of each 4IR technology) and the independent variables. All independent variables were organised into constructs with a series of statements which were measured on a five-point Likert scale ranging from 1) strongly disagree, 2) disagree, 3) neutral, 4) agree, 5) strongly agree. If a construct had more than one statement, the independent variable was computed to combine all statements results relating to that construct by finding the mean of all statements that make up the construct.

5.4.1 *Discussion on H1: Relative advantage and observability positively influence the level of digital procurement technology adoption.*

The literature related to observability shows that it is a prominent barrier to technology adoption (Arunachalam et al., 2017; Lorentz et al., 2021; Rejeb et al., 2018). Innovation diffusion theory proposes that technology adoption is enhanced when the benefit vs cost of technology implementation is well known, understood and measurable (Lorentz et al.,

2021). This research paper confirms this as the correlation and regression analyses proved that digital procurement technology adoption would increase as observability increases.

Rejeb et al. (2018) and Arunachalam et al. (2018) maintain that technological immaturity is a crucial inhibiting factor of technology adoption, especially when these technologies are in their proof of concept stage of their development. This is further displayed in the BCT adoption results (i.e., 48%) of this research paper, as the BCT is considered a newer technology, without a high level of awareness and understanding of the technology capabilities, use cases or off-the-shelf solutions for purchase. Interestingly, the “low maturity level of the desired technology” is observed to be the most important influencing factor in developed markets (Raj et al., 2019), whereas, in this research, it is viewed as a prominent factor impacting adoption in an emerging market. A possible reason for this could be that South Africa is unlike other emerging markets and is viewed as a leader on the digital maturity scale in a developing market context (Luthra & Mangla, 2018).

5.4.2 *Discussion on H2: Technology competence positively influences the level of digital procurement technology adoption*

Poor IT infrastructure is highlighted in the literature as a key challenge for digital procurement adoption as all firms have different tools, technologies, and systems, implemented at different times and with different levels of integration (Kache & Seuring, 2017). This research paper confirms this as the correlation and regression analysis prove that digital procurement technology adoption will increase as technology competence matures. This is aligned with the findings from a study in the Indian context, where “lack

of infrastructure" was noted as the third most influencing factor impacting the non-adoption of new digital technologies (Raj et al., 2019). The results of a 2016 Penton survey further re-iterates and aligns with the above sentiment as it explains that 33% of respondents believed that a lack of IT infrastructure negatively impacts IoT adoption (Buntz, 2016). A lack of digital skill, which forms an integral part of the technology competence construct, is cited by Hung (2016) and Breunig et al. (2016) to materially impact technology adoption. This research is aligned with the above findings.

5.4.3 *Discussion on H3: Resource scarcity negatively influences the level of digital procurement technology adoption.*

Bienhaus and Haddud (2018) and Kosmol et al. (2019) highlight that IT human resources are vital to adopting advanced technologies. Kosmol et al. (2019) explain that digital procurement practice skills differ greatly from a procurement manager's (i.e., analytical and strategic vs operational). The correlation and regression analysis conducted in this research paper confirms this and infers that resource scarcity minimally influences the level of digital procurement technology adoption as the nature of the correlation is positive but non-significant. The regression analysis explains 17% of the variability in adoption, meaning many other factors not accounted for in this model have a greater impact on adoption. This weak correlation is possibly explained by Schroder (2016), whereby the study highlights that resource scarcity goes hand-in-hand with the lack of a clear digital strategy, and perhaps the latter has a larger influence on non-adoption. Furthermore, Schroder (2016) explains that SMEs may experience greater challenges with resource scarcity due to smaller firm sizes and the ability to attract talent with the desired digital

skill sets. Once again, the sample population of this study is skewed towards larger enterprises could explain why resource scarcity is not a prominent barrier in this context.

5.4.4 *Discussion on H4: A clear digital strategy positively influences the level of digital procurement technology adoption.*

An unclear digital strategy is considered the most prominent barrier to digital technology adoption in both developed and emerging countries in the manufacturing sector (Raj et al., 2019). It can be inferred from this research that having a clear digital strategy, clear digital procurement plans and processes in place will positively influence the level of digital procurement technology adoption. Further, the linear regression analysis conducted in this study revealed that having a clear digital strategy is the most prominent factor impacting adoption as it explains 42% of adoption variability and therefore fully supports the literature.

5.4.5 *Discussion on H5: Large firm size positively influences the level of digital procurement technology adoption.*

Firm size is a critical organizational factor to influence IT usage (Zouari et al., 2021). In the IT literature, past studies found a correlation between firm size and IT adoption, stating that higher investments in digital transformation are required for at least five years (Breunig, 2016; Kache & Seuring, 2017; Zouari et al., 2021). There are opposing opinions regarding how the size of a firm impacts resource availability and structural flexibility. Some research suggests that the larger the firm, the higher the turnover and therefore increased access to funding for large transformations and more skilled resources available to manage the transformation (Geissbauer et al., 2015). Opposing views

suggest that smaller firm size will positively impact adoption as smaller firms are more agile in their organisational structure, allowing faster decision-making (Zhu et al., 2006). This research supports the above although it results in a non-significant correlation. It can be inferred from this research paper that firm size minimally influences the level of digital procurement technology adoption. As per Table 8: Firm size and adoption cross-tabulation, 71.6% of the sample size was made up of large enterprises, which skewed the results to reflect a high adoption rate in this category. Small to medium enterprises and micro-enterprises make up the rest of the sample, which will show moderate to low adoption rate results due to the sample majority consisting of large enterprises.

5.4.6 *Discussion on H6: Large turnover positively influences the level of digital procurement technology adoption.*

Digital technology implementations are noted to involve a significant increase in investment, and it can be inferred that larger turnover firms will have greater access to funding for digital initiatives (Geissbauer et al., 2015). This research paper supports literature although minimally, as the Pearson's correlation resulted in a weak and non-significant correlation, and the regression analysis resulted in turnover accounting for only 8% of the variation in adoption. Furthermore, the results displayed in Table 9: Annual turnover and adoption cross-tabulation show that higher turnover firms display higher adoption % than firms with lower turnover, which supports the literature and is supported by the analysis. A key consideration, as in the case of "firm size", is that the sample size is skewed towards high turnover firms and may be the reason for these findings; hence further research would be required. Raj et al. (2019) suggest that "high investment in

Industry 4.0 implementation" is a resulting barrier, a barrier most influenced by other barriers and is perhaps another explanation for the findings.

5.4.7 *Discussion on H7: A lack of standards and government regulations negatively influences the level of digital procurement technology adoption.*

Ambiguous standards and regulations are seen as key factors that impair firms' ability to participate in value-creation activities (Raj et al., 2019; Schröder, 2016). The results of this research paper somewhat supports the above statements as the correlation analysis between adoption and a lack of standards and government regulations showed a weak positive correlation coefficient below the cut-off. The most notable influencing factor highlighted in an Indian firm context (i.e., emerging markets) was a 'lack of standards, regulations, and forms of certification'. A possible reason for this research not showing a higher Pearson's correlation result is that developing countries have adopted Industry 4.0 technologies at a corporate level (i.e., not a national government level as developed countries have), replying on individual firm's strategies and roadmaps to influence adoption. The South African firms that make up the sample population in this study are largely multinational firms with clear digital strategies and implementation plans rendering poor government regulation and standards less influential on the adoption decision.

5.5 Conclusion

The results of research questions 1 and 2 are fully supported by the digital procurement literature cited in this paper. Of the hypothesis from research question 3, all are supported as they show p-values of below the significance value of .05. Hypotheses 1,2 and 4 are

fully supported by the literature cited in this paper and further supported by the strong Pearson's correlation results, but hypotheses 3, 5 and 6 need further research to be conducted to convincingly prove or disprove those hypotheses.

CHAPTER 6. Conclusions and recommendations

6.1 Introduction

This chapter integrates the summary of the findings of each research question, the gaps in the literature review, and provides a summary of the conclusion to each question.

6.2 Conclusions on the key digital technologies adopted in the procurement functions

The key technologies adopted by procurement functions of South African manufacturing firms are Cloud Computing (CC), Big Data Analytics (BDA), the Internet of Things (IoT) and Blockchain technology (BCT) in order of highest level of adoption to the lowest. This research helped close the literature gap whereby most reviews and DSC studies were conducted in developing markets. This research was conducted in a South African emerging market context and further addressed research gaps by focusing the study on the manufacturing sector in South Africa.

6.3 Conclusions on the current level of adoption of digital tools in procurement functions

The study concludes that CC is the most adopted technology as 85.3% of respondents confirms basic to advanced technology use. 81.4% of respondents use BDA, the second most adopted technology. IoT adoption was observed to be 74.5% adopted, and BCT with the lowest level of adoption of 48%. This research study addressed the gap in the

literature by measuring the level of adoption and not just assessing adoption in a binary fashion, as displayed in Table 5: Characteristics of the outcome variables. This research paper further addressed the gap in assessing the level of digital procurement adoption by displaying measures of central tendency and variability that indicate that BDA and IoT technologies hover on the basic to developing adoption scale. In contrast, the CC adoption score was developing, and the BCT adoption score revealed no started or basic adoption levels.

6.4 Conclusions on the determinants impacting the level of adoption of digital tools in procurement functions

Past studies are useful for highlighting the barriers to digitization and digitalization for firms worldwide. However, it could be possible that a different set of key barriers and enablers would arise if the study were only conducted in emerging economies. Past studies do not compare the results by region and hence does not reveal the differences or similarities in the findings by region or country. This research paper contributed to understanding the factors that impact digital procurement technology adoption by focusing on an emerging market (i.e., South African manufacturing firm context). The research conclusions drawn from this study are as follows: Firms with a clear digital strategy, high degree of observability of technology, and technology competence will exhibit higher digital procurement technology adoption levels than other firms. Firm size and firm turnover factors revealed that larger firm size and firm turnover are associated with higher adoption rates, but this could be due to the skewed sample size, and further research would need to be conducted to provide conclusive results. Resource scarcity

and industry standards and regulations minimally impact technology adoption and are considered less impactful barriers to adoption.

6.5 Conclusions on the enhancement of the level of adoption of procurement 4.0 technologies

A keen focus on innovation diffusion, technology and organisational factors, such as a clear digital strategy, high degree of technology, technology, and technology competence (i.e., IT skills and mature IT infrastructure), will ensure firms exhibit a higher level of digital procurement technology adoption.

A firm's key strategic priority should be to develop clear digital procurement strategies, plans and processes for executing those strategies. The digital procurement strategies should be well communicated and understood by employees at all levels in the firm. Firms should focus on increasing technology awareness amongst senior leadership and key decision-makers to enhance their understanding of technology capabilities, technology use cases and performance in similar contexts to their own. Firms should focus on building an IT infrastructure that supports and facilitates inter-and intra- company communication and enhance people acquisition processes to secure the right IT staff with the skills necessary to build and maintain new digital procurement solutions. Firms should ensure that IT staff can train users to enhance the level of adoption.

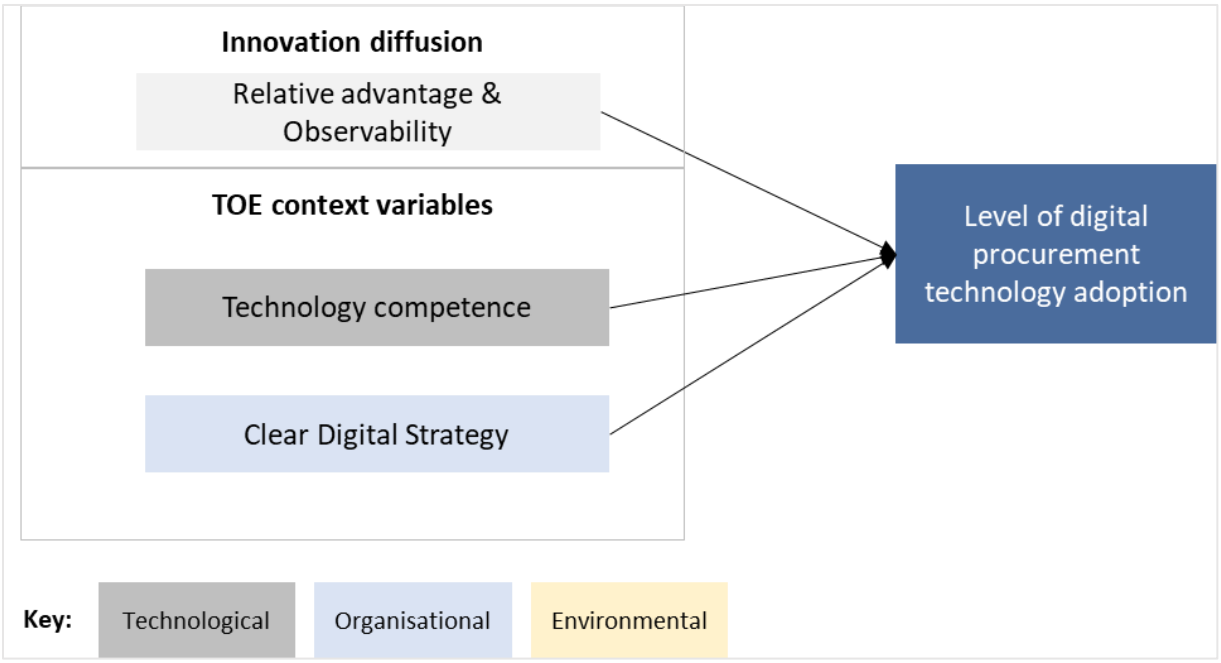


Figure 3: Prominent factors impacting digital procurement technology adoption in South African manufacturing firms

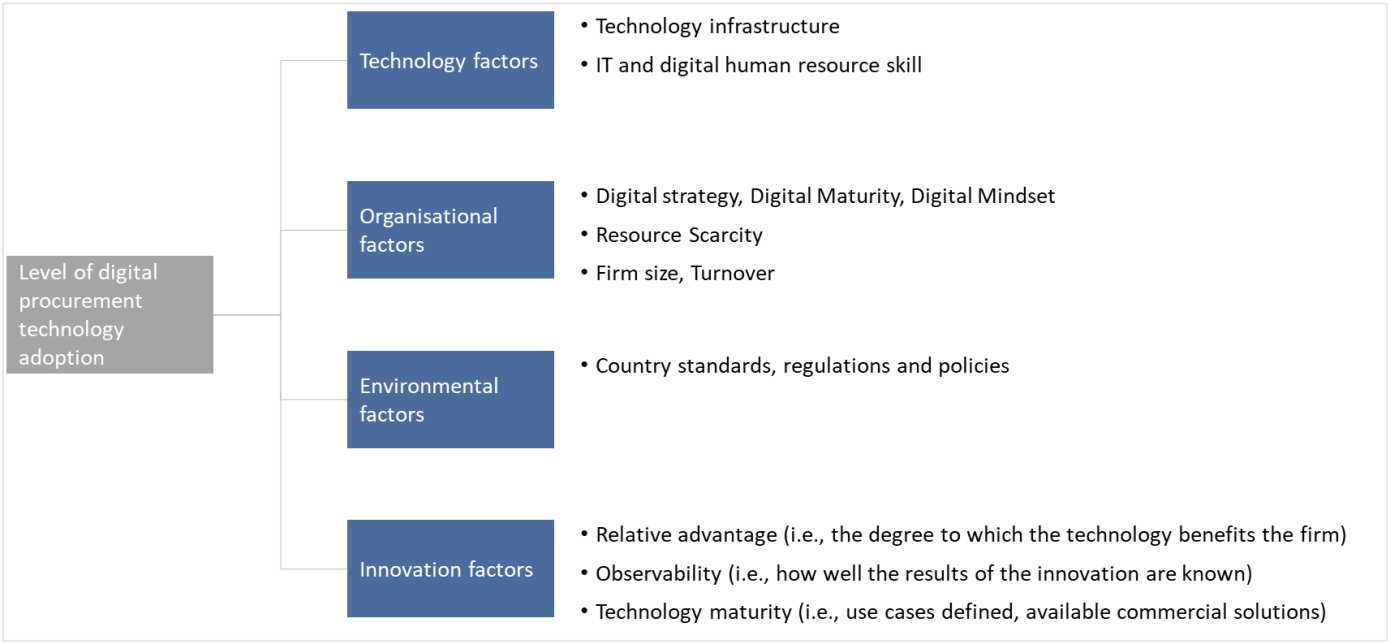


Figure 4: Influencing factors impacting adoption of digital procurement technologies in South African manufacturing firms

6.6 Recommendations

6.6.1 *Managerial implications and recommendations*

Supply chain and procurement managers in South Africa should first focus on implementing well-established enabling technologies (i.e., CC, IoT, BDA) before implementing more complex and less mature technologies (i.e., BCT).

To enhance the adoption of these enabling technologies, managers should focus on the three prominent factors that influence digital procurement adoption.

Firstly, managers should focus on organisational learning about the available enabling technologies, where they use cases, benefits in the firms' context, available commercial solutions, and their performance. Secondly, managers and executives should develop clear, concise digital procurement strategies with supporting action and implementation plans, accompanied by specific resource requirements for each key initiative. Lastly, managers should hire key talent to lead digital transformation initiatives. The strategic resource plan should ensure the firms' talent pool is rich with technical IT expertise capable of developing and maintaining enabling technology solutions. Linked to advanced IT skills are the firm IT capabilities and system infrastructure, whereby IT managers and business executives partner to ensure the firm has mature systems and digital tool landscape capable of sharing information seamlessly, ensuring information visibility, accessibility to internal stakeholders and most importantly, external ecosystem partners. Managers are involved in implementing any industry 4.0 technology to measure the success of every initiative. Furthermore, managers should focus on revealing the root

causes of digital procurement technology adoption barriers and explore the cause and effect relationships between the barriers observed in their respective firms. Exploring the causal relationships can help focus a firm's financial and human resources to mitigate the true barriers to adoption.

Future research could include other digital technologies used in procurement, such as cybersecurity, AI, RPA, 3D printing, and others, to determine the level of adoption. Further research could be conducted to investigate the cause and effect relationships between the barriers to adoption to determine the causal barriers from the influencing and resulting barriers.

6.6.2 *Organisational implications and recommendations*

Procurement executives could benefit from assessing the firms turnover relative to projected capital expenditure and operational expenditure plans for the next 1 – 5 years. Senior leadership should be well informed of the cost and timelines of digital procurement technology implementations and the benefits case to support long term initiatives, as high investments costs are a notable barrier to adoption. Furthermore, procurement executives in developing markets should focus on shaping and implementing company policies related to the transition to procurement 4.0 technologies without country-wide regulations and standards.

6.6.3 *Suggestions for further research*

- Further studies could be conducted with an equal number of participants in each firm size category to determine if large enterprises adopt technology more than the small, medium and micro-enterprises.
- Further studies could be conducted with an equal number of participants in each turnover category to determine if high turnover enterprises adopt technology more than the lower turnover enterprises.
- Further research could be conducted with a larger sample size to assess the levels of adoption in more granular detail
- Further research could be conducted to assess the level of adoption in each sub-sector of manufacturing
- Further research could be conducted to rank the factors impacting technology adoption

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Appendix A: Data collection instrument

Section 1: General overview of participant and firm

Please make use of the free text field to answer the below questions.

1. Provide your role title in the organization.
2. Provide a brief description of your responsibilities in your role.
3. How many employees does your firm have?
4. What is your firm's annual turnover? (in ZAR)
5. Years of work experience?

Section 2: Level of adoption of digital procurement technologies

Select the most appropriate rating for each technology related to the level of digital procurement technology adoption by your firm. The rating scale ranges from 1 to 5: (1) not started, (2) basic, (3) developing, (4) intermediate, and (5) advanced.

A description of the contribution of each technology to the digital procurement practice is provided to aid your selection.

Digital tool	Digital Procurement Capabilities	Contribution to digital procurement
Big Data Analytics (BDA)	Visibility, Decision Aid	BDA can be used to improve sourcing risk management, category management, supplier selection, sourcing cost improvement. BDA improves the resilience and agility of the procurement function. BDA coupled with other IT results in real-time communication and information flow.
The Internet of Things (IoT)	Accuracy, Collaboration, Efficiency, Traceability	IoT technologies facilitate information capture and sharing among partners. IoT can sense supply chain processes, improving interoperability and decision-making. IoT has enabled the development of smart infrastructure in procurement.
Blockchain Technology (BT)	Efficiency, Collaboration, Visibility	BT can be used in enhancing traceability and transparency of the procurement function. Blockchain assists with the development of execution of digital contracts. BT can improve the procure-to-pay cycle create improved supply partner collaboration and visibility of transactions.
Cloud Computing (CC)	Access, Efficiency, Decision Aid, Collaboration, Visibility	Cloud solutions, mobile applications, and cloud-based software solutions allow for a flexible work location. Cloud service platforms allow for global networking are based on real-time information sharing.

Section 3: Operation measurement scale related to the factors that influence technology adoption

Select the most appropriate rating for each statement. The rating scale ranges from 1 to 5: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree.

	Statement
1)	My company (MC) measures the performance of processes before and after the implementation of digital procurement initiatives (DPI)
2)	Existing IT infrastructure within my organisation can handle the procurement digitalisation transformation.
3)	MC has the appropriate skills to support the digitalisation of the procurement function.
4)	MC provides training for the procurement team to drive and support the digitalisation of the procurement function
5)	MC can rely on the digital skills internally to drive digital initiatives
6)	Services providers and/or supply chain partners drive procurement digitalisation as they have the right skills
7)	Existing job functions, roles, and descriptions can be transferred to the new role of procurement.
8)	MC has a clear digital strategy
9)	MC has outlined processes for managing the digital procurement initiatives (DPI)
10)	MC has developed a plan for managing DPI
11)	MC has dedicated appropriate intangibles and material resources to support DPI
12)	MC has the appropriate number of employees to manage the execution of the DPP
13)	MC organisational structure allows for agility when executing on the DPP
14)	MC turnover is sufficient to support the investment required for DPT adoption
15)	MC has sufficient coordinated internal standards and policies on Industry 4.0 to facilitate the adoption and use of DPT
16)	My country has sufficient coordinated national policies on Industry 4.0 to facilitate the adoption and use of DPT

Appendix B: Participant information sheet

Participant information sheet

Study title: The determinants of Procurement 4.0 adoption by South African manufacturing firms

Dear Sir/ Madam

I Karishma Singh am conducting research on understanding the organizational and technology factors that impact digital technology adoption in the procurement function of South African manufacturing firms. Research is a process used in seeking new knowledge. In this study we want to learn what type of Procurement 4.0 technologies have been adopted by your firm, to what degree they have been adopted and understand the barriers and enablers to technology adoption in your work environment.

We are inviting you to take part in a research study.

Participation in the study would include:

The completion of an online survey administered via an email with direct link to the survey on Google Forms. The survey would take approximately 15 minutes to complete. The survey will only be conducted if your provide your consent to take part in the study. The survey involves 5 general questions about your role and responsibilities in the firm, years of experience, the firm size and turnover. The second and third section has a total of 20 short statements to be answered by selecting the most appropriate option.

There is minimal risk to being involved in this study as no personal information will be revealed in the final results nor will your firms identity be revealed. There is no direct benefit in being involved in this study. Results of the study can be shared with you with your consent.

Appendix C: Participant consent form

Participant consent form

Study title: The determinants of Procurement 4.0 adoption by South African manufacturing firms

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts**.**

Contact details:

Karishma Singh, Principal Researcher, telephone no. XXX, or by e-mail at

Dr Fanny Saruchera, Supervisor, on telephone no. XXX, or by e-mail at

Appendix D: Participant agreement form



PARTICIPANT CONSENT SHEET

Study title: The determinants of Procurement 4.0 adoption by South African manufacturing firms

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Karishma Singh, Principal Investigator, telephone no. +27765925160, or by e-mail at { HYPERLINK "mailto:karishmasingh8915@gmail.com" }

Dr Fanny Saruchera, Supervisor, by e-mail at { HYPERLINK "mailto:fanny.saruchera@wits.ac.za" }

Appendix E: Ethics Clearance Certificate

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/DB302117/790

This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below).

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title	The determinants of procurement 4.0 technology adoption by South African manufacturing firms
Investigator / Researcher	Mrs. Karishma Singh
Nature of Project	MM (Digital Business)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	2021-09-03
Expiry date	Date of submission of the project report
Chairperson	Prof Anthony Stacey ☎ +27 11 717 3587 +27 82 880 4531 anthony.stacey@wits.ac.za

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am 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 undertake to resubmit the protocol to the Committee.

Signature

06/09/2021
Date:

Appendix F: Statistical Analysis

Frequency Table

Recoded Manu Sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pharmaceutical	13	12.7	12.9	12.9
	Food and Beverage	22	21.6	21.8	34.7
	Other	26	25.5	25.7	60.4
	Industrial	40	39.2	39.6	100.0
	Total	101	99.0	100.0	
Missing	System	1	1.0		
Total		102	100.0		

Recoded Turnover

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Greater than R10 million and less than R170 million	15	14.7	14.7	14.7
	Greater than R170 million	87	85.3	85.3	100.0
	Total	102	100.0	100.0	

Recoded BDA adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Adopted	19	18.6	18.6	18.6
	Adopted	83	81.4	81.4	100.0
	Total	102	100.0	100.0	

Recoded IoT adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Adopted	26	25.5	25.5	25.5
	Adopted	76	74.5	74.5	100.0
	Total	102	100.0	100.0	

Recoded BCT adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not adopted	53	52.0	52.0	52.0
	Adopted	49	48.0	48.0	100.0
	Total	102	100.0	100.0	

Recoded CC adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Adopted	15	14.7	14.7	14.7
	Adopted	87	85.3	85.3	100.0
	Total	102	100.0	100.0	

Frequency Table

BDA_Adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) not started	19	18.6	18.6	18.6
	(2) basic	26	25.5	25.5	44.1
	(3) developing	28	27.5	27.5	71.6
	(4) intermediate	18	17.6	17.6	89.2
	(5) advanced	11	10.8	10.8	100.0
	Total	102	100.0	100.0	

IoT_Adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) not started	26	25.5	25.5	25.5
	(2) basic	26	25.5	25.5	51.0
	(3) developing	21	20.6	20.6	71.6
	(4) intermediate	19	18.6	18.6	90.2
	(5) advanced	10	9.8	9.8	100.0
	Total	102	100.0	100.0	

BCT_Adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) not started	53	52.0	52.0	52.0
	(2) basic	16	15.7	15.7	67.6
	(3) developing	20	19.6	19.6	87.3
	(4) intermediate	9	8.8	8.8	96.1
	(5) advanced	4	3.9	3.9	100.0
	Total	102	100.0	100.0	

CC_Adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) not started	15	14.7	14.7	14.7
	(2) basic	20	19.6	19.6	34.3
	(3) developing	27	26.5	26.5	60.8
	(4) intermediate	26	25.5	25.5	86.3
	(5) advanced	14	13.7	13.7	100.0
	Total	102	100.0	100.0	

Frequency Table

TC1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	9	8.8	8.8	8.8
	(2) disagree	11	10.8	10.8	19.6
	(3) neutral	24	23.5	23.5	43.1
	(4) agree	45	44.1	44.1	87.3
	(5) strongly agree	13	12.7	12.7	100.0
	Total	102	100.0	100.0	

TC2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	5	4.9	4.9	4.9
	(2) disagree	21	20.6	20.6	25.5
	(3) neutral	18	17.6	17.6	43.1
	(4) agree	42	41.2	41.2	84.3
	(5) strongly agree	16	15.7	15.7	100.0
	Total	102	100.0	100.0	

TC3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	10	9.8	9.8	9.8
	(2) disagree	18	17.6	17.6	27.5
	(3) neutral	19	18.6	18.6	46.1
	(4) agree	43	42.2	42.2	88.2
	(5) strongly agree	12	11.8	11.8	100.0
	Total	102	100.0	100.0	

Frequency Table

RS1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	7	6.9	6.9	6.9
	(2) disagree	13	12.7	12.7	19.6
	(3) neutral	27	26.5	26.5	46.1
	(4) agree	38	37.3	37.3	83.3
	(5) strongly agree	17	16.7	16.7	100.0
	Total	102	100.0	100.0	

RS2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	4	3.9	3.9	3.9
	(2) disagree	19	18.6	18.6	22.5
	(3) neutral	25	24.5	24.5	47.1
	(4) agree	49	48.0	48.0	95.1
	(5) strongly agree	5	4.9	4.9	100.0
	Total	102	100.0	100.0	

RS3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	5	4.9	4.9	4.9
	(2) disagree	15	14.7	14.7	19.6
	(3) neutral	24	23.5	23.5	43.1
	(4) agree	46	45.1	45.1	88.2
	(5) strongly agree	12	11.8	11.8	100.0
	Total	102	100.0	100.0	

Frequency Table

DS1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	11	10.8	10.9	10.9
	(2) disagree	22	21.6	21.8	32.7
	(3) neutral	26	25.5	25.7	58.4
	(4) agree	27	26.5	26.7	85.1
	(5) strongly agree	15	14.7	14.9	100.0
	Total	101	99.0	100.0	
Missing	System	1	1.0		
Total		102	100.0		

DS2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	6	5.9	5.9	5.9
	(2) disagree	26	25.5	25.5	31.4
	(3) neutral	30	29.4	29.4	60.8
	(4) agree	31	30.4	30.4	91.2
	(5) strongly agree	9	8.8	8.8	100.0
	Total	102	100.0	100.0	

DS3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	7	6.9	6.9	6.9
	(2) disagree	24	23.5	23.8	30.7
	(3) neutral	33	32.4	32.7	63.4
	(4) agree	29	28.4	28.7	92.1
	(5) strongly agree	8	7.8	7.9	100.0
	Total	101	99.0	100.0	
Missing	System	1	1.0		
Total		102	100.0		

DS4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	5	4.9	4.9	4.9
	(2) disagree	26	25.5	25.5	30.4
	(3) neutral	37	36.3	36.3	66.7
	(4) agree	28	27.5	27.5	94.1
	(5) strongly agree	6	5.9	5.9	100.0
	Total	102	100.0	100.0	

Frequency Table

FS1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	10	9.8	9.9	9.9
	(2) disagree	23	22.5	22.8	32.7
	(3) neutral	37	36.3	36.6	69.3
	(4) agree	24	23.5	23.8	93.1
	(5) strongly agree	7	6.9	6.9	100.0
	Total	101	99.0	100.0	
Missing	System	1	1.0		
Total		102	100.0		

FS2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	6	5.9	5.9	5.9
	(2) disagree	25	24.5	24.5	30.4
	(3) neutral	26	25.5	25.5	55.9
	(4) agree	38	37.3	37.3	93.1
	(5) strongly agree	7	6.9	6.9	100.0
	Total	102	100.0	100.0	

TO1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	6	5.9	5.9	5.9
	(2) disagree	11	10.8	10.8	16.7
	(3) neutral	21	20.6	20.6	37.3
	(4) agree	34	33.3	33.3	70.6
	(5) strongly agree	30	29.4	29.4	100.0
	Total	102	100.0	100.0	

SR1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	5	4.9	5.0	5.0
	(2) disagree	20	19.6	19.8	24.8
	(3) neutral	31	30.4	30.7	55.4
	(4) agree	29	28.4	28.7	84.2
	(5) strongly agree	16	15.7	15.8	100.0
	Total	101	99.0	100.0	
Missing	System	1	1.0		
Total		102	100.0		

SR2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(1) strongly disagree	10	9.8	9.8	9.8
	(2) disagree	24	23.5	23.5	33.3
	(3) neutral	37	36.3	36.3	69.6
	(4) agree	26	25.5	25.5	95.1
	(5) strongly agree	5	4.9	4.9	100.0
	Total	102	100.0	100.0	

Correlations

		Adoption	OB	TC	RS	DS	FS	TOR	SR
Adoption	Pearson Correlation	1	.575**	.604**	.410**	.652**	.486**	.284**	.473**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.004	.000
	N	102	102	102	102	102	102	102	102
OB	Pearson Correlation	.575**	1	.612**	.514**	.641**	.543**	.342**	.481**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.000
	N	102	102	102	102	102	102	102	102
TC	Pearson Correlation	.604**	.612**	1	.642**	.755**	.745**	.333**	.648**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.001	.000
	N	102	102	102	102	102	102	102	102
RS	Pearson Correlation	.410**	.514**	.642**	1	.568**	.527**	.284**	.557**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.004	.000
	N	102	102	102	102	102	102	102	102
DS	Pearson Correlation	.652**	.641**	.755**	.568**	1	.721**	.376**	.625**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000
	N	102	102	102	102	102	102	102	102
FS	Pearson Correlation	.486**	.543**	.745**	.527**	.721**	1	.358**	.660**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.000
	N	102	102	102	102	102	102	102	102
TOR	Pearson Correlation	.284**	.342**	.333**	.284**	.376**	.358**	1	.419**
	Sig. (2-tailed)	.004	.000	.001	.004	.000	.000		.000
	N	102	102	102	102	102	102	102	102
SR	Pearson Correlation	.473**	.481**	.648**	.557**	.625**	.660**	.419**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	
	N	102	102	102	102	102	102	102	102

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

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	OB[b]		Enter

a. Dependent Variable: Adoption

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.575[a]	.330	.324	.86613

a. Predictors: (Constant), OB

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	37.002	1	37.002	49.324	.000[b]
	Residual	75.018	100	.750		
	Total	112.020	101			

a. Dependent Variable: Adoption

b. Predictors: (Constant), OB

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.664	.288		2.302	.023
	OB	.562	.080	.575	7.023	.000

a. Dependent Variable: Adoption

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	TC[b]		Enter

a. Dependent Variable: Adoption

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.604[a]	.365	.359	.84326

a. Predictors: (Constant), TC

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40.912	1	40.912	57.534	.000[b]
	Residual	71.108	100	.711		
	Total	112.020	101			

a. Dependent Variable: Adoption

b. Predictors: (Constant), TC

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.397	.302		1.315	.191
	TC	.653	.086	.604	7.585	.000

a. Dependent Variable: Adoption

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	RS[b]		Enter

a. Dependent Variable: Adoption

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.410[a]	.168	.160	.96550

a. Predictors: (Constant), RS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.801	1	18.801	20.168	.000[b]
	Residual	93.219	100	.932		
	Total	112.020	101			

a. Dependent Variable: Adoption

b. Predictors: (Constant), RS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.790	.414		1.910	.059
	RS	.532	.118	.410	4.491	.000

a. Dependent Variable: Adoption

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	DS[b]		Enter

a. Dependent Variable: Adoption

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.652[a]	.424	.419	.80293

a. Predictors: (Constant), DS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	47.550	1	47.550	73.754	.000[b]
	Residual	64.470	100	.645		
	Total	112.020	101			

a. Dependent Variable: Adoption

b. Predictors: (Constant), DS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.418	.266		1.573	.119
	DS	.705	.082	.652	8.588	.000

a. Dependent Variable: Adoption

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	FS[b]		Enter

a. Dependent Variable: Adoption

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.486[a]	.236	.228	.92506

a. Predictors: (Constant), FS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26.446	1	26.446	30.904	.000[b]
	Residual	85.574	100	.856		
	Total	112.020	101			

a. Dependent Variable: Adoption

b. Predictors: (Constant), FS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.961	.308		3.117	.002
	FS	.537	.097	.486	5.559	.000

a. Dependent Variable: Adoption

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	TOR[b]		Enter

a. Dependent Variable: Adoption

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.284[a]	.081	.072	1.01474

a. Predictors: (Constant), TOR

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.049	1	9.049	8.788	.004[b]
	Residual	102.971	100	1.030		
	Total	112.020	101			

a. Dependent Variable: Adoption

b. Predictors: (Constant), TOR

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.657	.333		4.976	.000
	TOR	.255	.086	.284	2.964	.004

a. Dependent Variable: Adoption

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	SR[b]		Enter

a. Dependent Variable: Adoption

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.473[a]	.224	.216	.93242

a. Predictors: (Constant), SR

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25.080	1	25.080	28.847	.000[b]
	Residual	86.940	100	.869		
	Total	112.020	101			

a. Dependent Variable: Adoption

b. Predictors: (Constant), SR

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.954	.320		2.986	.004
	SR	.528	.098	.473	5.371	.000

a. Dependent Variable: Adoption

Reliability Statistics

Cronbach's Alpha	N of Items
.933	16

Appendix G: Confirmation of Proof-editing

EDITING CONFIRMATION

To whom it may concern:

This memo serves to confirm that the manuscript/research project detailed below has been language-edited and/or proof-read.

Regards,

-IETS-

IET Innocent *(Cert. Lang. Ed.)*
Language Editor

****

Manuscript Title:

The determinants of Procurement 4.0 technology adoption by South African manufacturing firms

Author:

Karishma Singh

Issued on:

February 21, 2022

Disclaimer:
The editor/proofreader makes no claim as to the accuracy of the manuscript contents nor the objectives of the author. While all possible efforts have been made to ensure the text as edited is readable and grammatically correct, the author(s) have the option to accept or reject suggestions and trackable changes made to the document before submission.



*** Professional Editors ***

sarchcot@gmail.com