Investigating Outputs from University-Industry-Government Collaborations in the Technology Station Clothing and Textiles of the Western Cape, South Africa

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Dissertation

MConSci: Clothing Management

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April 2023

Investigating outputs from university-industry-government collaborations in the Technology Station Clothing and Textiles of the Western Cape, South Africa

by:

Sinqobile Thokozani Loyiso Sihlobo

Dissertation submitted in fulfilment of the requirements for the degree

Master of Consumer Science: Clothing Management

In the

Faculty of Natural and Agricultural Sciences

Department of Consumer Science

University of Pretoria

Supervisor: Dr S. Mbatha

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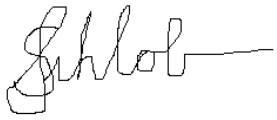
April 2023

DECLARATION

I, **Sinqobile Thokozani Loyiso Sihlobo**, declare that this dissertation, which I hereby submit for the degree, **Master of Consumer Science: Clothing Management,** at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution. I also confirm that all reference material in the dissertation has been duly acknowledged.



STL Sihlobo

March 2023

DEDICATION

I dedicate this master's study to my dear Heavenly Father, Jesus Christ, and the Holy Spirit. I could not have been able to do it without you.

I also dedicate this study to my mother – Lynn Gumbi; I could not have made it through this research journey without your sacrifices.

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We did it!

SUMMARY

Investigating outputs from university-industry-government collaborations in the Technology Station Clothing and Textiles of the Western Cape, South Africa

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Department: Consumer and Food Sciences

Degree: Master of Consumer Science (Clothing Management)

Keywords: triple helix (TH), national systems of innovation (NSI), Technology Innovation Agency (TIA), Technology Stations Programme (TSP), technology station (or research institution), collaboration outputs, clothing and textiles industry, socio-economic development

University-industry-government (UIG) collaborations are vital because they provide solutions to structural problems arising from challenges in higher education, research and development (R&D), and competitiveness. However, the literature on UIG collaboration outputs, specifically in the clothing, textiles, leather, and footwear (CTLF) industry, is limited in the Global South context. UIG collaborations are vital to the clothing and textiles industry because the value chain's success links are market access advantages, the value chain capabilities, and the success of government CTLF industry policies and incentives.

The research institution, Technology Station in Clothing and Textiles (TSCT) in Western Cape, South Africa, was purposively sampled out of 18 South African technology stations to gather data regarding the UIG collaboration outputs. A case study research design was used because there is limited research on UIG collaboration outputs in the CTLF industry in the Western Cape, South Africa, Africa, and the world. The case study allowed for vast application and exploration to investigate a social phenomenon such as the TSCT by combining multiple forms of data using the qualitative methodology.

The qualitative methodology was used because it allowed the research problem to be studied to understand a new phenomenon and analyse themes and conduct an inquiry reflexively. Data collection was conducted through document analysis and semi-structured in-depth interviews. The document analysis collection was in documents, infographics, photographs, and media articles from the websites with TSCT and TIA content. Interviews were conducted with the head of the Technology Stations Programme, who deals with all 18 Technology Stations, and one Technology Stations Programme (TSP) manager, who deals with a third (six) of the Technology Stations, with one being the TSCT. Then an interview was conducted with the Manager of TSCT who deals with the TIA, CPUT, and other various industry and government institutions. Thematic analysis was employed to analyse themes within the data using ATLAS.ti computer software. The researcher sought whether academic and socio-economic outputs led to tangible outcomes that solved structural problems.

This study used Kruss and Visser's (2017) traditional academic and socio-economic outputs. This study found that most academic outputs are moderate in quality at the TSCT. Scientific discoveries and graduates with relevant skills had good quality. However, there were no senior postgraduate degrees available. For the socio-economic outputs, new and improved products and processes had good quality, while community infrastructure and facilities had moderate quality. However, no account of spin-off companies or cultural artefacts contributed to socio-economic benefit. The TSCT has seen success in the past, however, in a post-pandemic world, their current approach could possibly not survive if they do not consider restructuring.

The TSCT must figure out how to use outputs as a means for the Western Cape to be sought for to specific designs of speciality and create new international markets for uniqueness. In essence, the TSCT will benefit academically and socio-economically if the collaboration of the UIG outputs improves. It depends on the TIA's commitment to other government departments, organisations, and companies to invest in the TSCT.

OPSOMMING

Ondersoek universiteit-industrie-regering samewerkingsuitsitte in die klere en tekstiele tegnologiestasie van die Wes-Kaap, Suid Afrika

Deur

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Graad: Meester van Verbruikerswetenskap (Kleding: Klerebestuur)

Sleutewoorde: drievoudige heliks (TH), nasionale stelsels van innovasie (NSI), agentskap vir tegnologiese innovasie (TIA), program vir tegnologiestasies (TSP), tegnologiestasie (or navorsingsinstelling), samewerkingsuitsette, klere- en tekstielbedryf, sosio-ekonomiese ontwikkeling

Universiteit-industrie-regering (UIG) samewerking is noodsaaklik omdat dit oplossings bied vir strukturele probleme wat voortspruit uit uitdagings in hoër onderwys, navorsing en ontwikkeling (N&O), en mededingendheid. Die literatuur oor UIG-samewerkingsuitsette, spesifiek in die klere-, tekstiel-, leer-, en skoenebedryf (CTLF), is egter beperk in die Globale Suid-konteks. UIG-samewerking is noodsaaklik vir die klere- en tekstielbedryf omdat die waardeketting se suksesskakels marktoegangsvoordele, die waardekettingvermoëns en die sukses van die regering se CTLF-industriebeleid en -aansporings is.

Die navorsingsinstelling, Tegnologiestasie in Klere en Tekstiel in Wes-Kaap, Suid-Afrika, is doelbewus uit 18 Suid-Afrikaanse tegnologiestasies gesteek om data rakende die UIG-samewerkingsuitsette in te samel. ’n Gevallestudie-navorsingsontwerp is gebruik omdat daar beperkte navorsing oor UIG-samewerkingsuitsette in die CTLF-industrie in die Wes-Kaap, Suid-Afrika, Afrika en die wêreld is. Die gevallestudie het voorsiening gemaak vir groot toepassing en verkenning om 'n sosiale verskynsel soos die TSCT te ondersoek deur verskeie vorme van data te kombineer deur die kwalitatiewe metodologie te gebruik.

Die kwalitatiewe metodologie is gebruik omdat dit die navorsingsprobleem bestudeer het om 'n nuwe verskynsel te verstaan en temas te ontleed en 'n ondersoek refleksief uit te voer. Data-insameling is uitgevoer deur middel van dokumentontleding en semi-gestruktureerde in-diepte onderhoude. Die dokumentontledingversameling was in dokumente, infografika, foto's, en media-artikels van die webwerwe met TSCT- en TIA-inhoud. Onderhoude is gevoer met die hoof van die Tegnologiestasies Program, wat met al 18 tegnologiestasies handel, en een tegnologiestasies-program (TSP) bestuurder, wat met 'n derde (ses) van die tegnologiestasies handel, waarvan een die TSCT is. Daarna is 'n onderhoud gevoer met die bestuurder van TSCT wat te doen het met die TIA, CPUT, en ander verskeie industrie- en regeringsinstellings. Tematiese analise is aangewend om temas binne die data te ontleed deur gebruik te maak van ATLAS.ti rekenaarsagteware. Die navorser het gesoek of akademiese en sosio-ekonomiese uitsette tot tasbare uitkomste lei wat strukturele probleme oplos.

Die studie het Kruss en Visser (2017) se tradisionele akademiese en sosio-ekonomiese uitsette gebruik. Die studie het bevind dat die meeste akademiese uitsette matig in kwaliteit by die TSCT is. Wetenskaplike ontdekkings en gegradueerdes met relevante vaardighede het goeie gehalte gehad. Daar was egter geen senior nagraadse grade beskikbaar nie. Vir die sosio-ekonomiese uitsette het nuwe en verbeterde produkte en prosesse goeie gehalte gehad, terwyl gemeenskapsinfrastruktuur en fasiliteite matige gehalte gehad het. Geen rekening van afwentelmaatskappye of kulturele artefakte het egter tot sosio-ekonomiese voordeel bygedra nie. Die TSCTs het in die verlede sukses behaal, maar in 'n post-pandemiese wêreld kan hul huidige benadering moontlik nie oorleef as hulle nie herstrukturering oorweeg nie.

Die TSCT moet uitvind hoe om uitsette te gebruik as 'n manier vir die Wes-Kaap om uitgesoek te word vir spesifieke ontwerpe van spesialiteit en 'n nuwe internasionale mark vir uniekheid skep. In wese sal die TSCT akademies en sosio-ekonomies baat as die samewerking van die UIG-uitsette verbeter. Dit hang af van die TIA se verbintenis tot ander staatsdepartemente, organisasies en maatskappye om in die TSCT te belê.

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LIST OF ACRONYMS

3D	Three-dimensional
4IR	Fourth Industrial Revolution
AFI	African Fashion International
AGOA	Africa Growth and Opportunity Act
AI	Artificial intelligence
AMTL	Adaptronics Advanced Manufacturing Technology Laboratory
ATS	Agrifood Technology Station
AU	African Union
BoF	Business of fashion
CAD	Computer-aided design
CCTC	Cape Clothing and Textile Cluster
CCDI	Cape Craft Design Institute
CDI	Craft Design Institute (new name for CCDI)
CFTA	Continental Free Trade Area
CIP	Competitiveness Improvement Programme
CLOTEX	Clothing and Textiles Service Centre
CMT	Cut-make-trim
COFISA	Co-operative Financial Institute of South Africa
COMESA	Common Market for Eastern and Southern Africa
COVID-19	Corona Virus Disease 2019
CPUT	Cape Peninsula University of Technology
CSIR	Council for Scientific and Industrial Research
CSR	Corporate social responsibility
CTCP	Clothing and Textile Competitiveness Programme
CTFC	Cape Town Fashion Council
CTLF	Clothing, textiles, leather, and footwear
DEDAT	Department of Economic Development and Tourism
DSI	Department of Science and Innovation (the new name for DST)
DST	Department of Science and Technology
DTI	Department of Trade and Industry
DTIC	Department of Trade, Industry and Competition (new name for DTI)

EAC	East African community
ED	Enterprise development
EDD	Economic Development Department
ELSA	Exotic Leather South Africa
ERP	Enterprise resource planning
EU	European Union
FDI	Foreign direct investment
FP&M-SETA	Fibre Processing and Manufacturing Sector Education and Training Authority
GDP	Gross domestic product
GNI	Gross national income
GVC	Global value chain
HDI	Human Development Index
HEI	Higher education institution
HKRITA	Hong Kong Research Institute of Textiles and Apparel
IAT	Institute for Advanced Tooling
ICT	Information and communication technology
IDC	Industrial Development Corporation
IIEP	International Institute for Educational Planning
IIPF	Industry Innovation Partnership Fund
IP	Intellectual property
IPO	Input-process-output
IPR	Intellectual property right
IPAP	Industrial Policy Action Plan
ISI	Import substituting industrialisation
KZN CTC	KwaZulu-Natal Clothing and Textile Cluster
LATS	Limpopo Agro-Food Technology Station
McK	McKinsey and Company
MCTS	Metal Casting Technology Station
MFA	Multi-Fibre Arrangement
NACI	National Advisory Council on Innovation
NDP	National Development Plan
NELC	National Exotic Leather Cluster
NFLC	National Footwear and Leather Cluster

NIPMO	National Intellectual Property Management Office
NPC	National Planning Commission
NRCS	National Regulator for Compulsory Specifications
NSI	National systems of innovation
NTU	Nottingham Trent University
OECD	Organisation for Economic Co-operation and Development
PBR	Plant breeder right
PDTS	Product Development Technology Station
PEET	Process Energy and Environmental Technology Station
PIP	Production Incentive Programme
PLM	Product Lifecycle Management
PPPFA	Preferential Public Procurement Framework Act
QR	Quick response
R&D	Research and development
R-CTLF	Retail – clothing, textiles, leather, and footwear
RMPTS	Reinforced and Moulded Plastics Technology Station
SA	South Africa
SABS	South African Bureau of Standards
SACU	Southern African Customs Union
SADC	Southern African Development Cooperation
SAQA	South African Qualifications Authority
SATRA-UK	Shoes and Allied Trade Research Association
SC	Science Council
SDG	Sustainable Development Goal
SEDA	Small Enterprise Development Agency
SEO	Socio-economic output
SET	Science, engineering, and technology
SIF	Sector Innovation Fund
SME	Small and medium enterprises
SMME	Small, medium and micro enterprises
SPV	Special purpose vehicle
SSA	Sub-Saharan Africa
STATS SA	Statistics South Africa
STEM	Science, Technology, Engineering, and Mathematics

SU	Stellenbosch University
TAO	Traditional academic output
TCCoE	Textiles and Clothing Centre of Excellence (the new name for TECoE)
TECoE	Textiles Engineering Centre of Excellence
TH	Triple helix
TH I	Triple Helix Model 1
TH II	Triple Helix Model 2
TH III	Triple Helix Model 3
THRIP	Technology and Human Resources for Industry Programmes
TIA	Technology Innovation Agency
TIPS	Trade and Industrial Policy Strategies
TS	Technology Station
TSC	Technology station in Chemicals
TSCT	Technology Station in Clothing and Textiles
TSE	Technology Station in Electronics
TSP	Technology Stations Programme
TSPMT	Technology Station for Materials and Processing Technology
TSRSD	Technology Station in Rural Sustainable Development
TUT	Tshwane University of Technology
UCT	University of Cape Town
UIG	University-industry-government
UoT	University of Technology
UK	United Kingdom
UKZN	University of KwaZulu-Natal
UN	United Nations
UN SDGs	United Nations Sustainable Development Goals
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISA	University of South Africa
UP	University of Pretoria
US	United States
UWC	University of the Western Cape
VAT	Value-added tax
VUT	Vaal University of Technology

WC	Western Cape
WISP	Western Cape Industrial Symbiosis Programme
WSU	Walter Sisulu University
WTO	World Trade Organization
ZAR	South African Currency (Rand)

CHAPTER 1: THE STUDY IN PERSPECTIVE

"Once you plant seeds of success, your tree will bear fierce fruit." ~ Tyra Banks

The title of this study is: *Investigating outputs from university-industry-government collaborations in the Technology Station Clothing and Textiles of the Western Cape, South Africa.* To understand what this study is all about, this study's perspective – point of view – should be understood. This first chapter forms the seeds of what to expect in the following chapters.

1.1 INTRODUCTION AND BACKGROUND FOR THIS STUDY

National systems of innovation (NSI) are essential for a country's creation, adaptation, and application of knowledge for socio-economic benefits (Grobbelaar, Tijssen & Dijksterhuis, 2017; Manzini, 2015; Morris & Einhorn, 2008; Organisation for Economic Co-operation and Development (OECD), 1997). The South African National Commission created the National Development Plan (NDP) 2030 to apply NSI to meet strategic goals of socio-economic development (Department of Presidency, 2012; Manzini, 2015). More studies are required to explore NSI in the clothing, textiles, leather, and footwear (CTLF) industry.

The CTLF industry is a priority sector for the Western Cape provincial government (Co-operative Financial Institute of South Africa (COFISA), 2009; Wesgro, 2021) and the South African national government (Bluepeter Management Consulting & Access Market International, 2004; Department of Trade and Industry (DTI), 2007; 2010; 2014; 2017; 2018) due to its potential to reduce unemployment and contribute to socio-economic development (Mbatha, 2020; Mbatha & Mastamet-Mason, 2021; Morris & Einhorn, 2008). This study explores and describes university-industry-government (UIG) collaboration outputs between the Western Cape's university CTLF-related programmes, the CTLF industry, and the government found in the Technology Station in Clothing and Textiles (TSCT). The Western Cape is one of the leading provinces of the CTLF industry in South Africa, making it a suitable area of focus for this study (Mbatha, 2018; Mbatha, 2020 Mbatha & Mastamet-Mason, 2021).

The triple helix (TH) model is a highly recommended innovation model for studying the NSI. Various authors (Cho, 2014; Etzkowitz & Leydesdorff, 2000; Etzkowitz & Ranga, 2010; Migge, 2012; Mpehongwa, 2013; Santonen, Kaivo-Oja & Suomala, 2014; Sarpong, AbdRazak, Alexander & Meissner, 2017) used or recommended the triple helix model. The literature on UIG collaborations is generally from the Global North (Etzkowitz, Dzisah, Ranga & Zhou, 2007; Etzkowitz & Leydesdorff, 2000; Etzkowitz & Ranga, 2010; Etzkowitz & Zhou, 2018) with lesser

studies focusing on the Global South. The Global South emphasises applying UIG collaborations in regional contexts and non-Western approaches (Cai, 2014; Datta & Saad, 2011; Potgieter, 2012; Ye & Wang, 2019). The TH model has mostly been applied to science, technology, engineering, and mathematics (STEM) related sectors (Liche & Braun Střelcová, 2023; Kobzeva, Gribov, Snigireva & Raevskya, 2017; Malik, Kabiraj & Huo, 2021) with a weak focus on the CTLF industry.

UIG collaborations are vital due to their ability to solve structural problems arising from challenges faced in higher education, research and development (R&D), and competitiveness (Etzkowitz & Zhou, 2018; Ranga, 2012). UIG collaborations are essential to the CTLF industry because the success of the value chain links market access advantages, the value chain capabilities, and the success of government CTLF industry policies and incentives (Barnes, 2018a; Barnes, 2018b). Collaboration outputs are the "plans, products, and other tangible items generated by collaborative efforts" (Koebele, 2015:64).

There is a potential to provide the Western Cape CTLF industry with empirical findings that may lead to a better understanding of NSI, the role of each stakeholder and the outputs of UIG collaborations in the Western Cape Province of South Africa to pursue a competitive advantage. This study contributes to the knowledge of UIG collaborations in the Western Cape's CTLF industry.

1.2 PROBLEM STATEMENT

The current South African CTLF studies focus on:

- The challenges of the industry (Mbatha, 2020; Mbatha & Mastamet-Mason, 2015; Mbatha & Mastamet-Mason, 2021; Morris & Barnes, 2014; Morris & Reed, 2008);
- The competitiveness of the industry (Mbatha, 2020; Mbatha & Mastamet-Mason, 2021; Barnes, 2018a; Barnes & Hartogh, 2018; Chaddha, Dhanani, Murotani, Ndiaye & Kamukama, 2009; DTI, 2018; FP&M-SETA, 2014; Mbatha, 2018; Thenga, 2016); and
- Plans to better the industry (Barnes, 2018b; Barnes & Hartogh, 2018; DTI, 2007, 2010, 2011, 2014, 2016, 2017).

All the studies mentioned above stated that some form of collaboration was needed to exist for the CTLF industry to improve. Mbatha (2020) conducted a South African CTLF industry doctoral study that explored UIG collaborations, their challenges, opportunities, and the roles played by institutional spheres using mixed methods. This study found that UIG collaborations exist in the South African CTLF industry. These collaborations are driven mainly by government funding, the technology stations, and the government science council situated in

a university situation. Evidence of the collaborations also exists in the form of completed, ongoing, failed, and planned UIG collaborations.

Mbatha (2020) proposes studies in line with the gaps identified to improve the limited literature on UIG collaborations in the CTLF industry. Based on the gaps observed, this research focuses on the outputs from UIG collaborations in the Western Cape, specifically the Technology Station in Clothing and Textiles (TSCT).

As Kruss and Visser (2017) define, an output includes traditional academic and economic and social outputs. Traditional academic outputs are academic publications, dissertations, academic collaborations, policy documents and reports, scientific discoveries, and graduates with relevant skills. Economic and social outputs, referred to as socio-economic outputs for this study, are new or improved products and processes, community infrastructure and facilities, spin-off companies, and cultural artefacts. In the CTLF industry of South Africa, there are gaps in research available on traditional academic outputs and socio-economic outputs.

Kruss and Visser (2017) argue that South African industry and economic policymakers have a weak enhanced understanding of universities to improve collaborations and knowledge generation and transfer. By studying a technology station (situated inside a university), this study seeks to improve the understanding of a university in the UIG collaborations. The strategic importance of the Western Cape CTLF industry in the South African economy (DTI, 2007; 2010; 2011; 2013; 2014; 2016; 2017; 2018) highlights the importance of conducting this study.

1.3 JUSTIFICATION OF THIS STUDY

This study is vital because the clothing, textiles, leather, and footwear (CTLF) industry is a priority sector for the South African government (DTI, 2007; 2010; 2011; 2013; 2014; 2016; 2017; 2018). The South African CTLF industry manufacturing accounts for 3.12% of total manufacturing, 2.9% of gross domestic product (GDP), 10.45% of employment, 3.5% of output, and 4.23% of wages (DTI, 2017b; Statistics South Africa, 2019a). In 2005, the Western Cape Provincial Advanced Manufacturing Technology Strategy identified clothing as an initial focus sector with four technology focus areas of advanced materials, advanced product technologies, advanced production technologies, and logistics (COFISA, 2009).

This study focuses on the Western Cape because the CTLF industry's production output is higher than the country's percentage as the Western Cape specialises in the CTLF industry (COFISA, 2009; Mbatha, 2020; Mbatha & Mastamet-Mason, 2021). The CTLF industry is a strategic industry that offers the potential for significant job creation. It accounted for ZAR 74

billion in the value chain's GDP in 2016, making it a significant contributor to the South African economy (Barnes & Hartogh, 2018). The CTLF industry can absorb many unskilled workers (primarily women) due to the labour-intensive nature and low entry barriers of the CTLF industry (Fibre Processing & Manufacturing Sector Education and Training Authority (FP&M-SETA), 2014; Mbatha, 2020; Mbatha & Mastamet-Mason, 2021; Morris & Barnes, 2014).

Based on national systems of innovation (NSI), universities are to conduct relevant research and publish such research findings (National Advisory Council on Innovation (NACI), 2006). Approximately 170 centres, research units, and institutes within Western Cape universities involved in the research could potentially contribute to NSI (COFISA, 2009). The government is to help through relevant policies (regulations, taxes, financing, competition, and intellectual property) to identify innovation and enhance competitiveness (OECD, 1997). The government can adopt various policies, schemes, and programmes to diffuse technology into the industry (Department of Presidency, 2012; NACI, 2006). The industry is to collaborate to accumulate technical resources, achieve economies of scale, and gain the cooperation of complementary human and technical assets (OECD, 1997). Section 1.3 highlights the importance of NSI. Therefore, studies on NSI research are necessary to track the Innovation in the CTLF industry.

1.4 AIMS AND OBJECTIVES

1.4.1 Aim of this study

To investigate outputs from UIG collaborations in the Technology Station in Clothing and Textiles (TSCT) of the Western Cape, South Africa.

1.4.2 Objectives of this study

To achieve the aim, this study has developed the following objectives:

OBJECTIVE 1: To explore traditional academic outputs from UIG collaborations with the TSCT, focusing on their quality, challenges, and opportunities.

OBJECTIVE 2: To explore socio-economic outputs from UIG collaborations with the TSCT, focusing on their quality, challenges, and opportunities.

1.5 DEFINITIONS OF OUTPUTS FOR THIS STUDY

Table 1.1 presents the definitions of the concepts that formed the theoretical basis for the outputs of this study. These definitions are based on traditional academic outputs and socio-economic outputs.

TABLE 1.1: OUTPUTS AND DEFINITIONS

Output	Definition
Traditional academic outputs (TAOs)	
Academic publications	Academic research is published in conference proceedings, journal articles, books, and chapters within books (Kruss & Visser, 2017).
Dissertations	Documents submitted in fulfilment of an academic degree (master's and doctorate), presenting the author's research and findings (University of KwaZulu-Natal (UKZN), 2019).
Academic collaborations	Joint academic ventures by researchers of differing stature, funding status, and types of organisations (OECD, 1997).
Reports	Official documents are written to give information to a specific audience and for a specific purpose (Merriam-Webster, 2020).
Policy documents	Documents that provide implementation plans guided by the government's policy commitments and socio-economic development for information, communication, and technology (ICT) (IGI Global, 2020).
Scientific discoveries	New inventions or innovations are created by new or improved technologies to form products or processes from a successful scientific inquiry (Schickore, 2018).
Graduates with relevant skills	Students who can transfer skills learned from an academic degree to the workplace environment and who have competitive skills necessary for the industry (Ishengoma & Vaaland, 2016) (employability or industry placement)
Socio-economic outputs (SEOs)	
New or improved products	Products that contribute to intellectual property (licences, patents, copyright, and trade secrets, among others) that can be commercialised for socio-economic benefits (Kruss & Visser, 2017).
New or improved processes	Processes that contribute to intellectual property (licences, patents, copyright, and trade secrets, among others) that can be commercialised for socio-economic benefits (Kruss & Visser, 2017).
Community infrastructure	Physical systems of businesses or nations, such as transportation (air, water, road, and rail), communication, sewage, water, and electric systems are vital to a country's economic development (Chappelow, 2019).
Community facilities	Buildings that offer health and emergency services, social and cultural public services, civic services, social services, education services, or parks and recreation services in a country (CSIR, 2012).
Spin-off companies	New small and medium enterprises (SMEs – formally, informally or non-VAT registered businesses or start-up ventures (Small Enterprise Development Agency (SEDA), 2016)) created by a parent company.
Cultural artefacts	Designs and creative works that are non-textual outputs (images, performances, artefacts, and designs). These works result from original, systematic investigation to gain new knowledge and understanding, leading to new or substantially improved insights (Council of Higher Education, 2005:15; Madue, 2011:162).

1.6 RESEARCH DESIGN AND METHODOLOGY

1.6.1 Research design

A research design is a 'how-to' plan for conducting research with the end product and logic of the research (De Vos, Strydom, Fouché & Delport, 2005; Mouton, 2001). This study used the case study research design. The research design is used when a researcher wants to conduct an in-depth examination of the complexities in a bounded system of people and is suitable for poorly understood or limited research knowledge (Clark & Creswell, 2015; Creswell, 2014; Leedy & Ormrod, 2015). According to Clark and Creswell (2015), a system is a programme, an event, or an activity involving people, where the system of interest for a study is the case. Bounded refers to the researcher separating the case in terms of time, place, or some physical boundaries for the research study (Clark & Creswell, 2015).

This study employed a qualitative methodology. Qualitative research allows the researcher to study a problem for a deeper understanding of a new phenomenon, analyse themes, and conduct an inquiry reflexively (Clark & Creswell, 2015; Creswell, 2014). This type of research also allows a researcher to explore individuals' experiences and perspectives on a single concept and analyse words using text analysis procedures to uncover themes found in the data (Clark & Creswell, 2015).

1.6.2 Population, sample, and sampling techniques

1.6.2.1 Population

The population of this study consists of 18 technology stations in South Africa.

1.6.2.2 Sample

The sample consists of one technology station in the Western Cape specialising in CTLF.

1.6.2.3 Sampling techniques

This study used purposive sampling. The purposive sampling technique is where a researcher decides who or what to include in a sample based on sought-after characteristics (Kumar, 2011; Quinlan, Babin, Carr, Griffin, & Zikmund, 2015). The Technology Station in Clothing and Textiles (TSCT) was selected. The station was chosen because the Western Cape is a central location of the CTLF industry in South Africa (CCTC, 2017; DTI, 2015; FP&M-SETA, 2014; Mbatha, 2018; Mbatha, 2020; Mbatha & Mastamet-Mason, 2021) and because the TSCT is currently the only technology station wholly dedicated to the CTLF industry.

1.6.3 Measuring instrument

This study uses a semi-structured in-depth interview. Interviews involve an interviewer (researcher) reading questions to interviewees to record their answers (Kumar, 2011). An interview is needed when the subject matter is complex, and an individual is knowledgeable in their field (Rosenthal, 2016). The semi-structured concept of an interview refers to the researcher following standard questions with one or more individually tailored questions to get clarification of an interviewee's answers (Leedy & Ormrod, 2015). It combines open-ended and closed-ended questions (Hofstee, 2006). This study did not only use semi-structured interviews but used document analysis. Document analysis assists with using multiple sources of information to build the case for this study.

1.6.4 Data collection

According to Rouse (2016), data collection is a systematic approach to gathering information from various sources to get a complete picture of a phenomenon. Data should be collected, and new data added to improve the value of the data collection. The data collected from case studies include observations, interviews, documents, records, and audio-visual materials (Clark & Creswell, 2015; Creswell, 2007). For this study, interviews and document analysis are data collection tools. An interview schedule was used to list the questions, key points, and issues to ask participants (Quinlan *et al*., 2015). The interviews were conducted at an agreed location by the researcher and interviewee. To reference verbatim at a later stage and assist with data analysis, the interviews were recorded. The document analysis collected was from public websites, public documents, and in-house document analysis received from interviewees to build the case for this study.

1.6.5 Data analysis

Data analysis is the logical reasoning behind all research to search for patterns identified in the data (Leedy & Ormrod, 2015). Analysing qualitative data is less prescriptive than quantitative data. It relies on inductive reasoning processes indivisible into discrete, measurable variables (Leedy & Ormrod, 2015). For case studies, data is thematically analysed, which means that analysis uses themes within data (Braun & Clarke, 2006; Clark & Creswell, 2015; Quinlan *et al*., 2015). Data analysis organises and describes the set sets in detail and interprets various aspects of the research topic (Braun & Clarke, 2006). The thematic analysis could also be categorical aggregation when a researcher looks for a collection of instances from data to find issue-relevant meanings (Creswell, 2007). The case study was analysed using ATLAS.ti software. ATLAS.ti is a Windows-based programme that organises research content: text, graphic, audio, and visual data files with coding, memos,

and findings (Creswell, 2007). The ATLAS.ti software eliminates the possibility of human error and allows for accurate case study data analysis.

1.7 QUALITY OF THIS STUDY

Lincoln and Guba (1985) suggest standards to study qualitative research in terms of trustworthiness and move away from the terms, *validity* and *reliability*. There are four alternatives for assessing the trustworthiness of qualitative research that Lincoln and Guba (1985) suggest. These alternatives are credibility, transferability, dependability, and confirmability.

1.7.1 Credibility

Credibility is synonymous with validity in quantitative research. Judgement is by the extent of respondent agreement, whereby the researcher takes the research respondents' findings for confirmation, congruence, validation, and approval (Kumar, 2011; Leedy & Ormrod, 2015). According to Trochim and Donnelly (cited by Kumar, 2011), credibility involves establishing the results of qualitative research as credible or believable in the research from the respondent's perspective. Lincoln and Guba (cited in Creswell, 2007) suggest that techniques such as the triangulation of data sources, methods and researchers assist with achieving credibility. Qualitative research studies explore people's perceptions, experiences, feelings, and beliefs. Subsequently, respondents are supposedly the best judges in determining whether or not the research findings accurately reflect their opinions and feelings (Kumar, 2011). An example would be factual reporting by verbatim transcriptions to aid credibility.

1.7.2 Transferability

Trochim and Donnelly (Kumar, 2011) refer to transferability as the degree to which the results of qualitative research can be generalised or transferred to other contexts or settings. For this to happen, research must transfer between the researcher and the case study. The process adopted for others to follow, and replicate must be thoroughly described (Creswell, 2007). This study's methodology was thoroughly described to ensure this study's transferability by using ATLAS.ti software, thus allowing for efficient transfer of data exportation.

1.7.3 Dependability

Guba and Lincoln (Creswell, 2007) suggest that dependability is very similar to the concept of reliability in quantitative research. It concerns whether researchers would obtain the same results if the same thing were observed twice (Trochim & Donnelly in Kumar, 2011). Dependability in qualitative research is an extensive and detailed record of the process for

others to replicate and ascertain a level of trustworthiness. An example of this would be the use of ATLAS.ti software to analyse data.

1.7.4 Confirmability

Confirmability refers to the degree to which others can confirm or verify the results (Trochim & Donnelly in Kumar, 2011). Confirmability is similar to reliability in quantitative research. It is only possible if researchers follow the process identically for comparable results to establish the value of the data (Creswell, 2007). To achieve confirmability in this study, the researcher documented data and analysis procedures throughout this study to make judgements about potential bias in the limitations of this study.

1.8 ETHICS

Ethics is what is morally and legally right in the process of conducting research (Dantzker, Hunter & Quinn, 2018). Research ethics is concerned with working honestly, with integrity, and ensuring safety from harm to anyone or anything (Quinlan *et al.*, 2015). Ethical clearance was sourced from the University of Pretoria. There are two categories of stakeholders in ethical considerations, namely participant ethics and researcher ethics (Kumar, 2011; Leedy & Ormrod, 2015; Quinlan *et al.,* 2015).

1.8.1 Participant ethics

Participant ethics ensure that researchers apply ethically reflective tactics during the research process and eliminate any compromising factors from the research process (Joe, Raben & Phillips, 2017). Examples of participant ethics include confidentiality, informed consent, and voluntary compliance (Joe *et al.,* 2017; Quinlan *et al.*, 2015:46).

Confidentiality is the guarantee made to participants by researchers that their contribution to the research project will be free from the non-disclosure of specific information (Dantzker, Hunter & Quinn, 2018; Quinlan *et al*., 2015). There is no possibility of re-identifying participants, and participants were made aware of the conditions of this study in the consent form. Informed consent is when research participants are formally made aware of participating in a research project (Leedy & Ormrod, 2015; Quinlan *et al.*, 2015). Voluntary compliance or participation is when participants are made aware of their contribution to the research and compensation for participating (Dantzker *et al*., 2018; Leedy & Ormrod, 2015; Quinlan *et al.*, 2015). These participant ethics were satisfied by using the information leaflet and consent forms given to participating individuals for this study.

1.8.2 Researcher ethics

Researcher ethics are ethical principles that should be followed by the researcher, including integrity, harm, bias, and plagiarism (Quinlan *et al*., 2015). Integrity is when research is conducted by implementing honest practices (Quinlan *et al.*, 2015) that follow the University of Pretoria's (2018) Code of Ethics. Protection from harm ensures that the research participants are injury protected from any harm related to their participation in this study and the effect of the participant's contribution to this study (Joe *et al.*, 2017; Dantzker *et al*., 2018), such as leaked results or misuse of results for non-research purposes. Bias is the lack of objectivity; a researcher supports or unfairly opposes a person or thing by allowing subjective opinions to influence fair judgment (Dantzker *et al*., 2018; Sarniak, 2015). There was no prior expectation of results, which did not influence a particular result for this study. Plagiarism is information extracted without acknowledging the source, and researchers pose the work as their own (University of Pretoria, 2020). For this study, all works of other authors have been cited and referenced according to the UP-EMS Harvard style. Furthermore, a plagiarism report is attached to prove that this study complied with the requirements to avoid plagiarism.

Any information that would personally compromise participants was eliminated from the research. The signing of consent forms ensured it. The researcher upheld their right to refuse to participate or withdraw from the research without any prejudice. The researcher always consulted participants should there be information that might reveal their identity to get their consent or use a name that protects their identity. The researcher followed all steps required by the University of Pretoria and the research fraternity (Department of Consumer and Food Sciences) to ensure scientific professionalism. Before the chapters were sent for final approval by the supervisors, the researcher conducted a plagiarism test to ensure that the research met the professional, scientific requirements. The researcher was competent in conducting assessments, moderating assessments and facilitation, and further drew on previous research experience to ensure the professionalism of the research.

1.9 PRESENTATION AND OUTLINE OF THIS STUDY

This section presents summaries of the current chapter (Chapter 1) and the subsequent chapters (Chapter 2 to Chapter 8) that formed part of this study.

1.9.1 Chapter 1

Chapter 1 of this study introduced the importance of UIG collaborations and the importance of the South African CTLF industry and the Western Cape CTLF industry. The research problem was identified and explained, as well as the justification of this study. Also presented was the

overview of the research aim and objectives, research design and methodology, study quality, and ethical issues. Overall, this chapter presented an overview of this study and provided background knowledge for what this study entails.

1.9.2 Chapter 2

Chapter 2 of this study focuses on the literature observed and written in the form of a review. The literature review concerns the CTLF industry from a global, African, South African, and Western Cape perspective.

1.9.3 Chapter 3

Chapter 3 focuses on the literature review of the Technology Innovation Agency, Technology Stations Programme, and the Technology Station in Clothing and Textiles. It also briefly discusses current studies that employ UIG collaborations.

1.9.4 Chapter 4

Chapter 4 focuses on the theoretical aspects of this study. This study uses the triple helix framework, current discussions in literature, and the conditions of the framework, as well as NSI. There is a comparison made between both innovation systems. Then, this study's outputs are explored, and the conceptual framework is presented based on all the literature discussed.

1.9.5 Chapter 5

Chapter 5 of this study focuses on research design and methodology. The research aims and objectives map out the application of the research design, population, sample, sampling technique, instrument development, data collection methods, operationalisation of this study, data analysis, and quality and ethical issues.

1.9.6 Chapter 6

Chapter 6 of this study deals with the academic results obtained based on the methodology applied in Chapter 5. The results are presented and then briefly interpreted. The results are interpreted based on this study's OBJECTIVE 1: To explore traditional academic outputs from UIG collaborations in the TSCT, focusing on their quality, challenges, and opportunities.

1.9.7 Chapter 7

Chapter 7 of this study deals with the socio-economic results obtained based on the methodology applied in Chapter 5. The results are presented and then briefly interpreted. The results are interpreted based on this study's OBJECTIVE 2: To explore socio-economic outputs from UIG collaborations in the TSCT, focusing on their quality, challenges, and opportunities.

1.9.8 Chapter 8

Chapter 8 of this study is the concluding chapter, where recommendations and conclusions are drawn from this study and presented in this chapter based on the demographics and the two objectives of this study. In the conclusions, the researcher looks back at this study in retrospect, noting the limitations and implications of this study.

1.10 CONCLUSION

This chapter described this study's introduction and outlook of what to expect. This chapter highlighted the importance of innovation systems, explicitly using the TH model to study NSI. The chapter also highlighted the strategic importance of the CTLF industry in South Africa and the Western Cape Province. The research problem justified the research and provided the research aim and objectives. This study also provided an overview of the research design and methodology, the quality, and ethical issues related to this study. The next chapter has a detailed account of the literature reviewed for the stuff for the CTLF industry.

CHAPTER 2: OVERVIEW OF THE GLOBAL AND LOCAL CLOTHING, TEXTILES, LEATHER, AND FOOTWEAR (CTLF) INDUSTRY

"Success isn't about how much money you make, it's about the difference you make in people's lives." ~ Michelle Obama

2.1 INTRODUCTION

The clothing, textiles, leather, and footwear (CTLF) industry has the potential for significant technological innovation and a high degree of uncertainty (Milshina, Pavlova & Vishnevskiy, 2019). Throughout this chapter, these two main factors will play a significant role in defining the state of the industry. The purpose of this chapter is to focus on the current literature available related to the research topic. A review of the global, South African and Western Cape CTLF industry to understand the CTLF industry was done. Understanding the CTLF industry will assist with the focus of this study on the industry. Understanding the industry will also emphasise the strategic importance of the CTLF industry and this study.

2.2 OVERVIEW OF THE GLOBAL CLOTHING, TEXTILES, LEATHER, AND FOOTWEAR (CTLF) INDUSTRY

The World Trade Organization (WTO) presented the Multi-Fibre Arrangement (MFA) in 1974 to enable developing countries to enter international markets and as a way of protection from worldwide competition (Thenga, 2016). The MFA was signed, ratifying countries to impose import quotas on CTLF products and giving countries time to restructure their CTLF industries before opening to highly competitive suppliers such as China (Gereffi & Frederick, 2010). According to Staritz, Plank and Morris (2016), in 1994, the Uruguay Round of the General Agreement on Trade and Tariffs brought the CTLF trade under the newly founded WTO. The agreement aimed to phase out the MFA by the end of 2004. In 2005, buyers could freely source CTLF globally, except for China, due to temporary import restrictions until the end of 2008. Quotas were eliminated, but tariffs currently play a central role in the global CTLF trade. The most favoured national tariffs are 11% on CTLF imports, an average for the European Union and the United States (US), with considerable variations for product categories. The US tariffs can vary up to 32% (WTO 2015).

In 2020, the Coronavirus Disease 2019 (COVID-19) pandemic impacted the global economy and affected more than 200 countries (Segran, 2020; World Health Organization (WHO), 2020). COVID-19 is a disease that causes an upper (sinuses, nose, and throat) and lower (windpipe and lungs) respiratory tract infection (WebMD, 2020; WHO, 2020). The virus originated in China and affected a significant manufacturing hub for many industries, including the CTLF industry (Segran, 2020). China specialises in manufacturing more complicated, high-value CTLF products and has done so for over the last 20 years (Uddin, 2020). The country manufactures over a third of all CTLF manufacturing worldwide. However, its market share in CTLF manufacturing has declined slightly over the past few years (Segran, 2020). The financial distress caused by the global pandemic is worse than the global financial crisis in 2008 and will affect the future of the CTLF industry (Business of Fashion & McKinsey and Company (BoF & McF), 2020; Segran 2020). The pandemic led to many countries being in a state of lockdown. The lockdown was put in effect as a state of emergency to stop the spread of the virus by people staying at home except for essential services workers.

Before the pandemic, 34% of major CTLF global players were predicted to face potential challenges within the industry. Still, after three months of a lockdown period, this percentage was expected to rise to 84% (BoF & McF, 2020). The CTLF industry is urged to,

> "…adapt to the new market environment by evaluating divestment and acquisition opportunities to strengthen their core and capture whitespaces that emerge from the reshuffle" (BoF & McF, 2020:29).

The CTLF industry should be strategic by (BoF & McK, 2020:31):

- Identifying financial leverage, divestitures, and acquisition opportunities;
- Identifying strategic partners;
- Increasing earnings; and
- Creating operational and financial stability early in the recession.

Due to the pandemic, the CTLF industry switched purposes by manufacturing medical gowns and masks for healthcare professionals instead of fashion trend purposes. In many developing countries, workers in the CTLF industry are primarily women and endure poor working conditions for low pay levels (McCarthy, 2019). According to Uddin (2020), there is a shift from global retailers to shift their orders from China to Bangladesh as a CTLF industry alternative for garments. However, there are concerns that Bangladesh will not be able to cope with the sudden shift as many retailers rely heavily on China for importing their raw materials. On the other hand, there will be an increase in new sourcing markets such as Indonesia, Thailand,

and India. Figure 2.1 shows that in terms of wages, shifting away from China will result in cost cuts for many CTLF retailers.

FIGURE 2.1: MONTHLY MINIMUM WAGE FOR CTLF INDUSTRY PRODUCTION (MCCARTHY, 2019; UDODIONG, 2019)

In Africa, Ethiopia has begun to attract foreign direct investment (FDI) because the country has the lowest base wage in any African CTLF-producing country at USD 26 per month (Udodiong, 2019) (see Figure 2.1). The harsh reality is that Ethiopian CTLF workers and many other workers in developing countries cannot support their families with their wages. There is, however, a worldwide concern that new technologies will replace traditional working environments and result in the rise of unemployment and data security issues (Heinemann cited by Milshina, Pavlova & Vishnevskiy, 2019). New technologies will assist many CTLF firms in increasing their manufacturing efficiency by decreasing costs and delivering new customer value (Milshina *et al*., 2019). Nevertheless, this great win for the CTLF industry does not consider the livelihoods of the families impacted by such a change.

The CTLF industry is a priority sector in many sub-Saharan African (SSA) countries for export, employment generation, and industrial development (Staritz, Plank & Morris, 2016). The top ten SSA country exporters for the CTLF industry include Mauritius, Madagascar, Lesotho,

South Africa, Kenya, Swaziland (Eswatini), Ethiopia, Tanzania, Botswana, and Malawi (Staritz *et al*., 2016; United Nations Comtrade, 2015; Vika, 2016). The success of the SSA CTLF exporters is dependent on the following essential agreements (Staritz *et al*., 2016):

- Southern African Customs Union (SACU);
- Southern African Development Cooperation (SADC);
- Common Market for Eastern and Southern Africa (COMESA); and
- East African Community (EAC).

The SACU consists of Botswana, Lesotho, Namibia, South Africa, and Swaziland (Eswatini) and has the primary goal of promoting economic development through regional trade co-ordination (SACU, 2013). The SADC comprises 16 Southern African countries and acts as a Regional Indicative Strategic Development Plan reinforced by guiding principles that seek a shared future for the Southern African region (SADC, 2012). The COMESA is an organisation of 21 independent sovereign countries that have agreed to cooperate in developing their natural and human resources for the good of all their people. As such, it has a wide-ranging series of objectives that necessarily include in its priorities the promotion of peace and security in the region (COMESA). The EAC is a regional intergovernmental organisation of six partner countries: Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda. EAC is the most advanced integration of progress related to all the agreements (EAC, 2020).

Since 2008, there has been a tripartite initiative between COMESA, EAC and SADC to streamline the efforts of various integration projects (Staritz *et al*., 2016). Then in 2012, the African Union (AU) established a Continental Free Trade Area (CFTA) to include 54 African countries by 2017 to complement the tripartite initiative (Staritz *et al*., 2016). The objectives of the CFTA are to create a single African market, expand intra-African trade, resolve challenges of duplicated efforts or memberships, and enhance industry and business competitiveness (African Union Commission, 2022). The future will tell whether the efforts of the CFTA are beneficial. The CFTA and Boosting Intra-Africa Trade (BIAT) Action Plan form part of the comprehensive framework by the AU to pursue a developmental regionalism strategy (African Union Commission, 2022). The former (CFTA) is time bound, whereas BIAT is continuous with concrete targets to double intra-African trade flows from January 2012 and January 2022 (African Union Commission, 2022). However, the efforts of the Africa Growth and Opportunity Act cannot be ignored.

Since 2001, the Africa Growth and Opportunity Act (AGOA) allowed CTLF producers duty and quota-free access to the US market until 2015 for certain CTLF products (Morris & Barnes, 2014). The AGOA led to the CTLF industry signing numerous export orders to US retailers

while seeking massive profits instead of supplying the domestic market (Morris & Einhorn, 2008; Morris & Levy, 2014). According to Naumann (2015), the AGOA was extended for ten years, from September 2015 to September 2025. Between 2000 and 2004, South Africa was a leading CTLF exporter under AGOA. In 2014, the CTLF industry was the second largest beneficiary under AGOA, with the top exporting countries being Kenya, Lesotho, Mauritius, Swaziland (Eswatini), and Tanzania. However, South Africa was 8th for total CTLF exports in 2014 because of regulations restrictions not allowing the country to source fabrics from third-world countries (Naumann, 2015). The rules of origin for South Africa stated that they were compelled to utilise local or regional fabrics made from African or US yarns because the country is the most industrialised compared to other AGOA beneficiaries (Naumann, 2015).

Local CTLF manufacturers could not supply export and domestic markets, and South African retailers introduced large-scale imports from China as an alternative due to the appreciating exchange rate and higher buying power (Mbatha, 2018; Morris & Barnes, 2014; Van Zyl & Matswalela, 2016). The most prominent criticism of the AGOA is that AGOA has provided the US with preferential access to valuable commodities and has benefited the US more than beneficiary countries (Naumann, 2015).

Edwards and Jenkins (2015), Mbatha (2018), and Morris and Einhorn (2008) argue that the effects of trade growth with China have been adverse for manufacturing in South Africa, with several industries, most notably the CTLF industry, demanding increased protection from Chinese imports. What is interesting in Figure 2.1 is that China has the second-highest low wage per month (USD 326). At the same time, South Africa's wage is 6th (USD 244), which means that labour in South Africa is cheaper than in China. However, many manufacturers are still choosing to import CTLF from China. Many manufacturers choose to import from China because China has a well-established manufacturing sector for a developing economy, and compared to developed economies, it is relatively affordable (Edwards & Jenkins, 2015).

To understand the South African CTLF industry climate, the next section explores the South African CTLF industry.

2.3 OVERVIEW OF THE SOUTH AFRICAN CLOTHING, TEXTILES, LEATHER, AND FOOTWEAR (CTLF) INDUSTRY

South Africa has a population of 58,78 million (Statistics South Africa (Stats SA), 2019c) and a gross domestic product (GDP) of 0,8% (Stats SA, 2019b). South Africa is classified as a developing nation because of its unstable governments (local, provincial, and national) and high rates of population growth, illiteracy, and disease (Department of Presidency, 2012). The

GDP in Figure 2.2 of South Africa shows the economy's instability because, from 2011 to 2018, there was a general downward slope.

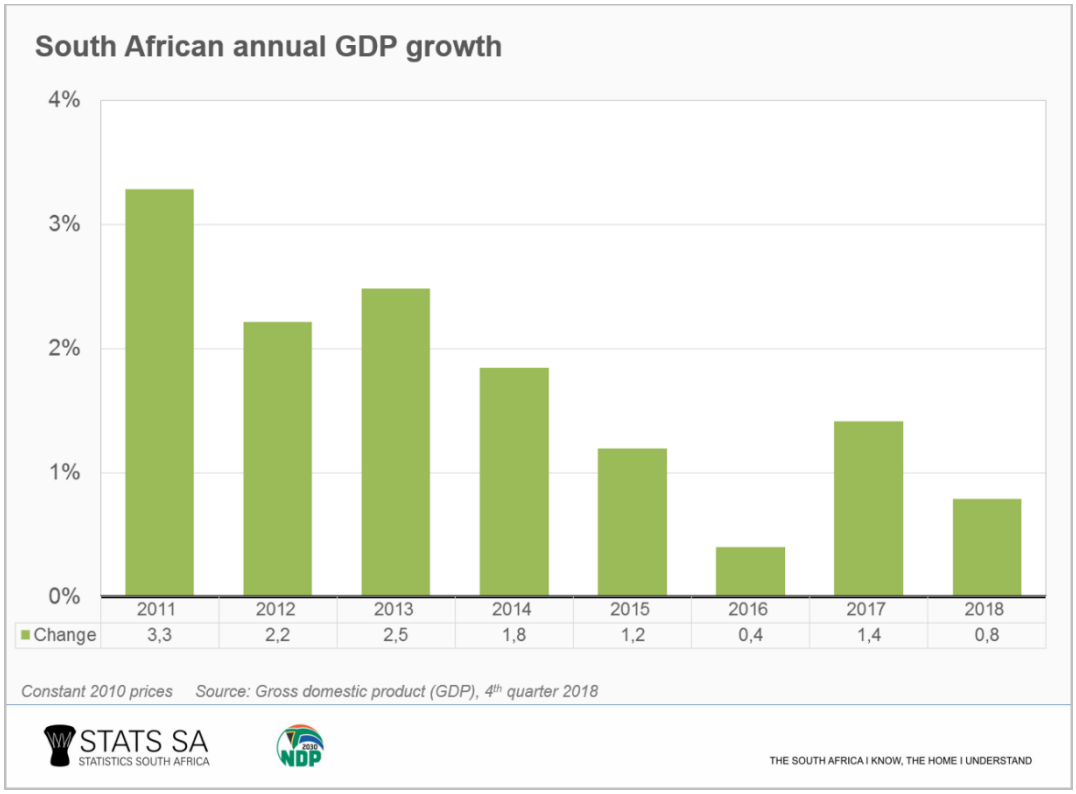


FIGURE 2.2: SOUTH AFRICAN ANNUAL GDP GROWTH (STATS SA, 2019B)

The CTLF industry is segmented into various value chain subsector groups. The competition and manufacturing activities of the CTLF industry value chain are essential strategies for a country's suppliers to upgrade, sustain, and improve their positions in the clothing value chain (Morris & Barnes, 2014). The value chain materials production is known as the Textiles Industry and includes dyeing and finishing, weaving, knitting, and spinning (Barnes & Hartogh, 2018).

The manufacturing sector (the CTLF industry is part of) is the 4th largest sector and contributes 14% to GDP (Stats SA, 2019b). The volatility of the manufacturing sector is seen through the difference between its 2018 Quarter 4 GDP versus 2019 Quarter 1 GDP. The difference in the quarters shows how unstable the manufacturing sector can be, in a few months going from a positive (4.5%) GDP contribution in 2018 to a negative (-8.8%) GDP contribution in 2019 (Stats SA, 2019b; 2020a). Suppose negative contribution becomes a trend in the economy. In that case, it could be a consequence for policymakers making future decisions regarding impacts on the manufacturing industry (Centre for Science, Technology, and Innovation Indicators (CeSTII), 2019). In 2018, the CTLF industry's manufacturing

negatively affected the economy (-2.4%) (Stats SA, 2019a). The negative contribution means that CTLF industry companies still choose to outsource manufacturing capabilities. There are about 20 countries that contributed to 96.5% of CTLF imports, which amounted to ZAR 16.12 billion in April 2019 (South African Market Insights, 2019). The top ten countries include China, Swaziland (Eswatini), Lesotho, Vietnam, India, Mauritius, Bangladesh, Madagascar, Italy, and Indonesia (South African Market Insights, 2019). China alone contributed 57.75% of total imports for the CTLF industry (South African Market Insights, 2019). The South African government cannot protect local manufacturers, as China is South Africa's most significant trading partner. Levying tariffs on imported CTLF goods against China could see tariff increases against South African goods exported to China (South African Market Insights, 2019).

In 2009, the Department of Trade and Industry (DTI) developed programmes to address CTLF industry challenges and support employment stabilisation and growth (DTI, 2014, 2016, 2017, 2018). In 2019, the DTI was restructured and became the Department of Trade, Industry and Competition (DTIC) through the incorporation of the Department of Economic Development (EDD) into the DTI. The restructure came with a new mission for the DTI (National Government of South Africa, 2020):

- “Promote structural transformation towards a dynamic industrial and globally competitive economy;
- Provide a predictable, competitive, equitable, and socially responsible environment conducive to investment, trade, and enterprise development;
- Broaden participation in the economy to strengthen economic development; and
- Improve the skills and capabilities continually of the DTIC to effectively deliver on its mandate and respond to the needs of South Africa's economic citizens”.

For this study, the DTIC will still be referred to as the DTI. The restructuring of the DTI is in line with the findings found by Mbatha, Mastamet-Mason, and Seda (2019), Mbatha (2020), and Mbatha and Mastamet-Mason (2021) in that government plays a dominant role in the CTLF industry. The future of the CTLF industry will tell whether the challenges Mbatha *et al.* (2019) found, such as lack of transformation and black economic policy, will be corrected with the new restructure and mission.

In the National Budget Speech 2019, ZAR 600 million was allocated to the programmes (Mboweni, 2019). The programmes are the Clothing and Textile Competitiveness Programme (CTCP), which is then subdivided into the Production Incentive Programme (PIP) and Competitiveness Improvement Programme (CIP) (Barnes & Hartogh, 2018; DTI, 2014; 2016;

Mbatha, 2018; 2020; Mbatha & Mastamet-Mason, 2021). According to Barnes and Hartogh (2018), the CTCP assists in funding CTFL manufacturers to stabilise employment and improve overall competitiveness to drive sustainability. The PIP is a market-neutral incentive that supports industrial upgrading by moving manufacturers up the value chain through upgrading and competitiveness improvement projects via an upgrade grant facility. The CIP is a cluster-based grant incentive initiative that improves selected CTFL firms' competitiveness to create a sustainable manufacturing industry and grow employment in South Africa to enable manufacturers to compete internationally.

The government also designated the CTLF industry at 100% local content (the brand known as Proudly SA) under the revised Preferential Public Procurement Framework (PPPFA) Act in 2012 (DTI, 2017). The PPPFA Act was implemented to support local manufacturers in building competitiveness and capacity by securing market access to public entity consumption (DTI, 2017). However, even with the CTLF industry contributing ZAR 74 billion in GDP in 2016 (Barnes & Hartogh, 2018), support from the government has not been sufficient. The CTLF industry continues to have research and development (R&D) funding challenges due to failing to meet the competitive advantage/s other countries possess (Barnes, 2018; Mbatha & Mastamet-Mason, 2015; Morris & Barnes, 2014).

In 1994, there was a shift from import substituting industrialisation (ISI), where the government initiated a radical garment phase-down which saw a considerable reduction of import quotas and a movement toward a more uniform tariff structure and reduced nominal tariffs (Morris & Barnes, 2014). Since the introduction of China into the World Trade Organization (WTO) in 2001 (Edwards & Jenkins, 2015; Martin, United Nations Educational, Scientific and Cultural Organization (UNESCO) & International Institute for Educational Planning (IIEP), 2011), Chinese competition has directly impacted South African production output and employment. Figure 2.5 shows that particularly in the CTLF industry (Department of Presidency, 2012; Edwards & Jenkins, 2015) due to a shift of manufacturing responsibilities to China and other neighbouring economies (Department of Trade and Industry, 2017b; Thenga 2016). Whereas China's WTO accession has benefited its CTLF industries (Xue & Zhou (in Martin et al., 2011)), and as such, they need corrective action through university-industry-government (UIG) collaborations. South Africa could implement the following corrective measures:

- Aligning innovative ideas through R&D;
- Upgrading skills;
- Revitalising the industry through financial resources, technology, and policy; and
- Bringing about economic growth through unemployment reduction and competitiveness improvement.

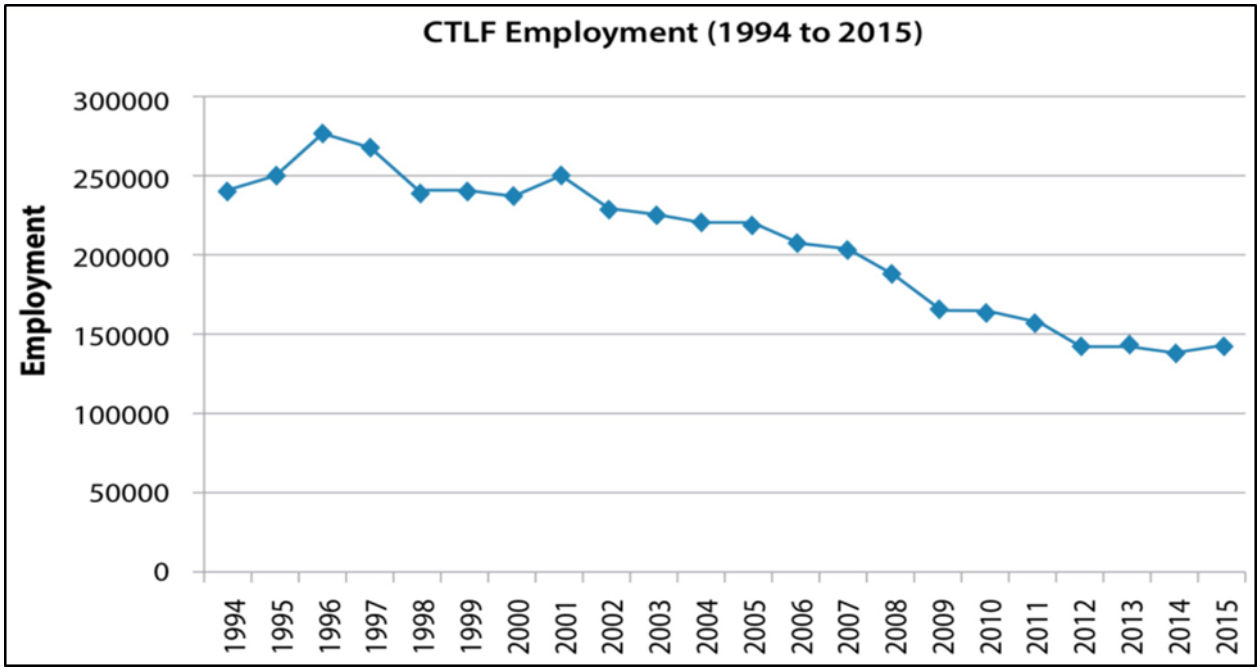


FIGURE 2.3: CTLF EMPLOYMENT FROM 1994 TO 2015 (DTI, 2017:91)

Figure 2.3 shows how the CTLF industry employment has decreased over the years. These figures align with Statistics South Africa's (2020b) findings, where the CTLF industry only operates at 71.3%. There is a 28.7% under-utilisation of the industry, with the biggest under-utilisation stemming from insufficient demand at 22.9%. When there is insufficient demand for the CTLF, jobs will not be created or needed to supply the CTLF industry. In terms of under-utilisation employment factors, there was a shortage of 0.9% of skilled employees and 0.3% of semi-skilled and unskilled employees. In 2015, employees in the CTLF industry were 148 747, but in 2016 there were 140 552 (DTI, 2018), meaning there was a 5.51% decrease in employment. Much intervention is needed to correct these happenings of the CTLF industry, and COVID-19 also came into play in 2020. The CTLF industry needs radical change to recover.

Van Zyl and Matswalela (2016) conducted a comparative competitor benchmark analysis of the level of competitiveness of the CTLF industry from export data from 1990 to 2013. The conclusions drawn from the study are that there is a large and widening gap between the levels of competitiveness of the South African CTLF and Asian CTLF industries. It is due to increase unit labour costs and declining export shares that are significant determinants of the increasing weak competitiveness of the South African CTLF industry. Solutions offered by the study were proper policy responses from the government, retail industries, labour unions, and other stakeholders within the economy. The dual objectives suggested for South Africa in the CTFL sector that will boost the competitiveness of products and sustainable industry growth include (CCTC, 2017):

- Deepening of lean production practices to maximise efficiency; and
- Quick response supply chain model to create a competitive advantage over international competition around flexibility and speed-to-market.

In 2020, B&M Analysts (2020) reported on the impact of COVID-19 on the CTLF industry. The B&M Analysts engaged with 94 CTLF firms and 40 CTLF manufacturing firms. The analysts predicted that on an annual basis, the CTLF industry sales would decrease from 10% to 24%. The decrease in sales affects manufacturing and employment in the CTLF industry. The B&M Analysts found that 29% of manufacturers cancelled investments in 2020, 33% of firms pursued retrenchments, and 15% of formal job losses were experienced. Now, more than ever, the CTLF industry should shift radically. With grave threats come growth opportunities as well. Of the firms, 89% reported increased localisation opportunities, and 85% of manufacturers have a decreased faith in the reliability of international suppliers. This suggests that South Africa has an opportunity to grow the CTLF industry.

The B&M analysts (2020) report acknowledges CTLF clusters, national departments and entities and city municipalities for contributing to the report. However, the report failed to mention any academic institution or science council, which means the B&M analysts consult with industry and government to contribute to the structural problems of the CTLF industry. The omission by the report does not allow all members of the UIG collaboration to be explored. The report did, however, acknowledge the parties contributing to the Western Cape CTLF industry, which is drawn from as the Western Cape CTLF industry is a focus of the current study. This study seeks to find ways in which academic and socio-economic outputs could exist in the CTLF industry to better job opportunities or employment.

The sections mentioned above highlight the importance of the CTLF industry in South Africa, and the next section will look at the CTLF industry from the Western Cape Province perspective.

2.4 OVERVIEW OF THE WESTERN CAPE CLOTHING, TEXTILES, LEATHER, AND FOOTWEAR (CTLF) INDUSTRY

The Western Cape is one of nine provinces in South Africa. It is the third-largest province in South Africa, with a population of about 6.76 million (11.5% of South Africa's total population) (Krige, 2019). In 2017, the Western Cape contributed 14% to the national GDP (see Figure 2.4) and was the third-largest contributor compared to the other provinces (Stats SA, 2019c).

The sectors driving the Western Cape's industry are finance, trade, manufacturing, government, and other sectors (Stats SA, 2019c). Figure 2.4 shows that Western Cape

Manufacturing is the fourth biggest sector out of the five sectors shown for the province. In terms of research and development (R&D) for the province, Western Cape was the second-highest province that had an R&D expenditure of ZAR 8.33 million in 2016/2017 (Centre for Science, Technology, and Innovation Indicators (CeSTII), 2019).

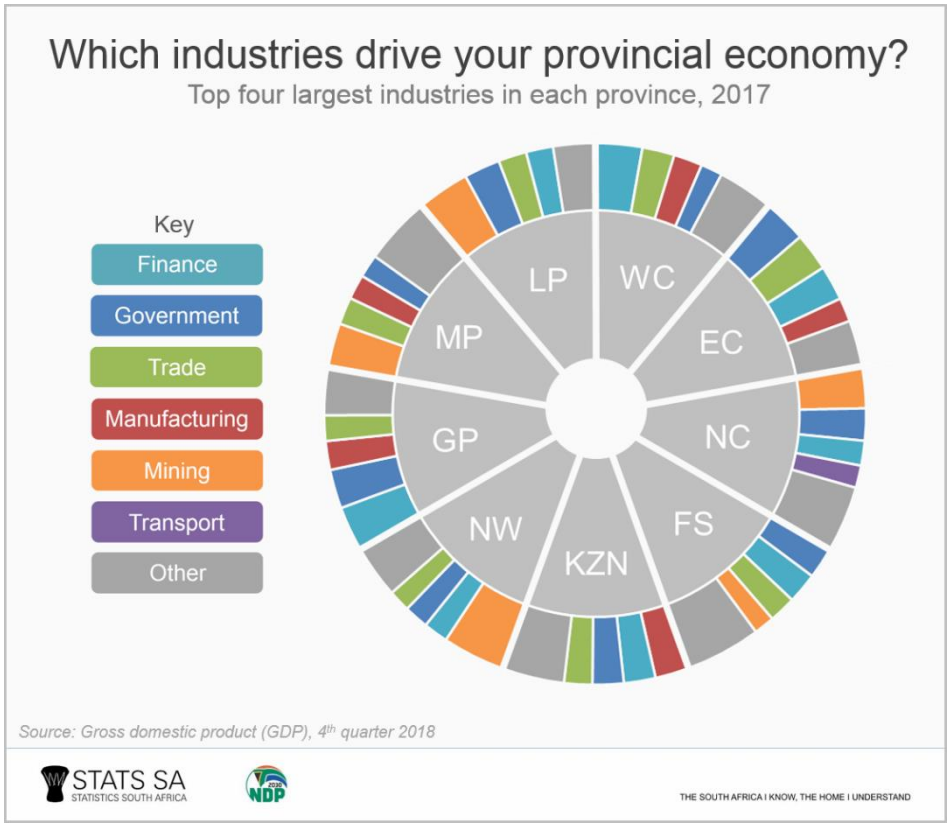


FIGURE 2.4: INDUSTRY DRIVERS AS PER PROVINCE 2017 (STATS SA, 2019C)

The Western Cape CTLF industry has a diverse assortment of firms at every stage in the value chain (CCTC, 2017). Most South African significant retailers are in the Western Cape and represent local manufacturers with a comparative advantage in terms of speed, flexibility, and customer relationship when looking at the rest of South Africa (CCTC, 2017; Cape Town and Western Cape Tourism, Trade and Investment (Wesgro), 2021). The advantages are essential to the global context of the industry trend towards a quick response (QR) supply chain model. The QR model is a management strategy that relies on the process, systems, organisation, and culture to improve enterprise commitment, cooperation, and long-term vision to create a fully integrated supply chain (Hadjiconstantinou, 1998). However, compared to KwaZulu-Natal, the Western Cape does not offer as much capacity or capability in fabric production and finishing (CCTC, 2017), which are crucial areas for the province's development (CCTC, 2017).

The Western Cape Government, specifically the Department of Economic Development and Tourism, is serious about university-industry-government (UIG) collaborations and hosts an annual Sector Connect Event. (However, no empirical evidence was found on this specific event beyond 2014.) This event celebrates the successes and future endeavours of the Sector Development Programme by bringing together businesses, government, embassies, and academia to form collaborations across industries in the Western Cape (Western Cape Government, 2014). The various industries include manufacturing, resource-based, services, and green economy, with the programme purpose of strengthening the regional economy and improving the growth of priority industries (Western Cape Government, 2014). The Sector Development Programme is a leading programme in South Africa and has been recognised globally for the practical application of economic development tools (Western Cape Government, 2014). These tools include the cluster methodology, establishment, facilitation, and ongoing oversight over the vital sector bodies (Western Cape Government, 2014).

The effectiveness of the programme is dependent on the development of long-term collaborations. It is across industry, government, and academia, with a base of over 5000 firms. The programme led to significant trade and investment deals, firm upgrades, innovative sectoral skills development, and project spinouts (Western Cape Government, 2014). The institutions or special purpose vehicles (SPVs) involved in the Western Cape CTLF industry and funded by the provincial government include the Cape Clothing and Textile Cluster (CCTC), Cape Town Fashion Council (CTFC), Western Cape Clothing and Textiles Service Centre (CLOTEX) and Cape Craft and Design Institute (CCDI/CDI) (Department of Economic Development and Tourism, 2018; Vos, 2019; Mboweni, 2019; Western Cape Government, 2014; 2022).

The Western Cape's CTLF industry has historically been one of the hubs of the Western Cape's manufacturing sector (CCTC, 2017). The CTLF industry became fully established in 1925 and continued to grow until 1939 (Nicol, 1984). After 1939, the industry expanded rapidly, and it emerged as a leading employer of labour in the Western Cape and a manufacturing hub in South Africa (Nicol, 1984). Today, the industry continues to be vital to socio-economic development in Western Cape (CCTC, 2017; Wesgro, 2021). For the financial year 2019/2020, the Department of Economic Development and Tourism in the Western Cape focused on developing the manufacturing sector to stimulate the economy and job creation (Western Cape Government, 2019; 2022). The Department allocated ZAR 132 million in stimulus funding to support manufacturing for three years (2019/2020, 2020/2021 and 2021/2022) (Western Cape Government, 2019; 2022).

The Cape Clothing and Textile Cluster (CCTC) consists of over 40 member firms and has secured ZAR 27 million from the Industrial Development Corporation (IDC) to run the Continuous Improvement Programme (CIP) over the next three years (Department of Economic Development and Tourism (DEDAT), 2018). The firms have projected benefits from the CIP through research, benchmarking, exports, and shared learning (Department of Economic Development and Tourism, 2018). The CCTC implemented the following interventions with member firms (CCTC, 2017; DEDAT, 2018):

- World Class Manufacturing Programme;
- Best practice study tours;
- Total quality management (TQM) and just-in-time (JIT) workshops;
- Quick response (QR) Programme;
- Development of the second edition QR handbook; and
- Export promotion.

Interventions such as best practice research, shared learnings, lean manufacturing principles, and a government-supported programme have assisted in the consistent employment and sales growth of CCTC members since 2014 (CCTC, 2017). Over the last four years, there has been a 34% sales growth above inflation and a 35% growth in employment for CCTC member firms (Vos, 2019).

The Cape Town Fashion Council (CTFC) was founded as an industry association in 2006 for the Western Cape fashion industry's representation, development, support, and growth (iFashion, 2015; CTFC, 2019a). The council is an industry body representing designers and other industry specialists in growing the CTLF industry of the country with the vision of being nationally and internationally recognised (Ngubane, 2014). Cape Town is the fashion capital of Western Cape, South Africa and has been ranked 39th as a global fashion capital for three years in a row (Global Language Monitor, 2018; Ngubane, 2014). This ranking could reiterate why the CTFC refers to itself as 'Pioneering the South African Fashion Philosophy' because of its uniqueness and excellent contribution to the CTLF industry (CTFC, 2019a). These are the services offered by the CTFC (A Fashion Friend, 2015):

- Skills development;
- Business support and marketing intelligence;
- Promotion; and
- Representation of fashion brands.

All the services contribute to the function of the CTFC when representing the diverse views of the fashion design industry, marketing at an international capacity, and ensuring that crucial

interventions grow and promote this vibrant industry (CTFC, 2019b). Evidence is in the CTFC board, which comprises four fashion designers and eight industry players within the clothing and textiles value chain (CTFC, 2019b).

The Western Cape Clothing and Textile Service Centre (CLOTEX) was established over 20 years ago. Its role is to support and enhance the competitiveness of local SMMEs in the CTLF value chain (Bizcommunity, 2019). The CLOTEX contributes to long-term economic growth and employment by aligning the value chain and training and development programmes with accreditation (Bizcommunity, 2019). CLOTEX offers the following services (African Textiles, 2018):

- Access to information, advice, and counselling;
- Mentoring and coaching SMMEs;
- Accredited skills development;
- Incubator development and support;
- Referrals to partners and Business collaborations;
- Enterprise development;
- Social development;
- Support in turnaround strategies;
- Business services and support in all industry; and
- Specific issues:

The CLOTEX received ZAR 4.053 million and assisted SMMEs with proactive interventions such as the Value Chain Alignment Programme, local economic development, industry market development, incentive schemes, and investment opportunities (DEDAT, 2018).

The Cape Craft Design Institute (CCDI) started in 2001 as a non-profit craft and design sector development agency with a mission to develop capable people and build responsible, creative enterprises trading within local and international markets (Craft Design Institute (CDI), 2019). The CCDI focused on developing and promoting the Western Cape craft and design sector because it was a priority creative sector by the provincial and national government of its potential to build the small business sector and create jobs (CDI, 2019). The organisation re-branded and moved from a provincial organisation to a national one and is now referred to as the Craft Design Institute (CDI) and does not necessarily fall under the CTLF industry but is a craft manufacturer organisation (DEDAT, 2018). CDI views craft and design as “synergistic, mutually inclusive, and part of a broader creative sector” (CDI, 2019:1). The core programmes offered are (CDI, 2019):

- Product support;

- Business support; and
- Market support.

The CDI offers support and aims to achieve (CDI, 2019):

- Design-ready businesses;
- Business-ready design practitioners;
- Design in the public sector; and
- Involved citizens.

The CDI has more than 4 000 creative enterprises on its database and is the official implementing agency for the sector in the Western Cape (CDI, 2019). CDI is also identified as a model craft and design hub by the national DTI, serving as a role model for creative industry development in other provinces of South Africa (CDI, 2019).

Another notable mention of a role player in the Western Cape CTLF industry is the Western Cape Industrial Symbiosis Programme (WISP). Industrial symbiosis is when

> "…residual or under-utilised resources (waste, energy, water, logistics, expertise etc.) from one business can be used by another business as a resource, creating economic, social and environmental benefits for companies involved" (GreenCape, 2019:4).

This programme is vital because the CTLF industry produces 20% of global wastewater and 10% of global carbon emissions, while textile dyeing is the second-largest polluter of water globally (United Nations Environment Programme (UNEP), 2018). The United Nations stated that if the CTLF industry continues on this path, the industry will use up a quarter of the world's carbon budget by 2050 (UNEP, 2018).

The WISP started in 2013, was administered through the Department of Economic Development and Tourism (DEDAT) and funded by the Western Cape Government's GreenCape green economy initiative (GreenCape, 2019; Lyons, O'Carroll, Bonstein, Kasese & Basson, 2016). The WISP predominantly focuses on the manufacturing sectors of the Western Cape. The CTLF industry is prioritised because it significantly contributes to the economy and the risks related to imports and inputs (GreenCape, 2019; Lyons *et al.*, 2016). The plan to improve the CTLF industry's financial sustainability and competitiveness was to implement resource efficiency without affecting profit (GreenCape, 2019).

Below is a summary of WISP support to CTLF firms from 2013 to 2018 through improving water resilience and resource efficiency (GreenCape, 2019:6):

- Firms assisted – 41;

- Firms completed WISP synergies (resource exchanges) – 30;
- Water diverted from landfill – 1 200 tonnes per year; and
- Private investment into recycling textiles – ZAR 6.5 million.

During the drought season in the Western Cape from 2017 to 2018, WISP was able to over-firm support and safeguarded 3 600 jobs, and firms had an average reduction of 35% in water consumption (GreenCape, 2019).

In 2021, the Cape Town and Western Cape Tourism, Trade and Investment (Wesgro) agency reported on Western Cape trade as a province during the COVID-19 pandemic (Wesgro, 2021). Western Cape saw a 7.4% increase in its exports, totalling ZAR 136.8 billion of goods exported. However, when exploring the top 15 export products, none of the products includes the CTLF industry (Wesgro, 2021). Then when exploring the top 14 imports, there are about four ranks (7, 8, 11, and 13 – see Figure 2.5) that included finished products of the CTLF industry and accounted for ZAR 5.28 billion (Wesgro, 2021). The Wesgro highlights the CTLF industry as a priority sector for Cape Town and the Western Cape. Through their offerings and partnerships, they seek to better the Western Cape economy to have a South African, African, and global impact (Wesgro, 2021).

Top 14 Import Products (HS6) by the Western Cape, 2020				
Rank	Product (HS6)	Value 2020 (Zarbn)	% Ave Growth, 2016- 2020	% Share 2020
1	Petroleum oils and oils obtained from bituminous minerals, crude	36.52	1.71%	18.64%
2	Light oils and preparations	33.42	1.49%	17.06%
3	Electric generating sets and rotary converters: Wind-powered	4.06	77620.42%	2.07%
4	Semi-milled or wholly milled rice, whether or not polished or glazed	1.96	32.95%	1.00%
5	Medicaments: Other	1.89	7.28%	0.96%
6	Wheat and Meslin: Other	1.73	8.56%	0.88%
7	Men's or boys' suits, ensembles, jackets, blazers, trousers, bib and brace overalls, breeches and shorts: of cotton	1.67	10.00%	0.85%
8	Other made up articles, including dress patterns: Other	1.36	277.16%	0.69%
9	Telephones for cellular networks or for other wireless networks	1.32	506.40%	0.68%
10	Parts suitable for use solely or principally with the apparatus of electrical machinery and equipment: Other	1.29	651.20%	0.66%
11	T-shirts, singlets and other vests, knitted or crocheted: Of cotton	1.17	6.50%	0.60%
12	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes (LED)	1.15	66.98%	0.59%
13	Other footwear with outer soles and uppers of rubber or plastics: Other	1.08	-4.63%	0.55%
14	Sardines, sardinella and brisling or sprats	0.95	4.17%	0.48%
TOTAL IMPORTS WC, 2020		**195.89**	**0.90%**	**100.00%**

Source: Quantec, 2021

FIGURE 2.5: TOP 14 IMPORTS FOR WESTERN CAPE IN 2020 (WESGRO, 2021)

This section shows that the Western Cape Government values the CTLF industry and knows it is a manufacturing driver in the province. This section highlights the strategic importance of the province. Moreover, it also emphasises why this study focuses on researching the Western Cape Province.

2.5 CONCLUSIONS

This chapter presents the South African CTLF industry and the various programmes supporting industry competitiveness. Various CTLF industry clusters were explored to understand better the support currently available from the government and industry. The various research institutions and departments assist with economic science and technology competitiveness in the CTLF industry. The next chapter will undertake another literature

review based on the Technology Innovation Agency (TIA) and university-industry-government (UIG) collaborations. This literature review will detail how the CTLF industry fits into TIA and UIG collaborations.

CHAPTER 3: LITERATURE REVIEW OF SOUTH AFRICAN KEY INSTITUTIONS AND COLLABORATIONS

"Be on guard. Stand firm in the faith. Be courageous. Be strong. And do everything with love." ~ 1 Corinthians 16:13-14

3.1 INTRODUCTION

The purpose of this chapter is to review the current public documentation available from the Technology Innovation Agency (TIA), the Technology Stations Programme (TSP), and the Technology Station in Clothing and Textiles (TSCT). The chapter will assist with understanding the research outputs and what exists. Then, finally, an overview of available South African university-industry-government (UIG) research and development (R&D) collaborations was reviewed. For this study, research and development (R&D) is defined as

> "…creative and systematic work undertaken to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge" (DST, 2019: viii).

3.2 STRATEGIC OVERVIEW OF THE TECHNOLOGY INNOVATION AGENCY (TIA)

Various national institutions and departments in South Africa are associated with the CTLF industry. This list is not exhaustive and includes departments such as:

- Department of Arts and Culture (now Department of Sports, Arts and Culture (DSAC));
- Department of Higher Education and Training (DHET);
- Department of Science and Technology (DST) (now Department of Science and Innovation (DSI));
- Department of Trade and Industry (DTI) (now Department of Trade, Industry and Competition (DTIC)); and
- Economic Development Department (EDD) (was incorporated into DTIC).

The CTLF-related industries also include institutions (not an exhaustive list) such as:

- Council for Scientific and Industrial Research (CSIR);
- Fibre Processing and Manufacturing Sector Education and Training (FP&M SETA);
- Industrial Development Corporation (IDC);

- National Intellectual Property Management Office (NIPMO);
- National Research Framework (NRF);
- South African Footwear and Leather Export Council (SAFLEC);
- Small Enterprise Development Agency (SEDA);
- Technology Innovation Agency (TIA);
- Textile Industry Export Council (SATIEC);
- National Regulator for Compulsory Specifications (NRCS); and
- South African Bureau of Standards (SABS).

These departments and institutions explore opportunities to improve South Africa's economic competitiveness through science and technology (DTI, 2010; 2011; 2013; 2016; 2017; 2018), and are associated with the CTLF industry. Investing in science, technology, and innovation (STI) can grow the economy in the following ways (DTI, 2018:99):

- Creating new firms and increasing the competitiveness of existing firms;
- Increasing exports and reducing imports; and.
- Lowering entry barriers to create opportunities for emerging black and female entrepreneurs.

The TIA strategic overview will be based on the agency's legislative and policy mandates, strategic focus, and performance measurement.

3.2.1 Legislative and policy mandates

The South African Department of Science and Technology (DST), which is now called the Department of Science and Innovation (DSI), is the executive authority and the financial support provider through the TIA (DTI, 2018). The TIA was formed by merging DST entities tasked with enabling and supporting technological innovation in all sectors of the economy to deliver socio-economic benefits and to enhance global competitiveness in South Africa (DTI, 2018). The DSI has 11 legislative mandates for all reporting entities, and the Technology Innovation Act of 2008 (Act No. 26 of 2008) is one of them (DST, 2018a; 2018b). This Act empowers the TIA "to promote the development and exploitation of discoveries, inventions, innovations, and improvements in the public interest" (DST, 2017:27; 2018b:27). Although TIA was founded in 2008, it only became operational in 2009/2010 (DST, 2010). The TIA's objective as an agency is,

> "to support the state in stimulating and intensifying technological innovation to improve economic growth and quality of life for all South Africans by developing and exploiting technological innovations" (TIA, 2020b:5).

The TIA wants to achieve its objective in South Africa, Africa, and the world, so they hope to achieve ten policy mandates over 40 years (2019 to 2063). Below are the policy mandates of the TIA (TIA, 2020b:5-7):

- United Nations Sustainable Development Goals (UN SDGs) 2030;
- African Union (AU) Agenda 2063;
- National Development Plan (NDP) 2030;
- 2019-2024 Medium-Term Strategic Framework;
- National Spatial Development Framework 2050;
- White Paper on Science, Technology, and Innovation (STI);
- Department of Science and Innovation (DSI) Decadal Plan;
- Alignment with DSI research and development (R&D) roadmaps;
- Bio-economy Strategy; and
- District Coordination Service Delivery Model.

Achieving the set goals, targets, or plans from the set policy mandates will assist TIA in being a trailblazing organisation in South Africa, Africa, and the world.

3.2.2 Strategic focus of the TIA

The strategic focus of the TIA has to do with what TIA stands for as an organisation. The TIA is assigned

> "…to provide customer-centric technology development funding and support, to provide an enabling environment for technology innovation in collaboration with other role players, and to develop an effective and efficient internal environment for the execution of the strategy" (DST, 2018a:40).

The TIA does this by supporting the development and commercialisation of research outputs from higher education institutions (HEIs), science councils (SCs), public entities, and private research institutions (DTI, 2018a). To carry out its directives, TIA requires formalised collaborations with universities, public research institutions, and other government instruments (e.g., DTI and competition) (TIA, 2020b). The TIA provides financial support, non-financial support, and funding instruments (TIA, 2020a). For financial support, the TIA (TIA, 2020a):

- Sources investments and provides funding for technologically innovative opportunities;
- Drives commercialisation and exploitation of technology innovative opportunities;
- Promotes the national and local technology innovation agenda through thought leadership initiatives; and

- Participates, co-ordinates, and contributes to building the national system of innovation (NSI), as well as seeks alignment with key stakeholders.

The TIA focuses on technology development, from proof of concept to pre-commercialisation (TIA, 2020a). To achieve this, the TIA established the following funding instruments: seed fund, technology development fund, and pre-commercialisation support fund (TIA, 2020a). Then the TIA implemented the pre-investment process to support potential applicants with funding application writing to minimise non-value-added administration (TIA, 2020a) through events such as roadshows, training sessions, mentoring programmes and opportunity pitching sessions (TIA, 2020a).

The Youth Technology Innovation Programme (YTIP) and the Global Cleantech Innovation Programme (GCIP) offer non-financial support. The YTIP is designed to assist young innovators in accessing risk funding, mentorship, and business skills support (TIA, 2020a). In contrast, the GCIP is a global initiative to promote clean technology innovation and support entrepreneurs in growing their start-ups into viable, investment-ready businesses (TIA, 2020a).

The two programmes mentioned above may offer non-financial support. However, it does not mean there are no financial means available. There are also other programmes from TIA. The following are all the programmes currently available in the TIA (TIA, 2020a):

- Global Cleantech Innovation Programme;
- Innovation for Inclusive Development;
- Innovation Skills Programme;
- Technology Stations Programme; and
- Youth Technology Innovation Programme.

In 2013, the Department of Science and Innovation (DSI) did a Ministerial Review report on TIA's performance against its directives and positioning within the NSI. The assessment report highlighted areas where the TIA needed to improve, which were:

- Serve as a hub where entities would interface the objective of converting ideas into commercial activities;
    - Entities include:
        - Publicly funded research institutions;
        - Large and small commercial and industrial businesses;
        - Innovative private individuals;
        - Non-governmental organisations and community-based organisations; and

    - Technological innovation support instruments funded by government departments and public and private entities.
- Assume the role of the publicly funded instrument and ensure NSI functions at maximum efficiency and effectiveness;
- Play a role as the grant-giving agency and accrual return of investment (ROI) in terms of benefits to the South African economy from commercialisation;
- Enhance ability to support SMMEs through Technology Stations Programme (TSP);
- Implement an effective regional strategy;.
- Improve operational efficiencies and reputation (in terms of turnaround times);
- Promote a culture of innovation.

As much as TIA needs improvement, there are some noteworthy achievements by the TIA in the strategic period 2015-2020 (TIA, 2020b:21):

- Distributed ZAR 2.2 billion to support new technological developments;
- Emergence of 348 new knowledge products and 296 innovation products (i.e., protectable intellectual property and technology demonstrators);
- Technical support to over 10 530 SMMEs; and
- Commercialised products and services were 63 technologies.

The TIA critically reviewed its execution of mandates and supported many innovations, but the translation and commercialisation success rate has not been where it should be. Then, the TIA drafted a new strategy with three pillars to reposition itself strategically within the NSI. Figure 3.1 shows this new strategic plan to be implemented by the TIA.

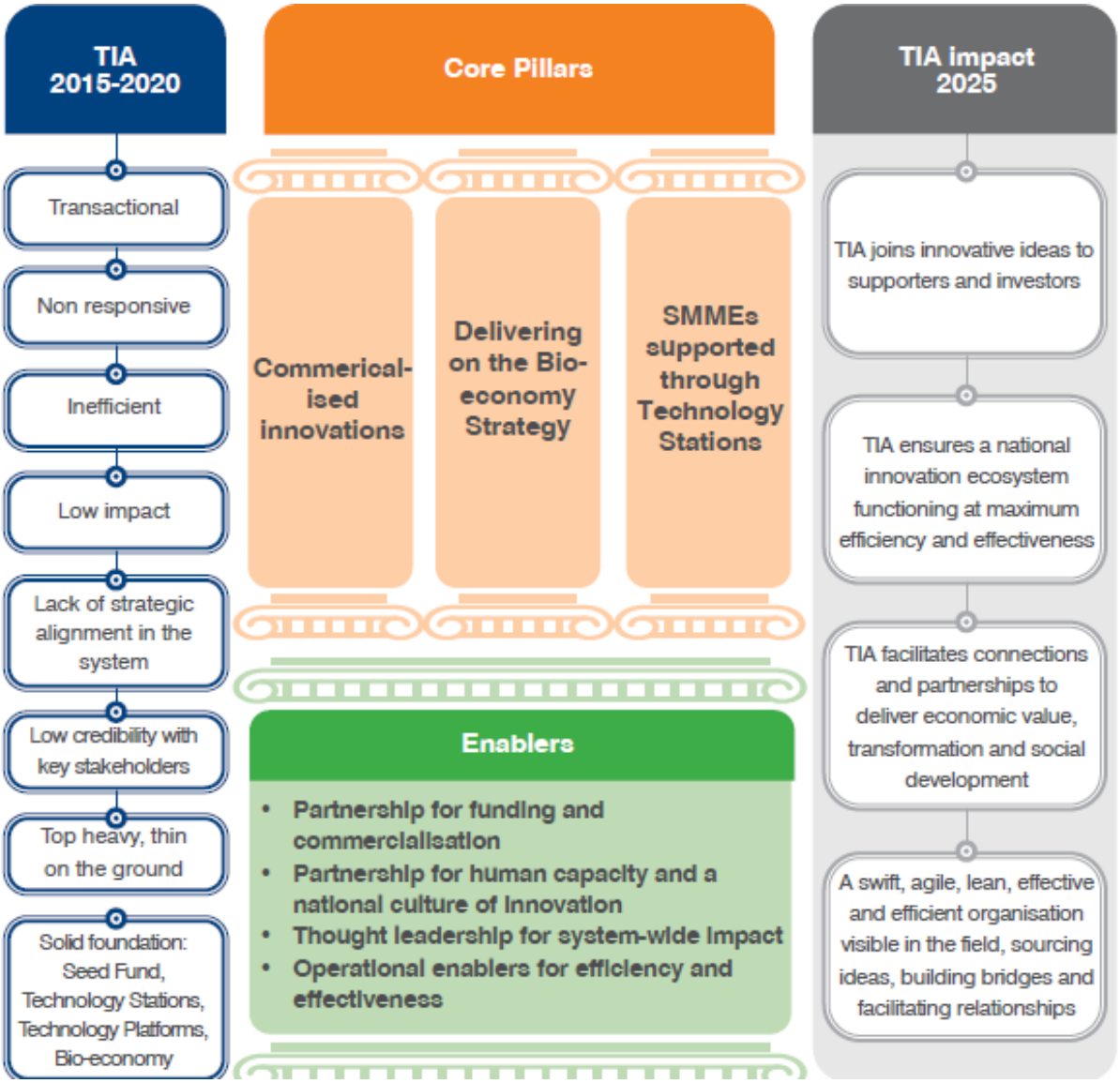


FIGURE 3.1: TIA'S STRATEGIC FOCUS FOR THE 2020-2025 STRATEGIC PERIOD (TIA, 2020B:13)

Figure 3.1 shows how the TIA took criticism received BETWEEN 2015 to 2020 and used it to form three pillars and the impact they would like to have by 2025 with the help of enablers. For the 2020 to 2025 strategic cycle, these are the factors that affect TIA into becoming a rapidly maturing global environment (TIA, 2020b:12):

- Institutional and private funders;
- Expanded research base;
- Active entrepreneurship community; and
- Support intermediaries

The three pillars of the TIA are the commercialisation of innovations, delivering on the bio-economy strategy and SMMEs supported through Technology Stations. For commercialising innovation, the TIA plans to:

- Intensify efforts to increase the rate of locally developed technologies;
- Exploit intellectual property from publicly-funded institutions.
- ensure commercialisation promotes economic growth and competitiveness of the industry; and
- Respond to imperatives of transformation and inclusive development.

The TIA had a strategic objective 2: "to provide thought leadership and enabling environment for technology innovation in collaboration with role players (TIA, 2018)". The strategic objective was achieved by the key performance indicator of the number of knowledge innovation products produced because of TIA funding and support programmes (TIA, 2018). There were 98 knowledge innovation products produced for 2017/2018, and these were various categories (TIA, 2018):

- Prototypes developed – 46;
- Intellectual properties – 10;
- Technology demonstrators developed – 35; and
- Technology transfer packages – 7.

The new efforts by TIA will focus on commercialised innovations in national and global collaborations to support the translation of knowledge from HEIs, SCs and the private sector (TIA, 2020b). These innovations will hopefully translate into addressing some of the challenges South Africa faces, and commercialised outputs will be more (TIA, 2020b).

For bio-economy strategy delivery, TIA will focus on creating new bio-based products and processes to promote the creation of new enterprises. The TIA plans to increase indigenous knowledge systems for development and transformation inclusion. For SMMEs' support through technology stations, the TIA is required to position technology stations' capabilities as part of support in NSI. The capabilities are (TIA, 2020b:14):

- Promote the growth of SMMEs;
- Contribute towards innovation-led industrialisation processes;; and
- Foster inclusive development.

More on technology stations will be discussed in the strategic overview of the Technology Stations Programme (TSP) (see Section 3.3). The three pillars discussed will form the performance measurement of TIA's strategic objectives.

3.2.3 Measuring performance

The Technology Readiness Levels (TRLs) must be observed to understand how performance is measured in TIA. The TRLs are

> "…a measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. It has a scale of 1 to 9 with TRL 1 being basic research and TRL 9 commercialisation" (TIA, 2018:59).

The various levels of TRL are depicted in Figure 3.2.

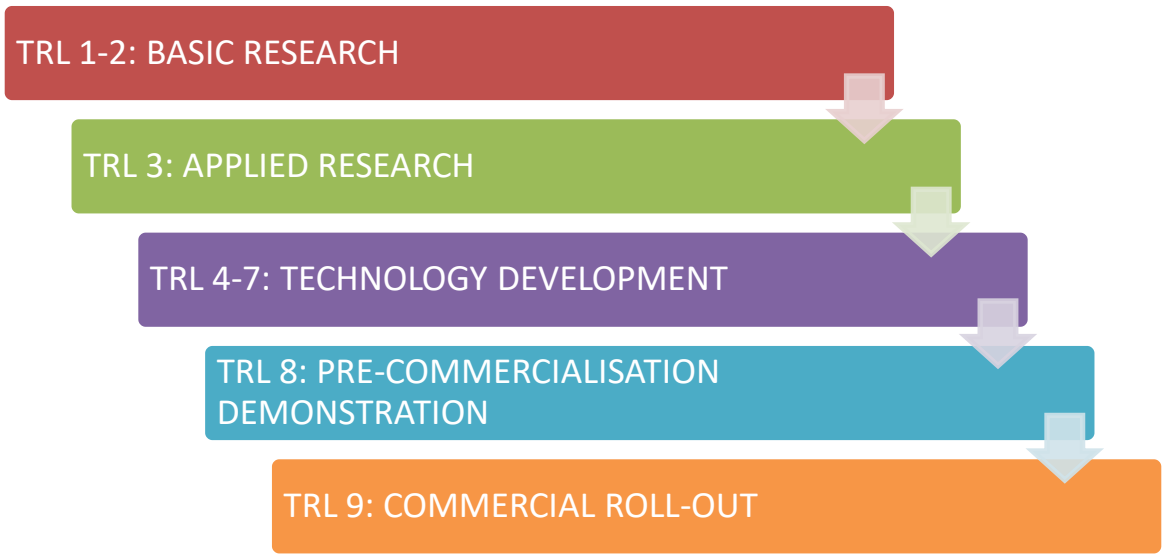


FIGURE 3.2: TECHNOLOGY READINESS LEVELS

In the last strategic period (2015 to 2020), TIA invested about ZAR 155,5 million towards the commercialisation project portfolio (TIA, 2019). The impact of the interventions amounted to revenue generated of ZAR 8,3 billion and the creation of over 14 000 jobs (TIA, 2019). In the past, commercialisation was narrowly approached from a view of market uptake (e.g., licensing, assignment of IP and direct sales). To broaden the view, TIA adjusted its previous sole focus on the Technology Readiness Levels (TRL) with new enhanced processes (TIA, 2019). These include the Business Readiness Level (BRL) approach for enterprise development and Market Readiness Level (MRL) for market and demand validation and feedback loops that flow back into the product design phase (TIA, 2019).

The three pillars will be explored in measurement performance terms. In terms of measuring commercialised innovations, there are three outputs (TIA, 2020b:53):

- Number of technologies developed;
- Number of technologies successfully diffused for inclusive development; and
- Total value of funding leveraged (based on the value of signed agreements entered with third parties).

These outputs will contribute to the National Development Plan (NDP) 2030, Medium-Term Strategic Framework and TIA's mandate. These will be achieved by the TIA developing and commercialising the 22 projects between TRLs 7 to 9, resulting in revenue generation and job creation.

In terms of bio-economy strategy delivery, there are four outputs (TIA, 2020b:54):

- Number of successfully demonstrated bio-based technologies;
- Number of existing Technology Platforms that are operational and functional;
- Number of new Technology Platforms in targeted regions; and
- Number of existing Technology Innovation Clusters that are operational and functional.

These outputs are to contribute to NDP 2030 and the Medium-Term Strategic Framework. The TIA will achieve them by implementing the Bioeconomy Strategy, which will contribute to increased productivity across the sectors (agriculture, health, industry, and environment) identified in the strategy.

In terms of the SMMEs supported by technology stations, there are two outputs (TIA, 2020b:55)

- Number of existing technology stations and centres providing science, engineering, and technology (SET) support that are operational and functional; and
- Number of new centres providing SET support in targeted regions.

These outputs are to contribute to NDP 2030 and the Medium-Term Strategic Framework. These will be done by investing in new forms of technology development infrastructure collaborations with other role players in the NSI with the aim of increasing SET for innovators across South Africa.

Molebatsi (2015) examined how TIA evaluates relationships between UoTs and SMMEs for technology transfer in the Technology Stations Programme (TSP). The author sought to find out how the TIA monitors and evaluates the economic and socio-economic outcomes of the Technology Stations Programme. The author claimed that the relationship between the

strategic objectives of the Technology Stations Programme and the performance indicators used for impact assessment was unclear. The study used the science, engineering, technology, and innovation (SETI) indicators scorecard as the framework for performance reporting the Technology Stations Programme. The study found that the SETI Scorecard was not well defined and lacked the properties required of a scorecard of indicators to make it an adequate tool for performance measurement. Other problems related to the Technology Stations Programme were (Molebatsi, 2015:5):

- Incomplete reports;
- Occasional incoherence; and
- Graphical errors in the reporting.

Molebatsi (2015) found inadequate monitoring, evaluation, and performance measurement during interview data collection and further found that the Technology Stations Programme successfully supported SMMEs. The Technology Stations Programme also offered SMME technology-related services that contributed to industrial policy through innovation. The failure of a functional SETI Scorecard of indicators showed that outcomes in the Technology Stations Programme affected proper programme evaluation. This evaluation means that the Technology Stations Programme technology transfer would be questioned on whether it achieved economically value-adding objectives. The study found that there are proper measures required to capture outcomes and future decisions of the Technology Stations Programme.

Only through exploring TIA's Technology Stations Programme will there be clarity on the reporting state and the current opportunities and challenges. This study will focus on the Technology Stations Programme, specifically the technology station in clothing and textiles, which will be discussed in the following section.

3.3 OVERVIEW OF THE TECHNOLOGY STATIONS PROGRAMME (TSP): TECHNOLOGY STATION IN CLOTHING AND TEXTILES (TSCT)

The TIA focuses on the priorities set out by the South African Department of Science and Technology (DST) in three areas (DST, 2019):

- Bio-economy strategy;
- Technology Stations Programme; and
- Commercialisation.

By advancing the three areas, TIA will align with broader national government socio-economic imperatives of poverty, inequality, and unemployment (DST, 2019). The DST planned to assess TIA's Technology Stations Programme and Technology Localisation Programme to ensure an increase in turnover and better large private-company contracts for small and medium enterprises (SMEs) (TIA, 2016). In the 2015/2016 period, the technology stations supported at least 34 projects with stakeholders in the NSI, leading to SMEs securing contracts. The DST views the role of technology stations within the NSI to be (DTI, 2016:74):

- Providers of specialised infrastructure aligned to focus of technology station;
- Providers of specialist knowledge and skills to improve innovation and new products and processes development;
- Solvers of industry problems and ensures industry requirements are incorporated into curricula for students to meet industry needs;
- Hosts or launcher of a sustainable platform from where government initiatives can provide support to SMEs and industry;
- Partners in DST's Technology Localisation Programme (TLP), where third parties provide technology support to approved firms; and
- Entities for human capital development where interns work in integrated learning programmes to complete qualifications and apply knowledge or gain exposure to industry problems.

The South African Department of Science and Technology (DST) is the financial support provider of the Technology Innovation Agency (TIA) to higher education institutions (HEIs). The TIA and HEIs house technology stations to provide technical support to small and medium enterprises (SMEs) for services and training solutions (DTI, 2018). Technology stations provide services to SMEs and also to individual innovators and researchers considering technology development (TIA, 2019). The strategic partners of the Technology Stations Programme (TSP) include (TIA, 2019:56):

- Higher education institutions (HEIs) – 11;
- Small Enterprise Development Agency (SEDA);
- National Intellectual Property Management Office (NIPMO); and
- South African Technology Network (SATN).

3.3.1 Technology Stations Programme (TSP)

In 2002, the Technology Stations Programme (TSP) was started as the Tshumisano Programme and was based on the German Steinbeis system (DTI, 2016). This system is where HEIs, mainly universities of technology (UoTs), establish a centre to distribute its

knowledge to the industry by solving industry problems (DTI, 2016). The problem-solving process involves the university staff and students remaining with current industry problems and technologies (DTI, 2016). This process is then merged into the formal and informal teaching programmes and research topics for graduate and postgraduate students (DTI, 2016). In 2008, the Technology Stations Programme hosting function was transferred to the Technology Innovation Agency (TIA) and still receives funding from the DST. Currently, 18 technology stations are geographically distributed across South Africa, with respective sectoral focus areas (DTI, 2016; 2018). The technology stations offer services from the prototyping/piloting stage to pre-commercialisation (TIA, 2019).

In 2016, TIA invested ZAR 63 million in grants for the 18 technology stations, ZAR 4.5 million in co-founded SME-related projects, ZAR 8.6 million in high-end technology infrastructure at four higher education institutions (HEIs) and ZAR 0.7 million in administration costs for the Technology Stations Programme. The performance overview of the technology station management achievements (TIA, 2016) linked to this study were:

- Products/prototypes developed (six for TSCT) – over 235;
- Competitive improvements for market access to products (15 for TSCT) – 285;
- SMEs secured contracts – 110;
- Official disclosures with NIPMO – 17;
- Funded youth projects for support with product design, CAD/CAM, and quality improvements – 33; and
- Enterprises' projects were implemented in collaboration with stakeholders and another agency in NSI – 95.

Table 3.1 shows how the core goal, objectives, key performance factors, and measures lead to socio-economic impact in each technology station.

TABLE 3.1: OPERATIONAL OBJECTIVES ADAPTED FROM THE TECHNOLOGY STATIONS PROGRAMME (DST, 2018A:3; TIA, 2016:105)

The core goal of the Technology Stations Programme is to contribute towards improving the competitiveness of industry through the application of specialised knowledge and technology; and facilitating the interaction between industry (especially SMEs) and academia in order to enable innovation.		
Objectives	Contribute to HEIs being more responsive to the needs of the industry	Enable industry, SMEs in particular, to benefit from the specialised knowledge and innovative technologies of the universities
Key performance area/s (KPA)	Institutional learning and development	Technology transfer and industry support
Measures	• Knowledge products supported, • Postgraduate studies and students on projects, • Equipment of the technology station used by the host, • Collaboration with other technology stations, • Contribution to academic content and by the host to technology station, • Interns hosted	• Technology-based support & training to SMEs, • Tech-based products/processes developed or improved (projects), • Industry-relevant services, • TS equipment used by industry, • Industry uptake of technology, • Financial contribution to technology station from industry/public sources, • Provision of industry-relevant training
SOCIO-ECONOMIC IMPACT		

Table 3.1 shows that for technology stations to get the desired socio-economic impact, they should uphold the core goal:

> "To contribute towards improving the competitiveness of industry through the application of specialised knowledge and technology; and facilitating the interaction between industry (especially SMEs) and academia in order to enable innovation" (DST, 2018b:3).

To achieve the goal, the objectives necessary are to:

- Contribute to HEIs being more responsive to the needs of industry; and
- Enable industry, SMEs in particular, to benefit from the specialised knowledge and innovative technologies of the universities.

An HEI should work on institutional learning and development to be more responsive to industry needs. The statistics are different when looking at technology stations' core staff and

HEI staff at the UoTs involved with technology stations. The scientific capacity of 244 staff members with postgraduate degrees is depicted in Figure 3.3 (TIA, 2016):

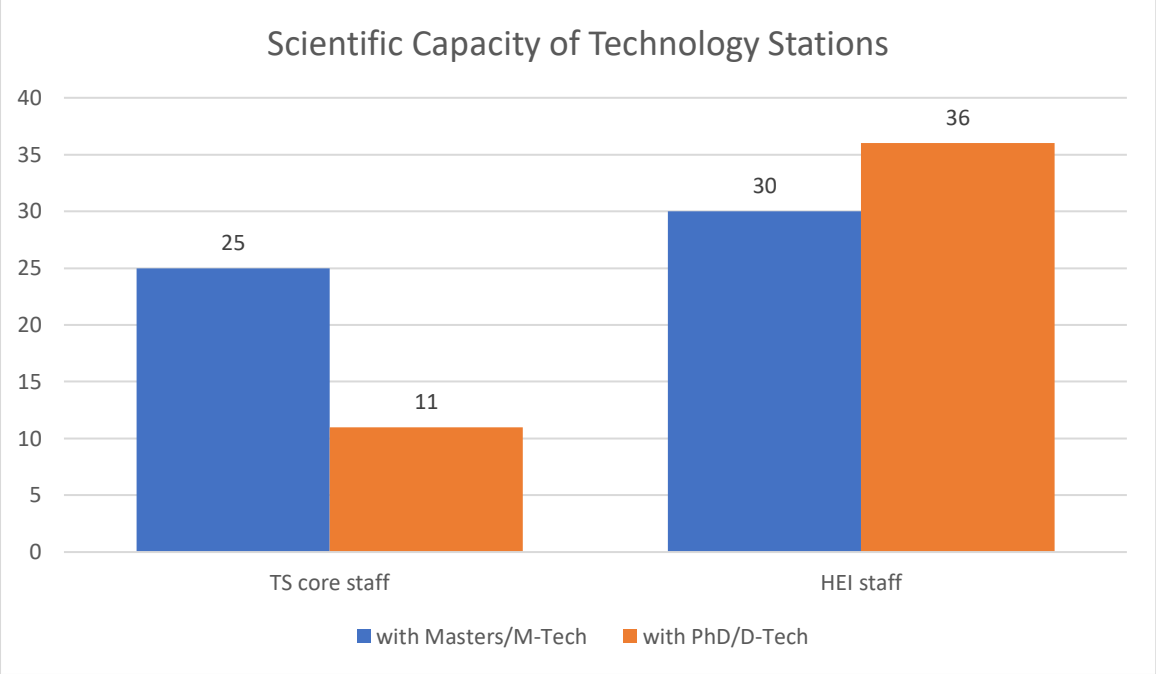


FIGURE 3.3: SCIENTIFIC CAPACITY OF TECHNOLOGY STATIONS

The technology station core staff had 36 (25+11) staff with master's or M-Tech and doctorate or D-Tech, while HEI staff had 66 (30+36) staff with master's/M-Tech and doctorate or D-Tech. There were more HEI staff than technology station core staff with qualifications of master's or M-Tech, and doctorate or D-Tech. The results show that 102 (41.8%) of 244 staff members have a postgraduate degree of master's/M-Tech or higher. These results mean that having a master's/M-Tech qualification is favourable in the Technology Stations Programme, and studying further must be encouraged because ten (4.1%) of technology station core staff are enrolled for a doctorate or D-Tech and want to improve their academic qualification. However, the scientific capacity decreased the following year to 232 staff members. The average age of staff was 35 years old – the Vika (2016) study mentioned by industry professionals that organisations usually fail to accommodate the youth.

Nevertheless, technology stations hosted 103 interns, and 12 interns got placed with industry partners. TIA's attempt to accommodate the youth by creating a separate programme targeted to the youth. The Youth Technology Innovation Programme,

> "…supports young innovators, between the ages of 18 and 35 who require funding, mentorship, and business support to take their innovative ideas with commercialisation potential to the next level. The Programme offers funding through a voucher system to enable access to prototype development, testing and certification, intellectual property

protection and enterprise development. The voucher includes a component for a small stipend to enable the entrepreneur's mobility as they develop their technologies" (TIA, 2017:72).

The results show that almost half of the staff are from technology stations; however, there should be a focus on youth. The results could be the reason why the Technology Stations Programme (TSP) supported 1 380 young people, received support from technology stations, and 124 students were allowed to work on industry projects at technology stations in the manufacturing and Agro-processing sectors in the 2018/2019 TIA financial year (TIA, 2019).

In terms of the academic output of the Technology Stations Programme, 53 non-journal articles and conferences and 28 accredited journal articles were published in 2015/2016. While 83 conference presentations were presented, and 22 accredited journal articles were published in 2016/2017. The results show an increase in outputs for papers presented at conferences but a decrease in outputs for journal articles published in accredited journals. These results make sense as only about 8% of the time spent per invention in technology stations is used for supplied R&D (TIA, 2017). Technology stations created the following number of knowledge innovation products for over five years (TIA, 2016, 2017, 2018):

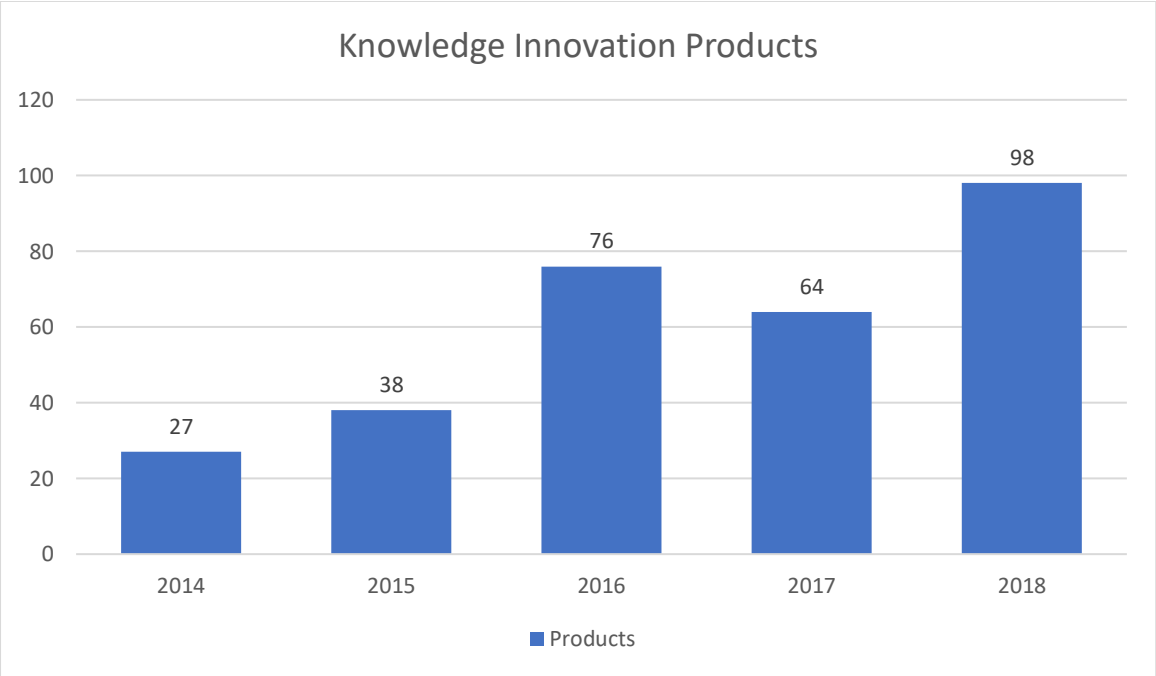


FIGURE 3.4: TECHNOLOGY STATIONS PROGRAMME PRODUCTS FROM 2014 TO 2018

Figure 3.4 shows an increase in products produced from 2014 to 2018, except for 2017, where there was a decrease in products produced.

Technology transfer and industry support should take place to enable the industry to benefit from the specialised knowledge and innovative technologies of the universities (Villani, Rasmussen & Grimaldi, 2017). The technology stations focus their outputs on SMMEs, and the number of products and prototypes developed for socio-economic benefits, such as new or improved companies or industries leading to new jobs and wealth and reduced environmental impact (TIA, 2018). Below is the SMMEs support provided by technology stations for five years (TIA, 2016, 2017, 2018):

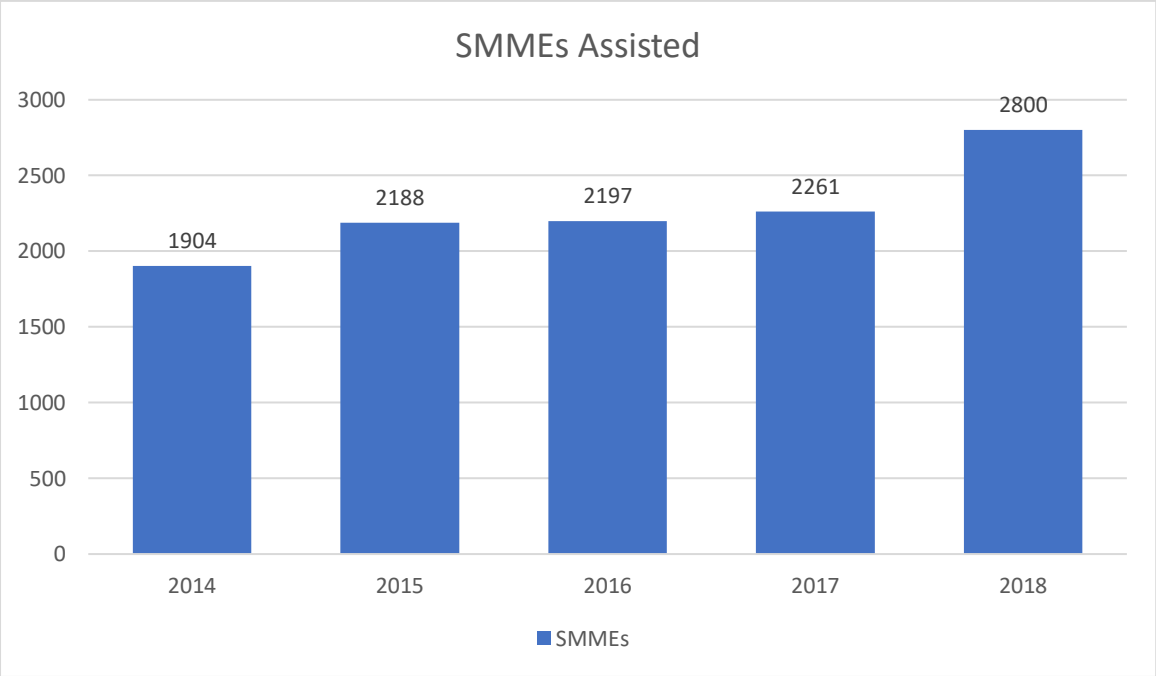


FIGURE 3.5: SMMES ASSISTED BY TECHNOLOGY STATIONS

Figure 3.5 shows that TIA supported over 10 000 SMMEs over five years. This progress was evident through repositioning the Technology Stations Programme to provide much-needed SET support to SMMEs through access to high-end innovation infrastructure and expert technical advice (TIA, 2020b). SMMEs are small businesses or start-up ventures formally, informally, or non-VAT registered and challenged by access to finance and markets, poor infrastructure, and labour laws (Small Enterprise Development Agency (SEDA), 2016). SMMEs play a vital role in an economy as they contribute to economic growth, innovation, and job creation (Kobzeva, Gribov, Snigireva & Raevskya, 2017; SEDA, 2016).

The SMMEs serve as technology nurseries that lower entry barriers for innovators and industries with various technology packages (TIA, 2019). In 2019, 3 272 SMMEs were supported, and 51 small enterprises secured business contracts that have the potential to result in the retention and creation of jobs (TIA, 2019). There were also 1 374 product testings, technology simulations, and analyses of products supported in applications of at least 64

research and development initiatives with firms to facilitate advancing the products or services to market for commercialisation (TIA, 2019).

3.3.2 Technology Station in Clothing and Textiles (TSCT)

In the Western Cape, there are four technology stations. Three of the technology stations are at Cape Peninsula University of Technology (CPUT). They are:

- Advanced Manufacturing Technology Laboratory (AMTL);
- Agri-food Technology Station (ATS); and
- Technology Station in Clothing and Textiles (TSCT).

One technology station is at Stellenbosch University (Institute for Advanced Tooling). Furthermore, for the financial year 2015/2016, the Western Cape Province received ZAR 14 million in grant funding for the Technology Stations Programme.

The Technology Station in Clothing and Textiles (TSCT) is located at the CPUT, Bellville Campus. The TSCT falls under a technology station in the Faculty of Engineering and Built Environment (CPUT, 2018). The TSCT was established to provide innovation support to SMEs in the CTLF industry to become more competitive (DST, 2018b). The TSCT technology competencies and offerings include (DST, 2018b:20):

- Manufacturing advisory services;
- Product analysis and testing;
- Product development;
- Technology platform;
- Research;
- Short courses; and
- Training.

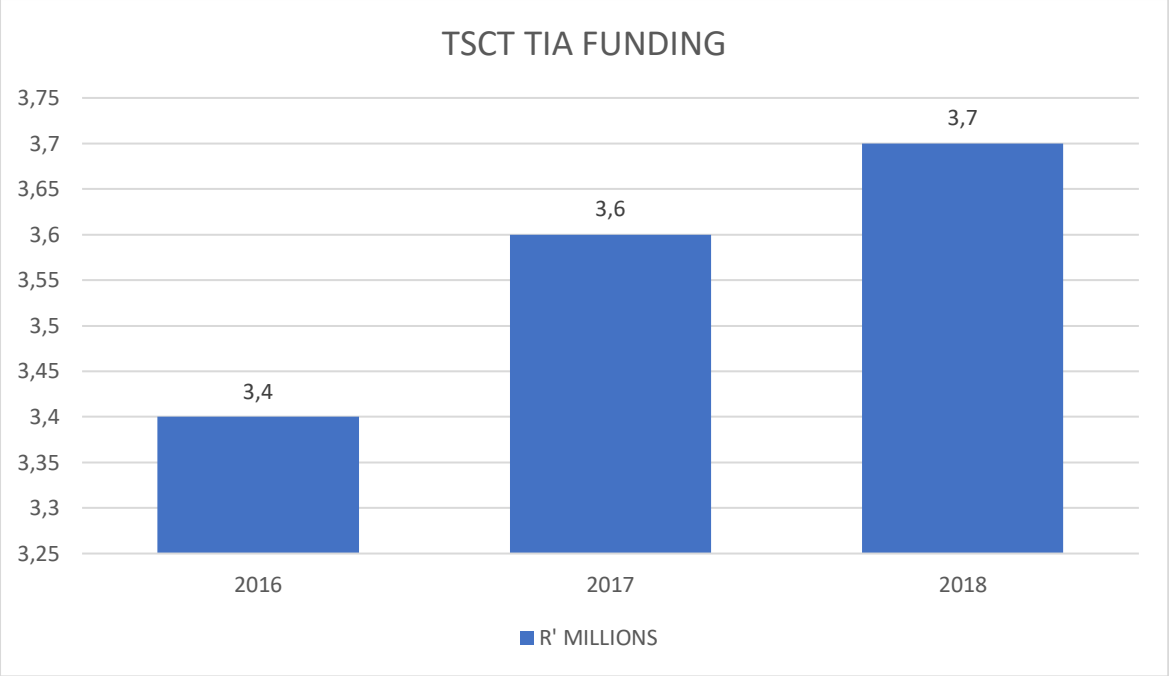


FIGURE 3.6: TSCT TIA FUNDING FOR 2016-2018

The TSCT was allocated ZAR 3.4 million in 2015/2016, ZAR 3.6 million in 2016/2017 and ZAR 3.7 million in 2017/2018 in grant funding from TIA (see Figure 3.6).

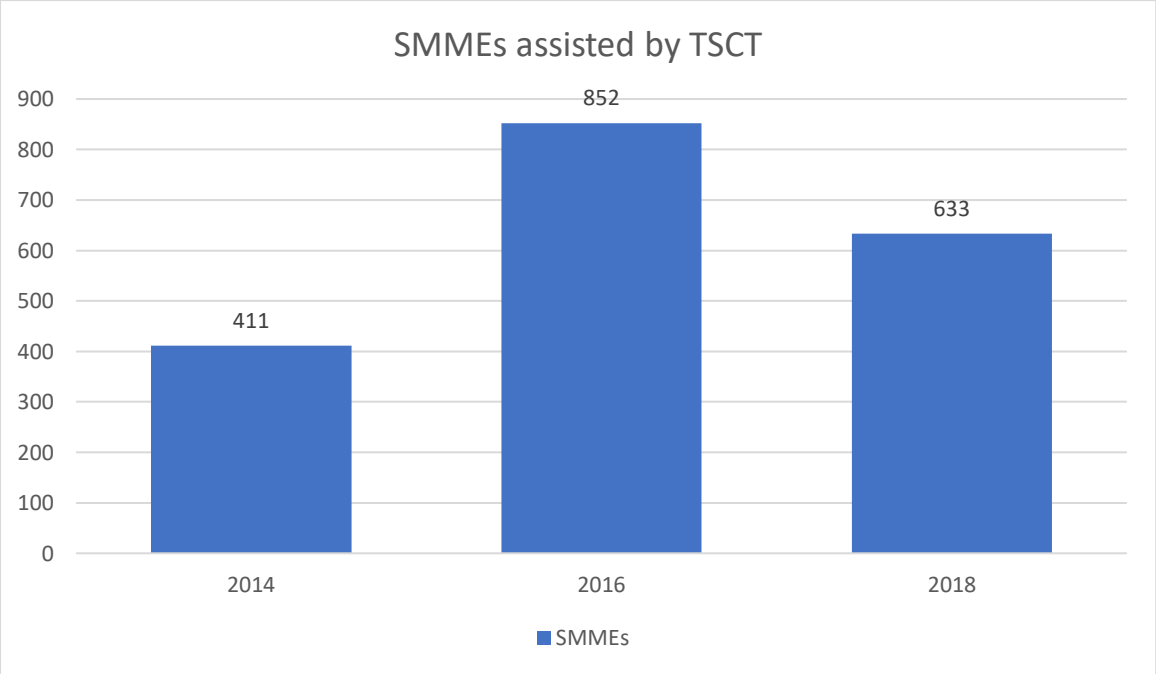


FIGURE 3.7: SMMES ASSISTED BY TSCT FROM 2014 TO 2018

Regarding the TSCT (see Figure 3.7), 411 SMMEs were assisted in 2014, 852 SMMEs in 2016, and 633 SMMEs in 2018 (CPUT, 2014, 2016, 2018). The years 2015 and 2017 did not have results for the TSCT (CPUT, 2015, 2017). The TSCT was one of ten technology stations

highlighted for its contribution to the NDP because 14 SMEs managed to secure contracts through the intervention of the technology station (TIA, 2016). In 2016, TSCT assisted the most SMMEs from the period, and the TIA highlighted the TSCT in the TIA report. The TSCT provides product testing and analysis services to CTLF industries to advise on material use, care, and fabric specification (CPUT, 2018; DST, 2018b; TIA, 2018).

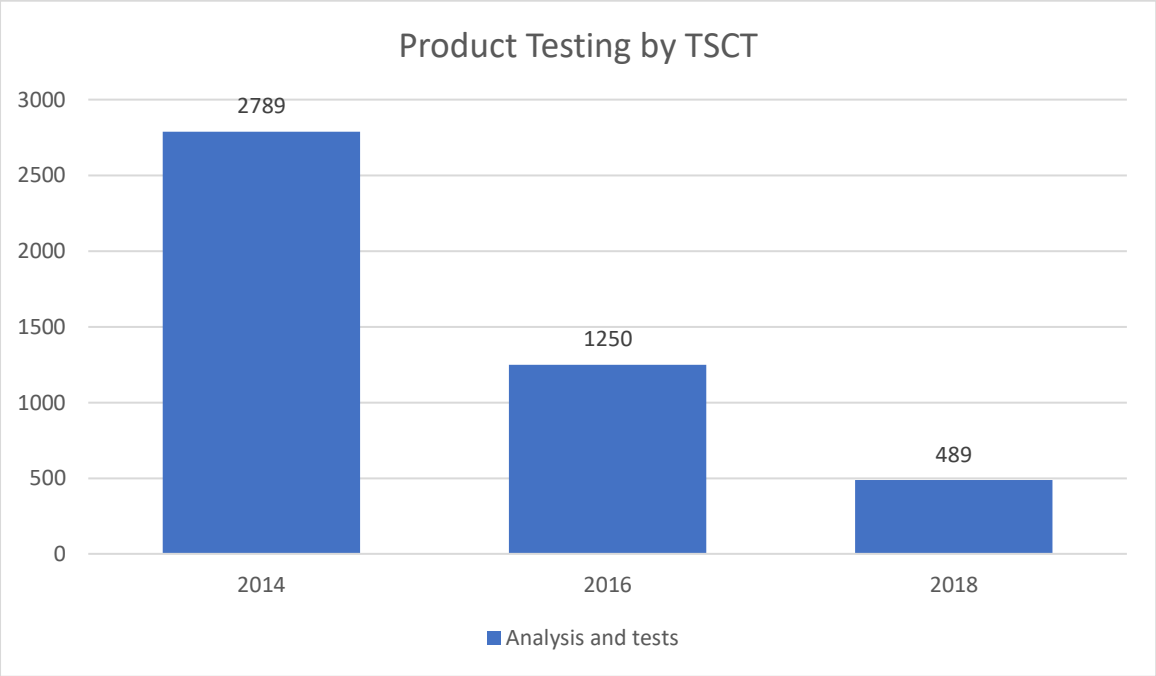


FIGURE 3.8: PRODUCT TESTING BY TSCT FROM 2014 TO 2018

In terms of the output for the TSCT (see Figure 3.8) in 2014, 2 789 analyses and tests were conducted for SMMEs, 1 250 for 2016 and 489 for 2018.

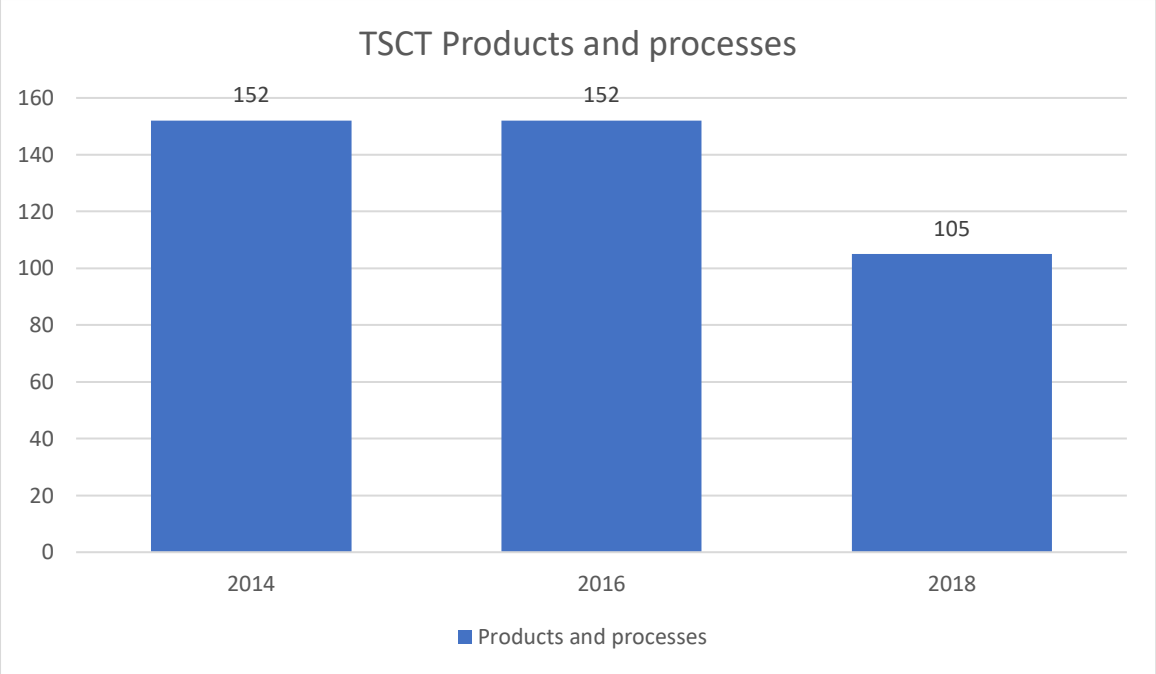


FIGURE 3.9: PRODUCTS AND PROCESSES BY TSCT FROM 2014 TO 2018

The TSCT (see Figure 3.9) also provides product development services, and 152 products and processes were developed for SMMEs in 2014 and 2016, and 105 products in 2018.

Information regarding specific traditional academic outputs for the Technology Stations Programme, specifically TSCT, was scarce and could not be found in public documents. From the Technology Stations Programme, the emphasis is on the socio-economic outputs of the TSCT. Data collection can investigate the 'why' specific results and the context for better understanding. This study focusing on the Western Cape and the TSCT to apply qualitative research will allow for a more strategically concentrated study evaluating the outputs.

3.4 SOUTH AFRICAN UNIVERSITY-INDUSTRY-GOVERNMENT (UIG) RESEARCH AND DEVELOPMENT (R&D) COLLABORATIONS

For a research and development (R&D) strategy to work in a country, it should be modern, efficient, and based on social and political support to generate confidence, guarantee stability, and ensure resources (Gutiérrez-Fuentes, 2015). The R&D intensity is the gross expenditure on research and development (GERD) as a proportion of gross domestic product (GDP) (Human Sciences Research Council – Centre for Science, Technology and Innovation Indicators (HSRC-CeSTII), 2019: xi). R&D intensity equals the total internal expenditures on R&D performed in a country in a year relative to GDP (HSRC-CeSTII, 2019).

In South Africa, the R&D intensity target was 0.76% in 2014/2015 when the target needed 1.00% by 2008/2009 (HSRC-CeSTII, 2019). Sithole, Moses, Ritacco, and Batidzarai (2015) state that the government set an R&D expenditure target of 2% of GDP by 2018. The result of the R&D shows that South Africa is not reaching the R&D target as a country, and thus there cannot be new knowledge generated. There should be a serious intervention to meet the targets set out. An investigation of the quality of the current R&D collaborations and the challenges may shed light on why there are low targets in R&D.

The Industry Innovation Partnership Fund (IIPF) has been implemented to raise industry R&D levels and improve competitiveness in specific industries through technology development (DTI, 2018). The Sector Innovation Fund (SIF) jointly funds R&D and postgraduate human capital development to address problems identified in industry-related technologies (DTI, 2018). The active SIF programmes include wine technology, sugar (post-harvest), fish breeding, mining, and minerals (DTI, 2018). In the active SIF programmes, no projects from the CTLF industry were highlighted and therefore showed a gap in the innovation for the CTLF industry.

From a South African perspective, key university-industry-government (UIG) collaborations were found in the following fields of studies by Nkosi (2015); Chakravarty (2019); Salie, De Jager, and Douglas (2019); Fongwa (2017); and Petersen and Magawana (2019).

Nkosi (2015) applied the aquaculture sector using the triple helix theoretical framework, which will be discussed in the following chapter. *Aquaculture* is the "breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all water environments" (National Ocean Service, 2020). The study employed a two-phase qualitative methodology, with document analysis being the first phase and a questionnaire being the second phase. The results from the study revealed that the functioning of a well-structured triple helix framework does not achieve collaborative innovation success. Nkosi's study could be similar to this study, as many factors were employed in the Nkosi study. However, the study lacks focus because it generalises in the industry and does not look at sub-sectors. The study's gap is focused on a specific institution instead of an industry.

Chakravarty (2019) and Salie, De Jager, and Douglas (2019) studied the medical sector. Chakravarty (2019) looked at frugal innovations for the medical sector as these products provide solutions to value-conscious economies. The study sought to discover how these innovations could contribute to long-term social and economic development. The study employed a case study research design for three firms. The study found that many firms were start-ups with strong collaborations with universities; however, maturing the firms to reach enough economic contribution cannot be achieved in the short term. The study's results were

generalised by presenting results contributing to the whole sector and other African countries. By this study being case-specific and focusing on the TSCT, the results will represent actions to be taken to reach academic and socio-economic goals for the case. The study's relevance was lost because the author found that South Africa has inadequate manufacturing capabilities to carry out innovations. The study probably contributed to the 'micro understanding of innovation'.

However, Salie *et al.* (2019) sought to find out if the problem with the lack of medical device support was due to government institutions. The study conducted a document analysis based on four national government departments and found much rich and relevant information. However, the study did not include other institutional spheres from healthcare, university, and industry sectors, which may influence the medical device landscape in South Africa. Only looking at documents leaves this study with many unanswered questions that could only be answered by individuals involved within the departments. On the other hand, this current study interviewed people involved with TIA, Technology Stations Programme, and the TSCT to ask questions based on the documents reviewed to avoid unanswered questions experienced by Salie *et al.* (2019).

Fongwa (2017) looked at how universities, knowledge, and innovation contribute to regional development, specifically in the Eastern Cape. The study applied focus well as it studied the Amatole region in the Eastern Cape, referred to as place-based development by the author. The study suggests a development policy framework to assist with co-ordinating university-community engagement collaborations. The author stated that policy measures are necessary to improve collaborations. The author's work has many significant contributions to regional development; however, the author's work is insufficient in theoretical backing, as the author did not apply the theorems mentioned, and seemingly the results do not encompass all institutional spheres of the university-industry-government collaboration.

This study aims to find results for all institutional spheres by dealing with the TSCT, as it has access to all the spheres. Bergman (2014) also looked at regional development, specifically in the Gauteng city region. Bergman also applied the triple helix framework as a new approach. The paper sought to find out if actors in the UIG play an active role in innovation transformation for regional development. The author felt that Gauteng is getting into the innovation game late and, thus, will be hard to catch up. The author used secondary data and missed the opportunity to get contextual solutions to how structural problems can be solved or efforts in place for technological catch-up. As this study includes both interviews and document analysis, an in-depth exploration can be made of matters related to TSCT.

Petersen and Magawana (2019) sought to find how innovation hubs enable entrepreneurship and innovation, specifically in the township of Philippi in Cape Town, Western Cape, South Africa. The study formed part of a more extensive community engagement study and focused on the Philippi Innovation Hub. The study used participatory visual methods (digital storytelling and photovoice) and semi-structured interviews with the following participants:

- Staff at key organisations of the Innovation Hub;
- Non-profit government organisations (NGOs);
- A university;
- Informal business owners; and
- Local government.

Petersen and Magawana (2019) found that the Innovation Hub presented a safe space to interact and share knowledge and resources. This space applies to informal business owners, NGO workers and development practitioners, university students and staff, researchers, and representatives from the government. The authors found this to be consistent with the objectives of the Hub and publicly available literature. However, the authors suggest improving innovation hub knowledge services. The authors studied a specific case, Philippi Innovation Hub. Still, when the authors made their conclusions, they made generalisations as they believed the Philippi Innovation Hub could be applied to all South African townships. The conclusions could be because, according to the authors, Philippi is one of the largest townships in South Africa. The study stated that government plans to set up Innovation Hubs in various regions. However, the authors could be short-sighted when using the generalisations of a study. More studies should focus on studying the various townships for the best services to offer the various townships, especially if they plan to open Innovation Hubs in various provinces.

All the studies mentioned above focused on other industries, such as health and did not focus on the CTLF industry. Most of the studies listed were national and did not focus on a specific region. The studies that did look at a specific region studied more than one factor or case. Most of the studies (except the Petersen and Magawana (2019) study) did not focus on the Western Cape.

Brundin, Wigren, Issacs, Frederich, and Visser (2008) published a study on the entrepreneurship development of the province, and the purpose of the article was to adapt the triple helix model in Western Cape, South Africa and the facilities and impediments used in the model. In this study, 15 respondents who equally represented UIG filled in a questionnaire and a follow-up interview over the phone was conducted. The data collection strategy

determined whether the three helixes of the triple helix concept in the Western Cape have any interaction and cooperation. The article found that when looking at the three spheres (university, industry, and government), two of the three spheres (university-industry or industry-government) were usually involved due to a lack of structure and could affect governmental changes on a national level. The findings found optimistic cooperation between universities, industry, and government. Then three examples of cooperation were selected to demonstrate problems, weaknesses, and successes in UIG collaborations. The three cases were:

- Implementation of a training programme for minibus taxi owners;
- Evaluation of real enterprise development project; and
- Employment creation at the Bot River mini-tunnel farming.

The three cases chosen were not from the CTLF industry, which showed that the CTLF industry is unseen as a priority to demonstrate problems, weaknesses, or successes in UIG collaborations.

COFISA (2009) wrote a report about Western Cape UIG collaborations. The report found that the Western Cape industry specialises in Clothing and Textiles, and the government views the CTLF industry as a significant sector. Fields such as medicine, engineering, environmental sciences, biological studies, social sciences, business, and commerce and mathematical sciences have intense university research. However, university research strengths in CTLF-related research fields do not appear. As much as the Western Cape government and CTLF industry view the CTLF field as a significant contributor to the province, the research universities do not seem to share the same view. The research universities view science, technology, engineering, and mathematics (STEM) fields as essential and justified to focus their research efforts. Investigating CTLF academic collaborations and publications will enlighten why the CTLF industry is not a university research strength.

Sihlobo and Mbatha (2019; 2022) focused on the forms of UIG R&D collaborations of academia in clothing-related education programmes in South Africa. The clothing-related departments were fashion, consumer science, textiles, and clothing management. The study found that most academia is never involved with UIG R&D collaborations due to weak government and CTLF industry support. Although the study was in the CTLF industry, it focused on the academic perspective and not the industry itself and did not consult with the government. The study only used quantitative research in the form of a questionnaire and relied on academic staff from various clothing-related departments. The study was quantitative and did not allow for a deeper understanding of the results. The study, therefore, generalised

on the results and was not region-specific. This study saw this as an opportunity to focus on a province and study a case to give rich results.

Mbatha (2020) explored UIG R&D collaborations in the CTLF industry of South Africa. The study applied a mixed-methods approach, allowing for optimum results and data triangulation. The study found that UIG R&D collaborations exist in the South African CTLF industry. These collaborations are driven mainly by government funding, the technology station, and the government science council within a university situation. Evidence of the collaborations also exists in the form of completed, ongoing, failed, and planned UIG R&D collaborations. Mbatha (2020) further found that the university and CTLF industry does not perform all their UIG roles, while government performs all its roles. The author found that the following are challenges affecting UIG R&D collaborations:

- Weak UIG collaboration directorate, time, and advanced skills;
- Mismatched curriculum for UIG R&D collaboration;
- Competing interests between institutional spheres; and
- Compliancy rule in UIG R&D collaborations.

This study suggests potential future solutions that delve in-depth into each CTLF industry or present new opportunities within the CTLF industry. The opportunities highlighted in the study were:

- Developing a governmental UIG R&D collaboration directorate;
- Conducting industry-relevant research;
- Developing industry-focused research conferences; and
- Improving transformation through UIG R&D collaborations.

However, the study was broad because it looked at South Africa's CTLF industry and made generalisations about it without being region-specific. The study also did not specify or separate the success or failures of each member of the CTLF industry. The study showed that clothing, textiles, leather, and footwear were grouped as one when other members performed better or worse. There was no way to tell where the industry's focus should be and where potential specialities lie.

From the literature surveyed, empirical studies might not focus on UIG collaboration outputs in the Western Cape CTLF industry nor employ qualitative research. The literature highlights the gap to which this study may contribute.

3.5 CONCLUSIONS

This chapter presented a strategic overview of the TIA, Technology Stations Programme, and TSCT for the South African UIG Collaborations. Strategically analysing TIA allowed for understanding how the organisation worked as a whole. The way TIA runs its operations affects the TSCT. A literature search found South African studies of UIG collaborations to ultimately find those applicable to the Western Cape and CTLF industry. In all literature explored, a standard gap was that limited studies focused on the outputs of the CTLF industry. In the next chapter, the theoretical perspective of this study will form a theoretical background and understanding to present the conceptual framework.

CHAPTER 4: THEORETICAL FRAMEWORK OF THE STUDY

"Consider it pure joy, my brothers and sisters, whenever you face trials of many kinds, because you know that the testing of your faith produces perseverance. Let perseverance finish its work so that you may be mature and complete, not lacking anything."

~ James 1:2-4

4.1 INTRODUCTION

The title of this study is *Investigating outputs from university-industry-government collaborations in the technology station of clothing and textiles*. Based on the title, various theories are in the upcoming sections. The purpose of this chapter is to focus on the theoretical background related to university-industry-government (UIG) collaborations. The innovation systems discussed were the national systems of innovation (NSI) and triple helix (TH) framework. The triple helix is discussed in greater detail because an overview and its models are discussed.

Furthermore, a table of comparison will further elaborate on the concepts of NSI and the TH framework. Then the dimensions for traditional academic outputs and socio-economic outputs will be explained. From all the literature based on Chapter 2, Chapter 3, and the theory of the current chapter, a conceptual framework formed the basis for exploring the methodology and data collection.

4.2 NATIONAL SYSTEMS OF INNOVATION (NSI) OVERVIEW

Authors Christopher Freeman (1987) and Bengt-Åke Lundvall (1992) credit each other for the origin of the concept of national systems of innovation (NSI) (Manzini, 2012). Manzini (2012) further states that Christopher Freeman was the first author to use the term in 1982 in an unpublished paper for the Organisation for Economic Co-operation and Development (OECD) on the role of government in developing a country's technological infrastructure. In 1987, he used the concept to understand the performance of Japan because the country was economically successful post-World War II (Grobbelaar, 2007). Freeman (1982) defined NSI as "the network of institutions of private and public sectors, whose activities and interactions initiate, import, modify and diffuse new technologies" (Grobbelaar, 2007:50; OECD, 1997:10). Bengt-Åke Lundvall, as an editor, used the NSI term in 1992 in a published book (Manzini,

2012). The author's use was to describe the interdependence between technical and institutional change after wide-ranging studies of institutions and national states in North America and Europe (Manzini, 2012). Lundvall (1992) defined NSI as:

> "The elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state" (OECD, 1997:10).

According to Manzini (2012), the concept of NSI appeared in South Africa in the 1996 White Paper on Science and Technology to introduce formal public policy discourse. He stated that the development of the country's science and technology policies was in the definition of the NSI. The policies set a system that would focus on creating and applying knowledge for the nation's social and economic advancement. He further quoted from the White Paper the definition of NSI to be the:

> "…means by which a country seeks to create, acquire, diffuse and put into practice new knowledge that will help that country and its people achieve their individual and collective goals" (Department of Arts, Culture, Science and Technology; 1996:18; Manzini, 2012:1).

According to the Department of Science and Technology (DST) (2008), the purpose of NSI in South Africa is to focus on long-term objectives to confront South Africa's scientific research results failure. The purpose is also to commercialise the inadequacy of the production of knowledgeable workers capable of building a globally competitive economy.

Since the 1996 White Paper on Science and Technology, there have been other milestones in the NSI, such as the Ten-Year Innovation Plan for 2008-2018 (DST, 2008; DTI, 2018). Part of the 2008 Ten-Innovation Plan was to create institutions like the Technology Innovation Agency (TIA) that would assist with NSI. The TIA started developing NSI's national capacity and ensuring the commercialisation of R&D into technology products and services (DST, 2010).

The new White Paper on Science, Technology and Innovation replaced the 2008 Ten-Year Innovation Plan (DTI, 2018). The new White Paper was created to respond to rapid technological changes such as the Fourth Industrial Revolution (4IR). The 4IR is defined by DST as

> "…technological developments that blur the lines between the physical, digital and biological spheres. It integrates cyber-physical systems and the Internet of Things, big

data and cloud computing, robotics, artificial intelligence (AI)-based systems and additive manufacturing" (DST, 2019: vi).

The White Paper was also created to address STI challenges constraining the progress of South Africa's overall NSI. It was also to help realise the STI objectives of the National Development Plan (NDP). The STI White Paper "aims to help drive STI to accelerate inclusive economic growth to make the economy more competitive" (DST, 2019:116).

From the new White Paper on STI, a Decadal Plan is in the development process to implement the White Paper as the White Paper serves as proposed policy action (DTI, 2018; DST, 2019). The Decadal Plan/s will elaborate on technology focus areas, future programmes, institutional arrangements and funding required, and ways to evaluate performance (DST, 2019). The plans will be reviewed and updated every five years or when the DST deems them suitable (DST, 2019).

For 2030 South Africa, the National Development Plan (NDP) 2030 is the government initiative of action on the role of economic development in the country (Department of Presidency, 2012; Manzini, 2015; DST, 2019). By 2030, South Africa aims to have competitiveness that will rely on NSI through innovation and learning, becoming fundamental to South Africa's competitive advantage or growth strategy (Department of Presidency, 2012; DST, 2019). Comprehensive reviews on science, engineering, and technology (SET) in South Africa have demonstrated that innovation is a vital policy construct in South Africa (Manzini, 2015). The NDP 2030's science and technology section views innovation as the primary driver of technological growth (Department of Presidency, 2012; Manzini, 2015). Innovation has enormous technological potential in developing countries, as there is a lack of skilled labour and capital, high levels of inequality and implementation, as well as co-ordination challenges (Department of Presidency, 2012; DST, 2019). The country must promote technological advances and invest in quality education and continuous skills training to combat the challenges (Department of Presidency, 2012; DST, 2019).

To contribute to the NDP, the Department of Science and Technology (DST) created a Strategic Plan 2015-2020 to identify ways in which the department's efforts and NSI would contribute to inequality reduction, poverty reduction, and unemployment reduction (Technology Innovation Agency (TIA), 2016). The DST's initiatives were for the NSI to support private companies and that STI and financial should generate greater employment and increased turnover (TIA, 2016).

Mbatha (2020) explored Manzini's (2015) argument that sectoral systems of innovation should be studied to identify gaps in NSI policy coherence and consistency, specifically in the CTLF

industry. The author did this by reviewing Industrial Policy Action Plans (IPAPs) from 2007 until 2017 and the retail clothing, textiles, leather and footwear (R-CTLF) master plan for 2030 of the South African clothing, textiles, leather and footwear (CTLF) industry. The study found that the South African CTLF systems of innovation have improved since 2007. However, the South African CTLF innovation systems have gaps, policy inconsistencies, and lack coherence. Evidence of this is a South African department's definition of policy coherence,

> "Achieving policy coherence involves the systematic promotion of mutually reinforcing policies across government departments in order to create synergies towards achieving agreed objectives and to avoid or minimise duplication and negative spill-overs in other policy areas" (DST, 2019: viii).

This definition of policy coherence only considers the government with other government departments and does not consider the collaboration between industries and universities. From what the Mbatha (2020) study found, there also seems to be a lack of collaboration between government departments. It means the definition of policy coherence is not currently applied but rather an aspiration to policy coherence. The study was at a national level and not a provincial level and provided generic solutions to problems found.

This study seeks to closely explore and close the gap and focus on the Western Cape CTLF industry. To better understand the involvement of the NSI parties, this study used a highly recommended innovation system, the triple helix. The triple helix system could diagnose and propose a solution to solving Science, Technology, and structural innovation problems between universities, industry, and government.

4.3 TRIPLE HELIX OVERVIEW

Ranga and Etzkowitz (2013) state that the works of Lowe (1982), Sábato and Mackenzi (1982) encompassed predecessor elements of the triple helix. The authors further state that the triple helix concept of UIG collaborations started in the 1990s by Etzkowitz (1993) and Etzkowitz and Leydesdorff (1995). Leydesdorff and Etzkowitz (1996) held a workshop in Amsterdam to discuss the triple helix relationships of the various UIG spheres. The workshop focused on university research as an emerging regime of knowledge production and dissemination (Leydesdorff & Etzkowitz, 1996). The concept explains the shift from a dyad industrial society dominated by industry and government (found in New England's efforts from the 1920s – Etzkowitz & Zhou, 2018) into a triadic university-industry-government (UIG) collaborative knowledge society. Simply put, the UIG collaboration begins when the university, industry, and

government enter a mutual relationship to enhance the performance of each other (Etzkowitz & Zhou, 2018).

The triple helix does not only denote the relationship of UIG but also internal transformation within each of the UIG spheres (Etzkowitz & Leydesdorff, 2000). The triple helix concept encourages the institutional spheres to work in an open space of circulation of aspirations, knowledge, and innovation (Singer & Petereka, 2012). The concept has grown in further exploring the knowledge society to inform policymakers at an international, national, and regional level in creating innovation and development strategies (Ranga & Etzkowtiz, 2013). Triple helix systems also assist in the challenges faced in higher education, R&D, competitiveness, labour market by bettering student and researcher training, creating more and better jobs, and ensuring sound and sustainable economic growth (Ranga, 2012).

Ranga (2012) states that triple helix systems could solve structural problems arising from the shift from an industrial society to a knowledge-based society. Industrial society refers to a society that uses mass production technologies to make goods in factories where importance is placed on land, the volume of labour and physical or financial capital (Crossman, 2018). A *knowledge society* is one in which knowledge creation, dissemination, and utilisation are perceived as essential factors of production in the form of knowledge assets or intellectual capital (International Encyclopedia of the Social Sciences, 2008). To transition from an Industrial Society to a knowledge-based society, social space (civil society) should open resources made available to form new organisations such as start-up firms or spin-off companies (Etzkowitz & Zhou, 2018).

4.4 TRIPLE HELIX – MODELS OF THE TRIPLE HELIX

There are three forms of tripartite collaboration of the triple helix model, namely the statist, laissez-faire, and integrated model (Etzkowitz, 2008; Etzkowitz & Zhou, 2018). These are briefly discussed below.

4.4.1 Statist (socialist) model – Triple Helix I

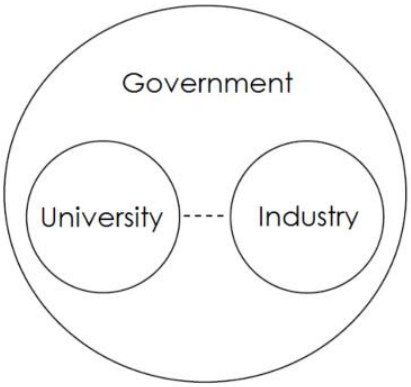


FIGURE 4.1: STATIST MODEL (ETZKOWITZ, 2008:12)

Figure 4.1 shows that the government of a country controls universities and industry in the statist model, and the model relies on the government playing a co-ordinating role in the specialised organisations (Etzkowitz, 2003; 2008; Etzkowitz & Leydesdorff, 2000; Etzkowitz & Zhou, 2018; Farinha & Ferreira, 2012). The government leads the development of projects and provides resources for new industry and university initiatives because universities and industries are viewed as weak and require strong guidance (Etzkowitz & Leydesdorff, 1996; 1998; Etzkowitz & Ranga, 2010). The model changed due to the need to speed up innovation systems by introducing new sources of initiatives. Governmental co-ordination concentrates on initiatives that suppress ideas that arise from universities and industries (Spinoglio, 2015).

In terms of the South African CTLF industry, this is the current model being utilised because the government is the dominant institutional sphere and performs the following roles (Mbatha, 2020; Mbatha & Mastamet-Mason, 2021):

- Funding collaborations;
- Policymaking;
- Providing science and technology ;
- Receiving progress reports;
- Funding research infrastructure;
- Availing infrastructure for research;
- Providing UIG collaboration incentives; and
- Making curriculum suggestions.

The South African CTLF industry utilising this model shows that the industry of the country still has a long way to go and grow.

4.4.2 Laissez-faire model – Triple Helix II

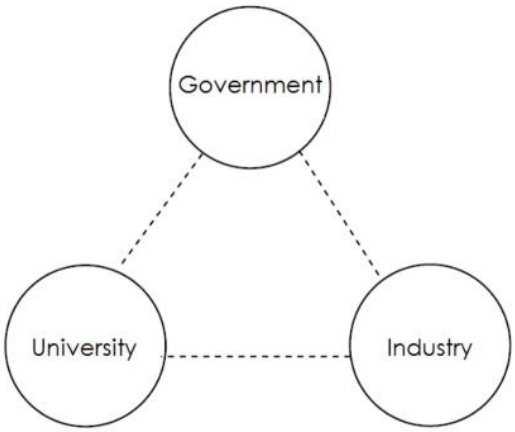


FIGURE 4.2: LAISSEZ-FAIRE MODEL (ETZKOWITZ, 2008:13)

The laissez-faire model (see Figure 4.2) has industry, university, and government separate from each other, and institutional spheres interact modestly across firm boundaries (Etzkowitz, 2003; Etzkowitz & Leydesdorff, 1998). The industry is the driving force in the system, and the government and university are supporting structures (Etzkowitz, 2008; Etzkowitz & Zhou, 2018). The university provides primary research and trains people. It connects with industry to supply knowledge in the form of publications and graduates who bring the knowledge to their new jobs (Etzkowitz *et al*., 2007; Etzkowitz & Leydesdorff, 2000; Spinoglio, 2015). The industry finds helpful knowledge from the universities without expecting assistance (Leydesdorff, 2006; Spinoglio, 2015), and the industry operates independently (Leydesdorff, 2006; Spinoglio, 2015).

Considering the literature (Bizcommunity, 2019; CCTC, 2017; CDI, 2019; CTFC, 2019a; CTFC, 2019b; Wesgro, 2021; Western Cape Government, 2014) on the Western Cape CTLF industry, this model could apply to the Western Cape. It is because the CTLF industry role players are more active than South African CTLF role players. Moreover, as much as there is more interaction between spheres, strong boundaries exist between the spheres.

4.4.3 Integrated model – Triple Helix III

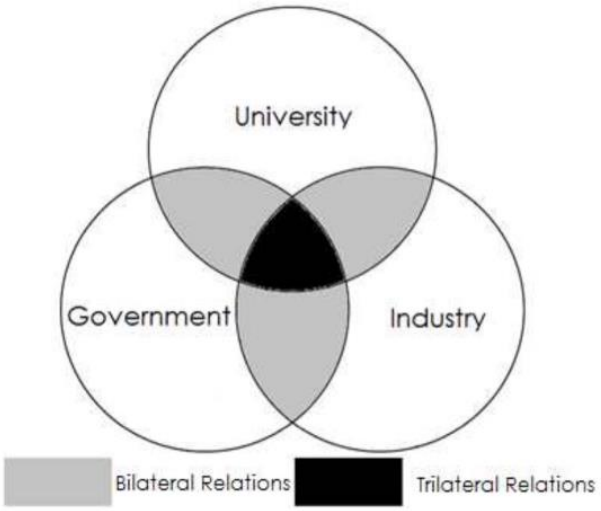


FIGURE 4.3: INTEGRATED MODEL (MORRAR, HAMAND & ARMAN, 2018:7)

The integrated triple helix model (see Figure 4.3) is a university (academic research), industry (innovation and investment), and government (legislation, grants, and IP) generating knowledge infrastructure in overlapping institutional spheres (Etzkowitz & Leydesdorff, 2000; Gutiérrez-Fuentes, 2015). It means that each UIG actor takes on the roles of each other, and hybrid organisations emerge at crossing points (Etzkowitz and Leydesdorff, 2000; Etzkowitz & Zhou, 2018). The institutional spheres have a mutual association in which each attempt to enhance the performance of the other (Etzkowitz, 2008; Etzkowitz & Zhou, 2018). The model integrates the UIG actors and also the integration of industrial, technological, and scientific policies (Gutiérrez-Fuentes, 2015). The university assumes a prominent role in innovation because it is on the same level as industry and government in a knowledge-based society (Farinha & Ferreira, 2012). The institutional spheres form collaborative relationships in which innovation policy is the outcome of interaction rather than a prescription from the government (Etzkowitz & Leydesdorff, 1998; Leydesdorff, 2006; Spinoglio, 2015). Figure 4.4 shows in detail how the model would work collectively to achieve a knowledge-based society (Compagnucci & Spigarelli, 2018:7).

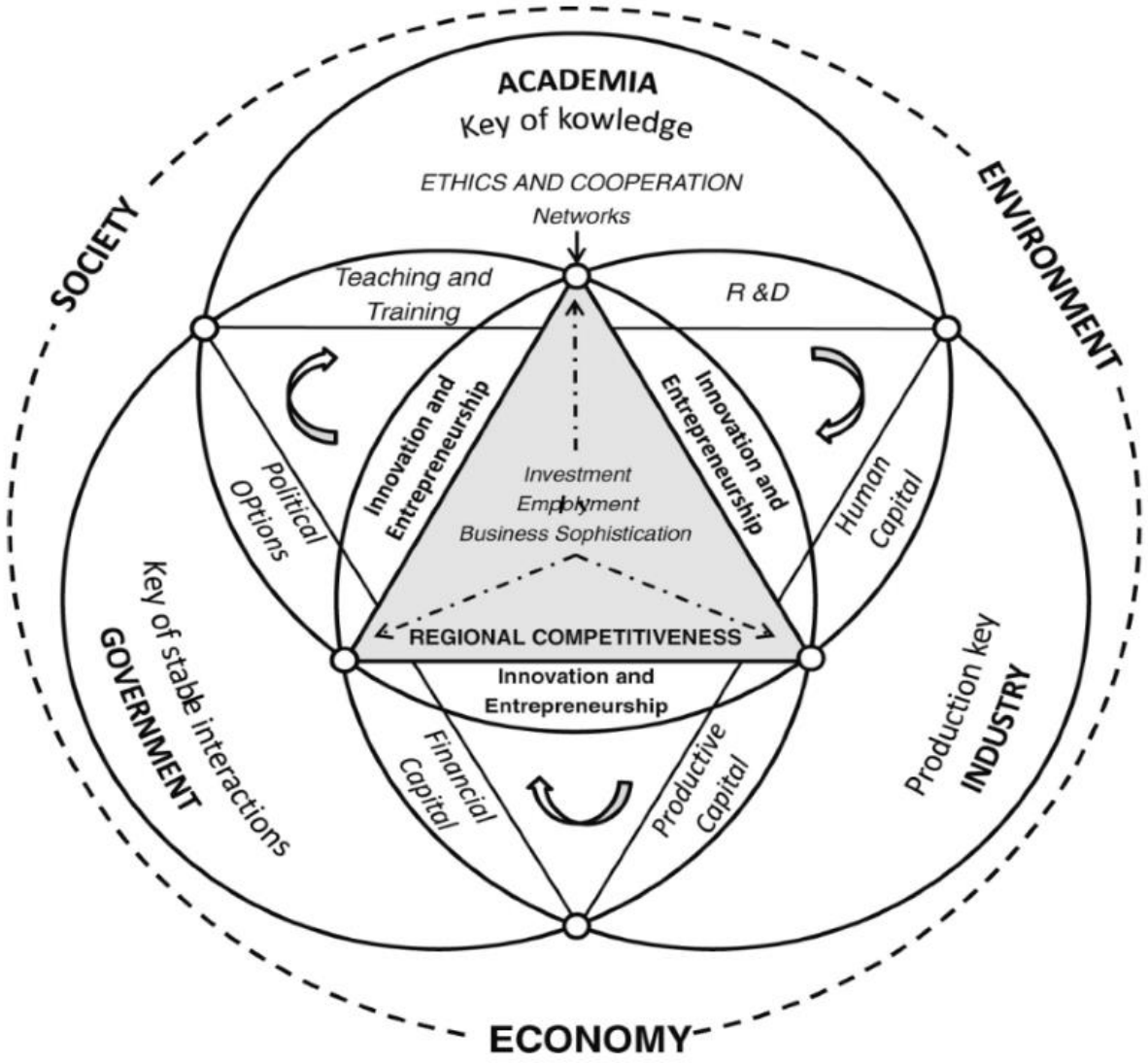


FIGURE 4.4: TRIPLE HELIX MODEL OF INNOVATION IN DETAIL (COMPAGNUCCI & SPIGARELLI, 2018:7)

In Sweden, the Textile Fashion Centre has been able to achieve an integrated model, and evidence is available from their website:

> "Three main partners form the core of the hub's operation, and their interaction takes the form of a triple helix: the City of Borås, Borås University, and the Sjuhärad business association. The basic idea is that creative processes come into their own in the interaction between municipality and society, company and academia – a concept for success that is renowned the world over" (Textile Fashion Centre, 2020).

This would be the ideal model for proper socio-economic development for the Western Cape and the South African CTLF industry. The Western Cape and South African CTLF industry

should strive for such a model because there would be an apparent collaboration between all institutional spheres.

4.5 COMPARATIVE ANALYSIS OF INNOVATION SYSTEMS – THE NATIONAL SYSTEMS OF INNOVATION (NSI) AND TRIPLE HELIX

The NSI and triple helix were discussed in the previous sections and may seem too alike to differentiate or argue using one innovation system over the other. There is a table of comparison (see Table 4.1) provided by Etzkowitz and Zhou (2018) to compare the two concepts.

On the surface, the table would seem like a direct comparison, but further exploration uncovers a more in-depth understanding. The NSI and triple helix are innovation systems; however, where the NSI falls short is its inability to provide models or theorems of application. It could mean that NSI is more flexible and allows for a general exploration of system networks. According to Leydesdorff (2018), NSI claims that innovation is systemic (arising from integrating two or more symbiotic technologies) and that innovation systems are evolving. The NSI also claims institutional organisation, influenced by and susceptible to government policies. It is at national or regional levels by combining the perspectives of policy and institutional analysis. The author finds this misleading as innovation is not taking place within administratively bordered nations, and innovation is not necessarily systemic. The author argues that the triple helix model is based on a knowledge-based economy grounded in discursive (broad) knowledge volatility and enables specific expectations. The expectations are improved by testing them against observations. Furthermore, expectations can be codified differently regarding market perspectives or technological opportunities.

TABLE 4.1: COMPARISON OF NSI AND TRIPLE HELIX ADAPTED FROM ETZKOWITZ AND ZHOU (2018:6-7)

	NSI (innovation system)	Triple helix
Origin	• 1986 • United Kingdom • Christopher Freeman • Analysis of post-war Japanese innovation and enterprises	• 1993 • United States of America • Henry Etzkowitz • Research on Massachusetts Institute of Technology (MIT)'s role in regional innovation in early mid-20th-century New England
Primary actor(s)	• Firm (industry) as a primary actor • Supporting actors: academia, government, intermediaries, financial institutions	• Interaction among university-industry-government is key to the invention of new innovation. • Civil society as a substrate
Academia's role	Supporting actor to other elements in the innovation system	Entrepreneurial university as a leading actor in a knowledge-based society
Operations	The system structure (networks) determines the operation of the system as a co-ordinated, coherent, and stable entity.	Interaction among relatively independent institutional spheres "taking the role of the other", produces novelty in an "endless transition.
Functions	Functions of elements	Functions of institutional spheres
Mechanism	System structure (networks)	Institutional and functional spheres
Innovation formation	• System upgrade/evolution • Fulfils four conditions for self-organisation evolution: open system, far from equilibrium, fluctuation, and non-linear actions	• Triple helix achievement • Develops interactions among relatively independent institutional spheres

Table 4.1, however, only shows the favourable integrated triple helix model (TH III) results that apply to developed countries or regions and does not consider the other two models (TH I and TH II). Moreover, most often than not, more countries or regions are in a state of TH I and TH II. According to Daniels, Ustyuzhantseva, and Yao (2017), developing countries face growing economic inequality and a lack of access to innovation for a large portion of their population. The authors looked at Brazil, Russia, India, China, and South Africa (BRICS). They found significant gaps in the literature in advancing knowledge of innovation as a mechanism for inclusive development. They found that BRICS countries cannot conceptualise and theorise innovation as a mechanism. Innovation should include the broader society in socio-economic and development activities. The authors claimed that there is an absence of specific public policies and policy support to critically analyse and explain the roles of the triple helix in innovation systems.

Ye and Wang (2019) state that sustainable economic growth is NSI-linked. They acknowledge that the triple helix relations are essential to technology innovation. However, they feel there are limited research methodologies to accurately study or estimate the innovation system. The NSI is an overarching theme that highlights how the system should work. However, there are severe problems of asymmetric structure between the knowledge and innovation networks in the NSI. The triple helix model puts into practice how the NSI may operate.

The greatest takeaway from Table 4.1 is that the systems complement each other with the goal of innovation development, adoption, and distribution. Based on Manzini (2012; 2015) and the Department of Science and Technology (now Department of Science and Innovation) (2018; 2019), South Africa still uses NSI as a primary innovation system. However, some challenges include measuring innovation and its capabilities (Daniels *et al.*, 2017). This study will be based on the triple helix innovation system because the models have succeeded in a specific industrial field or a specific region. This study wants to contribute to the limited body of knowledge related to the CTLF industry and triple helix in South Africa. Studying the collaboration outputs will illuminate the state of technology transfer between university-industry-government as per triple helix.

4.6 OVERVIEW OF COLLABORATION OUTPUTS

Outputs are short-term benefits commonly used through the input-process-output (IPO) model (Bushnell, 1990). The IPO is a systems theory model that states that “the general structure of a system is as important in determining how effective it will function as its individual components” (Psychology Research and Reference, 2020). The model applies to systems analysis (Hidayatno, Destyanto & Hulu, 2019), software engineering (Al-Fedaghi, 2017), and psychology (Mansikka, Harris, & Virtanen, 2017). The model is also applicable to any field. However, this study focuses not on the IPO model but on giving a theoretical background to outputs.

The focus of this study is to look at the UIG collaboration outputs from the TSCT. The focus is because outputs are effectiveness indicators, specifically, quality performance and perceptions of satisfaction (Psychology Research and Reference, 2020). This study adopted Kruss and Visser’s (2017) definition of outputs. According to Kruss and Visser (2017), there are two types of outputs, namely traditional academic outputs (TAOs) and socio-economic outputs (SEOs).

4.6.1 Traditional academic outputs

According to Kruss and Visser (2017), TAOs are outputs that have effectively measurable results. This output includes individuals who have published work such as academic publications, master's theses and doctoral dissertations, academic collaborations, reports and policy documents, scientific discoveries, and graduates who have the necessary skills. In the following sections, the various TAOs will be discussed.

4.6.1.1 Academic publications

An *academic publication* is scholarly research published in conference proceedings, journal articles, books, and book chapters (Kruss & Visser, 2017). In South Africa, there are five research sectors based on the Frascati Manual from the OECD (Human Sciences Research Council – Centre for Science, Technology, and Innovation Indicators (HSRC-CeSTII), 2019). These sectors are higher education, business, science councils, government, and not-for-profit organisations (HSRC-CeSTII, 2019). For this study, academic publications related to the higher education institution (HEI) sector will thus be the focus.

Madue (2011) states that South Africa created a research funding framework policy to encourage productivity by rewarding high-quality research output at public universities. It is through the Research Outputs Policy and the Department of Higher Education and Training (DHET) that the DHET wants to "encourage research productivity by rewarding quality research outputs at public higher education institutions" (DHET, 2018:10).

This framework does not measure all output but recognises the significant types of research output produced by universities and by using commissions to determine the quality of outputs (DHET, 2018; Madue, 2011). The research and development (R&D) funding comprises (Madue, 2011:144-145):

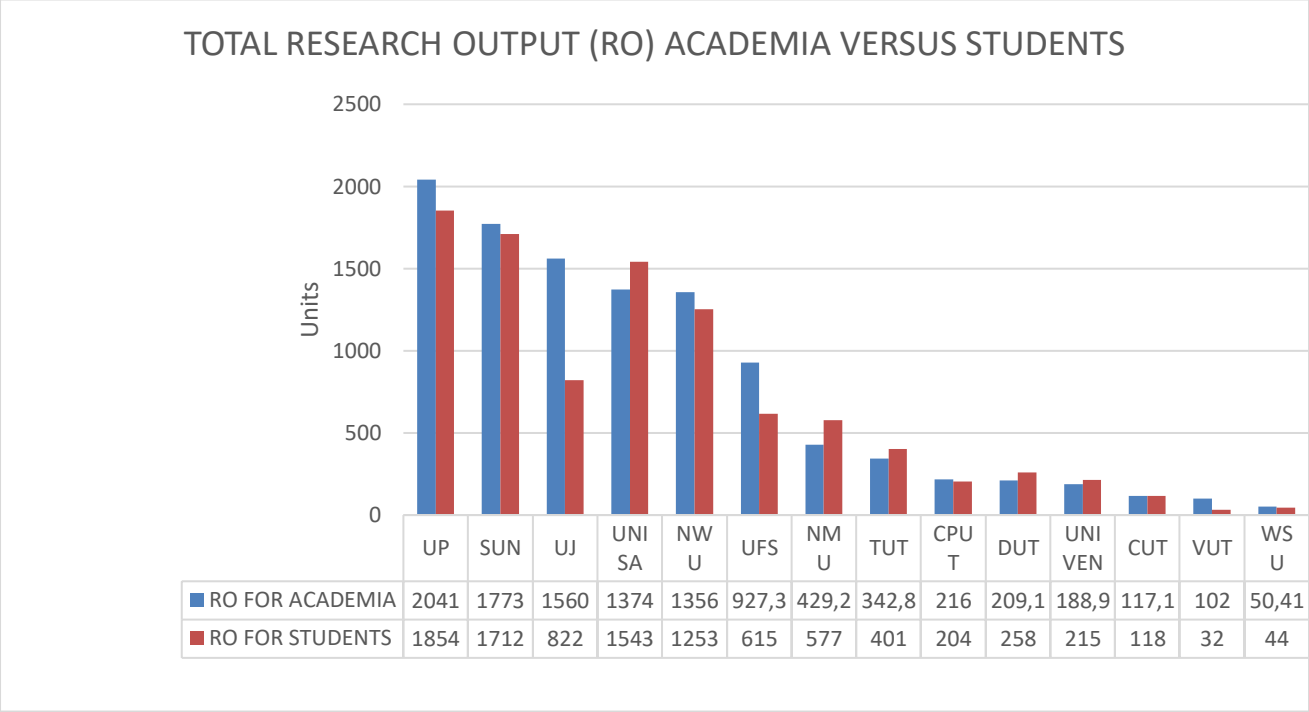
- Research scholarships at master's and doctoral levels;
- Facilitating research collaboration at regional and national levels; and
- Publication output.

The rewarding of quality research output at public HEIs forms the basis for sustaining current R&D and promoting increased productivity of R&D (DHET, 2018). The DHET and National Research Foundation (NRF) are in the process of developing an electronic system for capturing and evaluating submitted research publications for allocating research outputs subsidies to universities (DHET, 2018).

The various academic publication types will be discussed below according to public HEIs with CTLF-related departments. There are 26 public HEIs in South Africa, and 14 have CTLF-

related departments (DHET, 2018; Sihlobo & Mbatha, 2019; Sihlobo & Mbatha, 2022). These HEIs have degrees or diploma programmes with disciplines in Fashion, Consumer Science, Textiles and Clothing Management (Sihlobo & Mbatha, 2019; Sihlobo & Mbatha, 2022).

Academic publications are mostly expected from HEI staff and, to a lesser extent, from students. It is because part of the HEI staff's job description is to contribute to the HEIs through research, and therefore HEIs academia are researchers (HSRC-CeSTII, 2019). Students usually publish if it is part of the curricula as a requirement. According to the University of Pretoria (2020), the master's requirement for academic publication is that a draft article may be submitted based on the research done for the dissertation. It depends on the faculty requirements of the Dean. Whereas for a Doctorate study, a student must submit proof of submission of an article issued by an accredited journal to the Head of Student Administration. Evidence of this is in the research output by academia versus masters and doctoral students (DHET, 2018:33).



	UP	SUN	UJ	UNISA	NWU	UFS	NMU	TUT	CPUT	DUT	UNIVEN	CUT	VUT	WSU
RO FOR ACADEMIA	2041	1773	1560	1374	1356	927,3	429,2	342,8	216	209,1	188,9	117,1	102	50,41
RO FOR STUDENTS	1854	1712	822	1543	1253	615	577	401	204	258	215	118	32	44

FIGURE 4.6: RESEARCH OUTPUT FOR ACADEMIA VERSUS STUDENTS IN 2016

Figure 4.6 shows that most institutions' academia published more than the students except for five HEIs (UNISA, TUT, DUT, UNIVEN and CUT). Kruss and Visser (2017) state that public HEIs were established in diverse periods to meet specific economic and political purposes. Thus, the various HEIs shaped their differential and unequal nature as 'reputationally controlled work organisations'. The reviews from academic publication outputs show that there is a need for continuous investment in R&D. Master's and doctoral students have the potential

to be future researchers and academic publishers. The following section deals with master's theses and doctoral dissertations to understand the situation better.

4.6.1.2 Master's theses and doctoral dissertations

A thesis or dissertation is a document submitted in fulfilment of an academic degree (master's and doctorate), presenting the author's research and findings (University of KwaZulu-Natal (UKZN), 2019). It is because a master's graduate should be:

> "…able to demonstrate specialist knowledge to enable engagement with and critique of current research or practices, as well as advanced scholarship or research in a particular field, discipline or practice (South African Qualifications Authority" (SAQA), 2012:11).

A doctoral graduate is subject to expectations regarding their potential:

> "[Graduates should present] expertise and critical knowledge in an area at the forefront of a field, discipline or practice; and the ability to conceptualise new research initiatives and create new knowledge or practice" (SAQA, 2012:12).

The Department of Higher Education and Training (DHET) reported on the enrolment and graduation of all students in HEIs in the country. The proportion of students that graduated in public HEIs by qualification type in 2016 was 7.7% (6.3% master's degrees and 1.4% doctoral degrees) (Department of Higher Education and Training (DHET), 2018:16).

If students were meant to produce output is less than 10% for all HEIs in the country, there would be limited research theses or dissertations expected from masters and doctoral students.

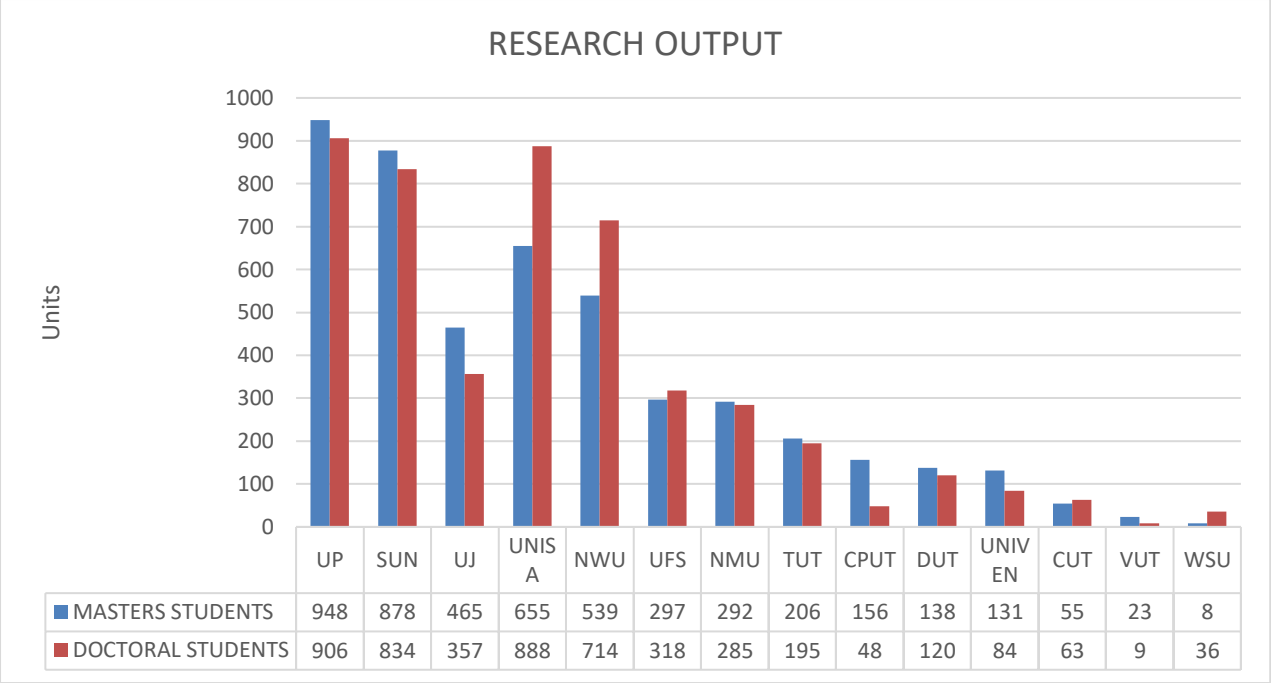


FIGURE 4.7: MASTER'S AND DOCTORAL RESEARCH OUTPUT

Figure 4.7 shows the 9 648 research output of master's (4 791 units) and doctoral (4 857 units) students in 2016/2017. The figure shows results for all fields of study in CTLF-related universities. When looking at the graduation rate versus research output, it shows that doctoral students may be less but are more likely to produce research, while master students are more prominent in number but produce less research. This difference could be due to the differentiation of master degrees, where coursework master courses produce mini theses or dissertations, while research masters produce full theses or dissertations.

There were 21 255 doctoral students for 2016/2017 (HSRC-CeSTII, 2019), meaning there is a potential for over 12 000 graduates, based on graduation statistics, unfortunately, not necessarily in the time frame the DHET had hoped. A doctorate is training for an academic career in which training's real intention is cultivating wisdom (Cloete, Sheppard & Bailey, 2015). A doctorate also allows the education of students into future scholars who will impact the wisdom critically, with insight and sound judgement to contribute to a knowledge economy (HSRC-CeSTII, 2019; Cloete, Sheppard & Bailey, 2015; Frick, McKenna & Muthama, 2017). Due to the low rates of postgraduate enrolment and graduation, little academic output and collaboration are expected. Grindle and Tang (2013:2) argue that students struggle to:

- Manage and transfer their knowledge and R&D results;
- Turn research results into tangible outputs;
- Integrate business needs and perspectives, intellectual property, and knowledge transfer matters;

- Learn skills and abilities needed for current employment demands; and
- Master internal procedures at firms regarding knowledge management and innovation objectives.

There is, however, significant concern about the effectiveness of higher education and doctoral education (Frick *et al*., 2017). The concern regards the future of science and the ability of such qualified people to remain creative and compassionate scholars (Frick *et al.,* 2017). In the Sihlobo and Mbatha (2019; 2022) study, 79% of respondents did not participate in forms of UIG R&D collaborations, while 71% held a master's qualification or higher. This result questions whether the effectiveness of higher education by Frick *et al.* (2017) creates compassionate scholars. The following section explores academic collaborations for research collaboration efforts to see if the lack of master's and doctorate holders to do research is due to the types of academic collaborations available.

4.6.1.3 Academic collaborations

Academic collaboration is a joint venture by researchers of differing stature, funding status, or types of organisations (OECD, 1997). The HSRC-CeSTII (2019) states that HEIs are crucial to R&D and innovation because the fourth industrial revolution (4IR) is a collaborative endeavour that requires all UIG sectors. Joint research activities include contract research and funding of university staff to conduct research and analysis using data published by government funding agencies, universities, and other sources (OECD, 1997). For industry, the key is highly skilled personnel and for HEIs to produce graduates relevant to industry needs. At the same time, the government uses its mechanisms to assist in bridging gaps between industry and HEIs (HSRC-CeSTII, 2019).

The Textile Fashion Centre (2020) states that Sweden brings industry and academia together to develop the CTLF industry in Sweden. The Textile Fashion Centre aims to become Europe's leading Science Park and consists of companies, research institutes, academia, and organisations that support business development. A cooperative agreement was signed between Kanico (a private real estate company), Borås University, and the City of Borås to bring to life the creative hub that is the Textile Fashion Centre for science, culture, innovation, and business opportunities in the textiles industry. The centre has collaborated with over 20 organisations to ensure its functioning.

Below are the academic research collaborations for the centre (Textile Fashion Centre, 2020):

- Grants and Innovation Office of University of Borås;
- Science Parks Borås;

- Smart Textiles research environment; and
- Swedish School of Textiles of the University of Borås.

The centre forms a suggested model to achieve favourable research collaborations. Through investigation, it will be clear what collaborations the Technology Station in Clothing and Textiles has.

Co-publications are developed by industry in collaboration with a university or research institute and compiled by analysing patent records and publication indices using computer technology (OECD, 1997). Madue (2011) defines patents as public documents to describe and legally protect technological inventions such as products or processes. Patents also provide economic monopoly rights as the invention can be made, used, sold, and imported only by or with the patentee's authorisation.

The Hong Kong Research Institute of Textiles and Apparel (HKRITA) has a collaborative research programme that aims to support local SMEs of the CTLF industry (HKRITA, 2018). The HKRITA enhances their technological level and solves technical problems through R&D projects (HKRITA, 2018). The CTLF industry co-applicant must collaborate with a local public research institution and contribute 50% or more of the total project cost (HKRITA, 2018).

In South Africa, there are concerns that most industries have the second-highest number of full-time R&D personnel (4 777.3) but very low concerning HEIs (19 228.8) and overall (27 656.2) (HSRC-CeSTII, 2019). Mbatha (2020) and Mbatha and Mastamet-Mason (2021) found that in the CTLF industry, most firms were not involved with R&D collaborations with topics such as:

- Speed to markets;
- Logistics of CTLF;
- E-business;
- Marketing strategies;
- Sourcing of raw materials;
- Labour productivity;
- Emerging markets;
- Quick response;
- Policies affecting the CTLF industry; and
- Technology in the CTLF industry.

Kruss and Visser (2017) state that universities of technology have a scientific reputation in niche areas and tend to engage with large national firms and SMMEs. The objective is to form

technology transfer relationships and to report on productivity benefits. Only through further investigation will a researcher be able to discover the state of academic collaborations, opportunities, and challenges for academic collaborations.

4.6.1.4 Policy documents and reports

A *policy document* is a document that provides an implementation plan guided by the government's policy commitments and socio-economic development for information, communication, and technology (ICT) (IGI Global, 2020). A *report* is an official document written to give information to a specific audience and for a specific purpose (Merriam-Webster, 2020).

The most recent initiative for the CTLF industry is the establishment of the Retail-CTLF (R-CTLF) Master Plan for 2030 (Barnes, 2018a; Barnes, 2018b; Barnes & Hartogh, 2018; DTI, 2018; Mbatha, 2020; Mbatha & Mastamet-Mason, 2021). The plan focuses on developing the retail value chain to communicate a clear vision and set of objectives, programmatic interventions, and policy support tools by 2030 (DTI, 2018).

The DTI commissioned this master plan via the Trade and Industrial Policy Strategies (TIPS) and reports on four phases for the R-CTLF industry, which include:

- Phase 1: Status quo analysis of the South African R-CTFL value chain (Barnes & Hartogh, 2018) – offers a detailed analysis of the CTLF industry of South Africa;
- Phase 2: Comparative economy lessons for the South African R-CTFL value chain (Barnes, 2018a) – offers industry lessons from similar countries doing well in the CTLF industry;
- Phase 3: South African R-CTFL value chain master plan to 2030 (Barnes, 2018b) – outlines the aims and objectives to be understood by stakeholders to achieve the R-CTFL master plan in 2030; and
- Phase 4: Not issued yet, but the phase is set to deal with policy development to achieve the objectives of the R-CTFL master plan produced through the above-mentioned phases (Mbatha, 2020).

The Master Plan identifies stakeholders such as unions, industry leaders, industry associations, and the DTI as collaborators for the success of the CTLF industry (Mbatha, 2020; Mbatha & Mastamet-Mason, 2021). However, there is a significant shortfall from the master plan as there is no mention of research institutions (such as technology stations or the CSIR) or universities as possible collaborators in solving structural problems of the CTLF industry. The lack of inclusion highlights policy inconsistency as the DTI's crucial action plans in IPAPs include universities as strategic partners (Mbatha, 2020).

This study seeks to determine what policy documents and reports are in place to assist with running the TSCT. It means that policy documents and reports allow for innovation to be tracked from inception to execution phase and thus making it a vital output.

4.6.1.5 Scientific discoveries

A *scientific discovery* is a new invention or innovation created by new or improved technologies to form products or processes from a fruitful scientific inquiry (Schickore, 2018). For scientific discoveries to take place, there are skills for ideal individuals to be successful in scientific inquiry, and they include (National Intellectual Property Management Office (NIPMO), 2017:41):

- Technical background in science and engineering;
- Understanding of the stages of R&D of technologies;
- Understanding the value and suitability of various forms of intellectual property protection;
- Ability to design IP protection strategies to enable commercialisation;
- Ability to market and develop commercial relationships with local and international partners; and
- Ability to negotiate complex transactions while meeting all statutory requirements of the Intellectual Property Rights (IPR) Act.

The NIPMO (2017) reported on Intellectual Property Technology Transfer (IPTT) from 2008 to 2014. The indicators mentioned in the points above will be discussed below, according to the report by NIPMO. In 2014, there were 306 actionable disclosures received from 22 institutions (a mixture of HEIs and science councils), equalling 67.8% of the disclosures received from that year. Actionable disclosures refer to disclosures that the Technology Transfer Function (TTF) has taken forward. The TTF manages various technologies, and in 2014, the TTF managed 1 244 technologies and 629 patent families. Patent families are suites of corresponding patents relating to a specific technology. Institutions filed 216 new patent applications in 2014.

Regarding licences executed, there were 28 for 2014, where 14 were exclusive (rights to single commercial partner), and 12 were non-exclusive (possibility of concluding rights to multiple commercial partners). Between 2008 and 2014, the highest number of licences issued was in 2013, and 37 licences were attributed to a higher licencing activity by one institution. The total IP transaction revenue of 2014 amounted to ZAR 35.6 million. The reports failed to mention industries where these various IPTTs came from, thus, making it hard to report on the CTLF industry. Only through exploration of the TSCT will it be known that individuals contributed to IPTT and were successful.

Internationally, some scientific discoveries related to the CTLF industry from the Advanced Textiles Research Group (ATRG) include (Nottingham Trent University, 2020):

- Fabrication of temperature-sensing fabric (Lugoda, Dias, Hughes-Riley & Morris, 2018);
- Solar energy harvesting textile (Satharasinghe, Hughes-Riley & Dias, 2019); and
- Vibration-sensing yarn for monitoring hand-transmitted vibrations (Rahemtulla, Hughes-Riley & Dias, 2019).

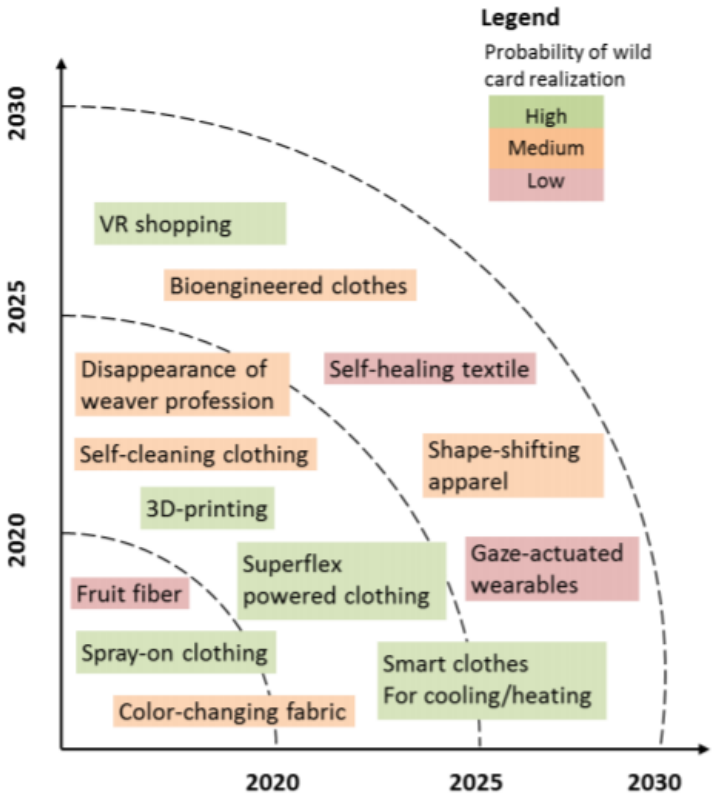


FIGURE 4.8: THE FUTURE OF SCIENTIFIC DISCOVERIES IN THE CTLF INDUSTRY (MILSHINA, PAVLOVA & VISHNEVSKIY, 2019:20)

Figure 4.8 shows several events with a low probability of occurrence but a high impact in case of happening based on the forecasting period as the global CTLF trends from the present time to 2030. By observing the studies from the ATRG, academia is on its way to meeting predictions of CTLF global trends. These global CTLF trends could fundamentally change the future of the CTLF industry to create new opportunities.

Scientific discoveries lead to new or improved products and processes in the CTLF industry. The products and process sections of socio-economic outputs will explain more about this.

4.6.1.6 Graduates with relevant skills

A graduate with relevant skills is a student who can transfer skills learned from an academic degree to the workplace environment and has the competitive skills necessary for the industry (HSRC-CeSTII, 2019; Ishengoma & Vaaland, 2016; Jacobs, 2018). Top-ranked attributes in South Africa for entry-level professions include a passion for the profession, trainability, willingness to learn, and communication skills (Schreck, Weilbach & Reitsma, 2020). In the CTLF industry, specific skills are required to be a successful employee. The Foschini Group (TFG) offers a list of skills to be successful in their graduate programme, such as working with people, building and networking relationships and adapting to change (TFG, 2019).

The TFG's skills requirements suggest that the CTLF industry's top attributes match those of United States graduates: creativity, the ability to work in groups and conflict management (Schreck *et al*., 2020). Graduates in the CTLF industry need skills and a combination of skills, knowledge, and competencies to be employable and thrive in the CTLF industry (Jacobs, 2018). Power, quoted by Jacobs (2018:29), suggests four essential skills areas that make CTLF graduates more employable:

- Technical competencies (knowledge, understanding and abilities);
- Life skills for a globalised knowledge economy (key and occupational skills which comprise interpersonal and intrapersonal skills);
- Higher-order cognitive skills (analysis, synthesis, and evaluation); and
- Metacognitive strategies (learning how to learn and appreciating skill development).

Graduates with relevant skills also have to do with the employability of the graduate or industry placement (experiential training or graduate preparedness) (HSRC-CeSTII, 2019; Ishengoma & Vaaland, 2016). There is a steep unemployment rate among graduates in South Africa (Manenzhe, 2018; Schreck *et al*., 2020), and graduates struggle to get into entry-level jobs. Employers usually require at least one year of work experience from a recent graduate, and most students have only had part-time work or lack work experience (Manenzhe, 2018).

Mbatha (2020) found a mismatch of curricula between the UIG collaboration actors. Industry and government were ahead of HEIs. The HEIs are trying to catch up with the technology being implemented by the industry, thus creating a gap. Jacobs (2018) stated there is a need to focus on curricula development and learning outcomes to prepare graduates for the CTLF industry because knowledgeable graduates add value, feed innovation, and enable global competitiveness. The points made by Mbatha (2020) and Jacobs (2018) require a cultural shift from all members of the UIG collaboration.

According to Tilson-Scoble (2017), there is a disparity between CTLF industry needs and HEIs' graduate provision, and bridging the gap would take an alignment of the expectations of students, educators, and employers. The author states that employers within the CTLF industry report that HEIs produce too many graduates with general CTLF degrees and very few graduates with high-level specialist skills. Many companies have opted to have interns, trainee employees, and graduate programmes to determine if recent graduates have what it takes to be full-time title-holding employees. The process can range from 12 to 36 months (Mr Price Group, 2018; TFG, 2019, Truworths, 2015). Companies created this graduate opportunity system to bridge the gap between graduates and the working environment. Tilson-Scoble (2017) states that there should be a transitional period where employers train graduates for company positions. It will help to build their knowledge and skills, moulding them into productive employees. The trial process allows employers to train and evaluate the graduates to see where the strengths of the graduates lie. The transitional period also allows employers to see if graduates have the potential for an entry to mid-level position in the companies and which position would suit them best.

Manenzhe (2018) states that this system usually benefits employers as they do not have to pay their graduates full benefits, and sometimes the contracts are unpaid. It then makes it harder for graduates as they cannot financially support themselves after graduation and usually must rely on family for financial support (Manenzhe, 2018; Worku, 2018). Recent graduates aspire to have white-collar jobs because labour-intensive jobs are perceived as non-legitimate career paths (Manenzhe, 2018). This perception is especially true for graduates from disadvantaged backgrounds. They end up not coping because of failing to make ends meet. However, companies like Truworths offer a permanent role in the company and receive a very competitive salary and benefits such as medical aid, retirement fund, group life assurance, and discount facilities (Truworths, 2015).

Christie's (2016) study explored an overview and analysis of skills development in the Western Cape CTLF Industry. The study was in the context of production upgrading to see if policy allegations were meeting industry requirements. The study found that public skills development institutions, such as Sector Education and Training Authorities (SETAs), cannot provide the training these CTLF firms require. There are 21 SETAs, and they are vocational skills training institutions responsible for managing and creating learnerships, internships, unit-based skills programmes, and apprenticeships (Chemical Industries Education and Training (CHIETA), 2017). The SETAs cannot provide the required training due to skills gaps and shortages at technical and managerial levels. There will be delays in transitioning to the new Quick Response (QR) production methods, and the retail supply model will be unsuccessful for firms. Publicly funded institutions not providing the required training encouraged

manufacturing firms to seek private funding training programmes to resolve the training problem. It is a short-term solution, as it does not ensure a sustainable transitional solution for the industry's development, growth, and success.

The preceding sections show that traditional academic outputs (TAOs) are vital. The TAOs showed that students, graduates, and academia are crucial stakeholders in driving these outputs. One major takeaway from the TAOs was that many of the TAOs led to socio-economic outputs. The following section will present socio-economic outputs to understand the benefits of various UIG stakeholders explored.

4.6.2 Socio-economic outputs

Socio-economic outputs (SEOs) are social and economic outputs. *Social outputs* benefit society only if they can be converted into marketable and consumable products (Bornmann, 2013). Economic outputs benefit a country's economy (Impact DataSource, 2014). SEOs are new or improved products and processes, community infrastructure and facilities, spin-off companies and cultural artefacts that depend on the country or region (Kruss & Visser, 2017). These will be briefly discussed below.

4.6.2.1 New or improved products

Products are items (physical, virtual, or cyber) made at a cost and offered for sale (The Economic Times, 2020). Each product has a useful life after which it needs replacement and a life cycle after which it must be re-invented (The Economic Times, 2020). New or improved products contribute to intellectual property (such as licences, patents, copyright, and trade secrets) and can be commercialised for socio-economic benefits (Kruss & Visser, 2017).

In 2015/2016, the DTI took on strategy differentiation to support the development of new products and processes through the Technology and Human Resources for Industry Programme (THRIP) (DTI, 2018; TIA, 2020a). The THRIP supports collaboration between government, industry and HEIs to produce technology solutions and relevant human resource skills to implement (DTI, 2018; Potgieter, 2012).

Mbatha (2020) reported that the government does fund CTLF industry UIG R&D through the THRIP. Such UIG collaborations have produced the following new or improved products: 1) An orthopaedic shoe for diabetic people to assist with foot problems associated with diabetes; 2) A research pilot produced a blended yarn that was mechanically modified. The modification was done by blending cutinised flex waste fibres with cotton-like fibres; and 3) An unsuccessful UIG R&D product with brailled price tags for clothing for blind or visually impaired people. The lack of success was due to the university acting alone in the project, and government and

industry were not part of the collaboration for the project. The braille price tag product was successful because it has intellectual property and benefited blind or visually impaired people.

There are opportunities for developing new or improved products found by Mbatha (2020). Due to South Africa's favourable weather conditions, the growth of natural fibres would be favourable. South Africa supplies massive volumes of raw wool and mohair fibres, and 95% of raw wool fibres are exported. Very little (5%) wool beneficiation takes place in South Africa, so the opportunity exists to improve wool products by increasing their local beneficiation.

This study seeks to find the outputs of various products created from the TSCT and see if they had socio-economic benefits. It would also be interesting to find out whether the focus of the TSCT would be on products or processes.

4.6.2.2 New or improved processes

According to Yin (2016a), manufacturing processes are a series of steps or actions executed to get from raw materials to the final product. The process manufacturing industry defines the flow between steps and highlights the continuous modification and deformation features of mass flow during the technological process. Process or product modifications are identified as necessary and include (Süli, 2019):

- Identifying additional workforce requirements for production and testing;
- Creating and updating a training plan;
- Conducting and updating process failure modes and effects analysis;
- Establishing process capability requirements;
- Creating and updating control plans and work instructions; and
- Identifying assembly processes.

New or improved processes are processes that contribute to intellectual property (IP) (such as licences, patents, copyright, and trade secrets) and can be commercialised for socio-economic benefits (Kruss & Visser, 2017). The Hong Kong Research Institute of Textiles and Apparel (HKRITA) have made a waterless dyeing process for polyesters and cotton using supercritical carbon dioxide (Sc-CO_2) (HKRITA, 2018). The dyeing technology addresses two environmental problems: water scarcity and wastewater production. This dyeing process is the non-aqueous solvent medium (NASM) dyeing technology (HKRITA, 2018). The NASM dyeing system could save 20% of operating costs and take between 60 to 240 minutes to complete the dyeing process, saving up to 66% of dyeing time (HKRITA, 2018). By HKRITA improving the dyeing process, they were innovative and pioneered a process that, if needed,

could reap many IP economic benefits and benefit the health of people and the environment socially.

The South African DTI and IDC collaborated to establish the exotic leather goods Quick Response (QR) design studio in New York (DTI, 2017). The goal of the QR process is inventory management and having stock on hand that accurately reflects consumer demand, resulting in fewer and less drastic stock-outs and left-over stock (Choi, 2017; White, 2017). Exotic Leather South Africa (ELSA) is part of the collaboration, and the purpose of the design studio is to integrate a Cape Town-based design facility with the New York studio (DTI, 2017).

The results of QR are evident in the findings in footwear exports in the CTLF industry. From 2011 to 2015, the footwear and leather industry exports increased from 2.6 million pairs to 4.1 million pairs. With the industry's growth rate, it was necessary to create a component-manufacturing industry (DTI, 2017). It led to the establishment by the DTI, IDC, and NFLC of the Footwear and Leather Goods component sub-national cluster. The cluster aims to enhance collaboration, advanced technology demonstration, and supply chain capabilities in the footwear and leather industry (DTI, 2017). The example shows how improving a process leads to establishing other avenues to benefit the CTLF industry and the socio-economic environment.

4.6.2.3 Community infrastructure and facilities

Community infrastructure is the physical systems of a business or nation, such as transportation (air, water, road, and rail), communication, sewage, water, and electric systems that are vital to a country's economic development (Chappelow, 2019). *Community facilities* offer health and emergency services, social and cultural public services, civic services, social services, education services, and parks and recreation services in a country (CSIR, 2012). Cho (2014) indicated that UIG R&D collaborations improve infrastructure and facilities as well as the ability of a university to become an entrepreneurial university. Universities should provide a supportive environment with access to necessary infrastructure and industry relationships that are encouraged by the department and, ultimately, the university (MacGregor, 2015; Spinoglio, 2015). The Hong Kong Research Institute of Textiles and Apparel (HKRITA) developed an artificial intelligence (AI) tool that makes real-time fashion colour trend predictions based on social media data (HKRITA, 2018). This technology allows decision-makers in the CTLF industry to monitor and forecast preferred colours and CTLF items (HKRITA, 2018).

Community infrastructure in the CTLF industry would be systems in place that would combat waste from the CTLF industry. The Western Cape Industrial Symbiosis Programme (WISP) is

an example of this. During the drought season in the Western Cape from 2017 to 2018, WISP was able to offer CTLF firm support and safeguarded 3 600 jobs, and firms had an average reduction of 35% in water consumption (GreenCape, 2019). Furthermore, from 2013 to 2018, the WISP was able to divert 1 200 tonnes per year of water diverted from landfill and invest ZAR 6.5 million of private investment into recycling textiles (GreenCape, 2019). By doing this, the CTLF industry implemented resource efficiency without affecting profit because of the community infrastructure that was in place.

Community facilities in the CTLF industry would be CTLF research centres or places that offer public services. The Council for Scientific and Industrial Research (CSIR) undertakes and supports research in diverse areas of science, technology, and innovation (STI) (DTI, 2018). It is to enhance industrial and scientific development to improve the quality of life of South Africans (DTI, 2018). The CSIR and DST created the Textiles and Clothing Centre of Excellence (TCCoE) (previously Textiles Engineering Centre of Excellence (TECoE)) in Port Elizabeth (now called Gqeberha) to implement skills strategy in the CTLF industry (DTI, 2007; DTI, 2010; Mbatha, 2020). In general, a Centre of Excellence is a

> "…physical or virtual centre of research that concentrates existing research excellence, capacity and resources to enable researchers to collaborate across disciplines and institutions on long-term projects that are locally relevant and internationally competitive in order to enhance the pursuit of research excellence and capacity development. The five key performance areas of Centres of Excellence are: research/knowledge production, education and training, information brokerage, networking, and service rendering" (DST, 2019: vi).

The initiatives to be developed through the TCCoE were (DTI, 2010):

- South African garment sizing database utilising 3D body scanner technology;
- Computer-aided design (CAD) using 3D scanner data;
- Processing capabilities of new natural fibres (flax, wild silk, cashmere, and Kenaf);
- Non-woven products and fibre-reinforced composites through new technologies; and
- Technologies in garment designing.

In 2014, HEIs with 3D body scanning technology, University of South Africa (UNISA) and Cape Peninsula University of Technology (CPUT) were added to finalise the 3D body scanner technology data for implementation by the South African garment manufacturers by 2015 (DTI, 2014; Mbatha, 2020). A notable achievement for the CSIR is the development of the world's first digital laser to assist in manufacturing at the TCCoE (Mbatha, 2018). Although the above-mentioned achievements fall under community infrastructure and facilities, they could also be

considered products or processes. However, the primary purpose of these additions was to improve the greater community rather than explicitly making a profitable product in the CTLF industry. The latest for the CSIR is developing a financial proposal for the CTLF Competency Centre in Port Elizabeth (now called Gqeberha) to develop new leather, leather goods and footwear testing capacities in collaboration with the Shoes and Allied Trade Research Association (SATRA-UK) (DTI, 2018). The TSCT plays a significant role in the community, and their contributions seek to be explored in this study.

4.6.2.4 Spin-off companies

Spin-off companies are formed by creating an independent company from a parent company, an existing business or the commercialisation of research (Etzkowitz *et al*., 2007; Fontinelle, 2019). On a smaller scale, spin-off companies are new small and medium enterprises (SMEs) or small, medium, and micro enterprises (SMMEs). They are formally, informally, or non-VAT registered businesses or start-up ventures (Small Enterprise Development Agency (SEDA), 2016).

Nottingham Trent University (2020) states that research spin-off companies have the potential to create:

- New collaborations with organisations and businesses;
- New jobs;
- Money going back into the local economy; and
- Money to fund further research.

In South Africa, publicly funded IP start-up companies only started in 2011. In 2014, 11 of the 15 new start-up companies were publicly funded (NIPMO, 2017). The total number of fully operating companies at the end of the financial year was 45 (NIPMO, 2017). Due to confidentiality reasons, the industries were concealed. It means CTLF-related spin-off companies could not be identified. This example shows that spin-off companies created through academic research are possible, specifically, a technology station, instead of the industry and will form the focus of this study. Empirical evidence was not found on spin-off companies that arose for research purposes in South Africa from the CTLF industry.

Worku (2018) found that out of 250 CTLF entrepreneurs, only 6.40% had a master's degree or above in the Tshwane (Pretoria) area. It means that entrepreneurs either cannot further their education or choose not to because education does not translate to a successful business. Most entrepreneurs start businesses as a means of living and not to solve socio-

economic issues in the province or country. Only through the exploration of the activities in the TSCT will there be knowledge of spin-off companies resulting from the technology station.

4.6.2.5 Cultural artefacts

Artefacts are designs and creative works that are non-textual outputs (images, performances, objects, and designs) that result from original, systematic investigation to gain new knowledge and understanding, leading to new or substantially improved insights (Council of Higher Education, 2005:15; Madue, 2011:162).

Internationally, a public display or celebration of cultural artefacts in the CTLF industry is the Met Gala, also known as the Met Ball. The ball is formally called the Costume Institute Gala. The Met Gala is an annual fundraising event for the benefit of the Metropolitan Museum of Art's Costume Institute in New York City (Teather, 2019).

FIGURE 4.9: MET EXHIBIT 2018 – A CHRISTIAN LACROIX WEDDING ENSEMBLE (TABLANG, 2019)

According to The Metropolitan Museum of Art (The Met) (2020), the Costume Institute has over 33 000 items in its comprehensive collection and items dating back to the 15th century. Every first Monday of May marks the opening of the Costume Institute's annual fashion exhibit. Figure 4.9) shows part of The Met's most visited exhibition, Heavenly Bodies: Fashion and the

Catholic Imagination (Tablang, 2019). This exhibition attracted over 1.65 million visitors to The Met Fifth Avenue and The Met Cloisters from May to October 2018. The exhibition featured a dialogue between fashion and medieval art to examine fashion's ongoing engagement with devotional practices and traditions of Catholicism. Highlights of the exhibition were papal robes and accessories from the Sistine Chapel sacristy, which had never been outside the Vatican (Tablang, 2019).

Another example of cultural artefacts is the Sweden Textile Fashion Centre. This institution enhanced the triple helix approach by having a Textile Museum to attract visitors to the Textile Fashion Centre (Textile Fashion Centre, 2020). The Textile Museum is a leading Nordic Region's Museum in textiles, and visitors can create research and experience textiles in all their forms (Textile Fashion Centre, 2020).

Both international examples show how CTLF cultural artefacts yield socio-economic benefits for society and have proven successful in developed countries. The research aims to deepen the understanding of CTLF industries through archives to inform new interpretations and develop contemporary art and design practices for future cultural and economic benefit. Bada (2013) stated that fashion tourism in Africa depends on developing a separate framework for fashion tourism: better marketing, security, and consistent promotion efforts. Adinolfi, Tichaawa and Banda (2018) state that there is insufficient research; however, fashion tourism has the potential for socio-economic development. The authors stated that fashion tourism could potentially shape the city's image. TSCT investing in fashion tourism will improve the City of Cape Town and Western Cape Province and attract international consumers.

Doctor of Arts and Design, Esther Mahlangu, has become an ambassador for South African Ndebele heritage and art (South African History Online (SAHO), 2020; Young, 2020). She does this by sharing Ndebele cultural heritage with the world through her geometric and symmetrical abstract paintings and murals that showcase Ndebele's traditional paintings (Mun-Delsalle, 2019). In 1991, she became the first woman and African to create artwork on a BMW 5 Series (525i) (see Figure 4.10) (Mun-Delsalle, 2019; SAHO, 2020; Young, 2020).

FIGURE 4.10: BMW 5 SERIES 1991 (BMW ART CAR COLLECTION, 2023)

In 2020, Mahlangu became the first South African to have her distinctive Ndebele artwork displayed on the interior of a customised Rolls Royce Phantom (see Figure 4.11) (Young, 2020). She was also the first South African artist to be commissioned to create a painting for The Melrose Gallery, Cape Town, inside a new Phantom (Young, 2020).

FIGURE 4.11: ROLLS-ROYCE PHANTOM (THE MELROSE GALLERY, 2020)

Mahlangu has successfully brought her traditional Ndebele art of painting into a new context, applying her artistic vocabulary to sculptures, ceramics, cars, and aeroplanes (Mun-Delsalle, 2019). Figures 4.10 and 4.11 show how much Mahlangu grew as a designer from 1995 to 2020. She received an honorary doctorate from the University of Johannesburg (AFI, 2018) based on a lifetime period of work and contribution. Although Mahlangu enjoys many prestigious accolades for her work, it is essential to note that her cultural artefacts were not linked to academia. Historians and artists have cited her for her contribution to African art. Her work contributes to socio-economic outputs because, through her work, South African art has been recognised internationally. Through financial support, she has been able to help keep the Ndebele culture alive. With her success and lack of formal education, it questions whether cultural artefacts may be found in the TSCT because involving educational processes is a lengthy process.

According to the National Intellectual Property Management Office (NIPMO) (2017), design and copyright protection are available in South Africa. Laduma Ngxokolo, a Textile Design and Technology graduate, developed the isiXhosa knitwear range using Xhosa beadwork and colours. The range won the 2010 Society of Dyers and Colourists Design Award (international design competition in London) and was presented at the 2011 Design Indaba Conference. To protect his IP designs, he sought support by filling in design registrations for the initial five designs he did at his HEI.

FIGURE 4.12: XHOSA-INSPIRED SHAWL BY LADUMA NGXOKOLO (DESIGN INDABA, 2020)

From that, he also sought funding, access to networks of support and space for manufacturing for his business. Through establishing his business, Maxhosa by Laduma, and continued IP maintenance, Ngxokolo could mature his business. In 2016, one of Ngxokolo's designs won 'The most beautiful object in South Africa' (see Figure 4.12) at the Design Indaba (NIPMO, 2017).

The example by NIPMO fails to acknowledge whether Ngxokolo received IP rights after he filed his designs and if they were all accepted or rejected. It also does not mention the length of the process to register designs formally or if it affected the continuation of his journey. Ngxokolo enjoyed socio-economic outputs: he received funding and established a business. Due to his cultural artefacts, his work was recognised internationally, and he won many awards.

Finding examples related to cultural artefacts proved challenging since formal registration of designs or disclosures is not highly populated or limited in South Africa. Through further research exploration, it can be established whether people are aware of such resources available to protect their IPs and whether people are not using their IPs for other reasons. Cultural preservation is important in all examples of cultural artefacts (Adinolfi *et al.*, 2018; Bada, 2013). IP registration preserves cultural artefacts for future generations to enjoy and learn about various cultures, as well as protects creative works to avoid infringements or stolen creative works.

South Africa is a culturally diverse and historically rich nation, with many examples of informal cultural artefacts (more specifically, fashion tourism) (Adinolfi *et al.*, 2018). People only find out through education and research that designs can be protected and considered valuable to society (Bada, 2013). Finding out whether cultural artefacts exist in the TSCT will put into perspective where South Africa is in terms of research. In addition, the researcher can then understand what benefits could be reaped economically or socially once the state of the cultural artefacts is known. Luo and Dong (2017) state that local designers could be inspired by cultural artefacts in their nations and will generate unique ''culturally-oriented products'' with distinct national features to maintain regional ethnic characteristics and cultural integrity. Cultural artefacts promote a country so that its unique designs are sought in international markets.

According to Kruss and Visser (2017), universities of technology have higher frequencies of socio-economic outputs than traditional academic outputs. With the Technology Station in Clothing and Textiles (TSCT) being situated at a university of technology, this research explores whether the finding by Kruss and Visser (2017) is accurate. Literature from the CTLF industry, TIA, and UIG collaborations was collected, as well as a theoretical perspective on

NSI, the triple helix, and outputs. The following section will conceptualise how all these factors work together.

4.7 PRESENTATION OF THE CONCEPTUAL FRAMEWORK

A conceptual framework (see Figure 4.13) contains all the key concepts in a research study of the reviewed literature and how the researcher will explain the topic under investigation by mapping out the actions required during the study (Quinlan, Babin, Carr, Griffin, & Zikmund, 2015; Regoniel, 2016). This study seeks to describe UIG collaboration outputs in the CTLF industry of the Western Cape Province, South Africa. Understanding innovation systems such as the triple helix innovation models (TH I, TH II and TH III) gave a theoretical perspective to understanding the role of university, industry and government in a society. In order to study the outputs of the UIG spheres, the collaboration of the UIG spheres were explored. These UIG spheres were explored according to the CTLF Western Cape industry of South Africa and various UIG collaborations were found.

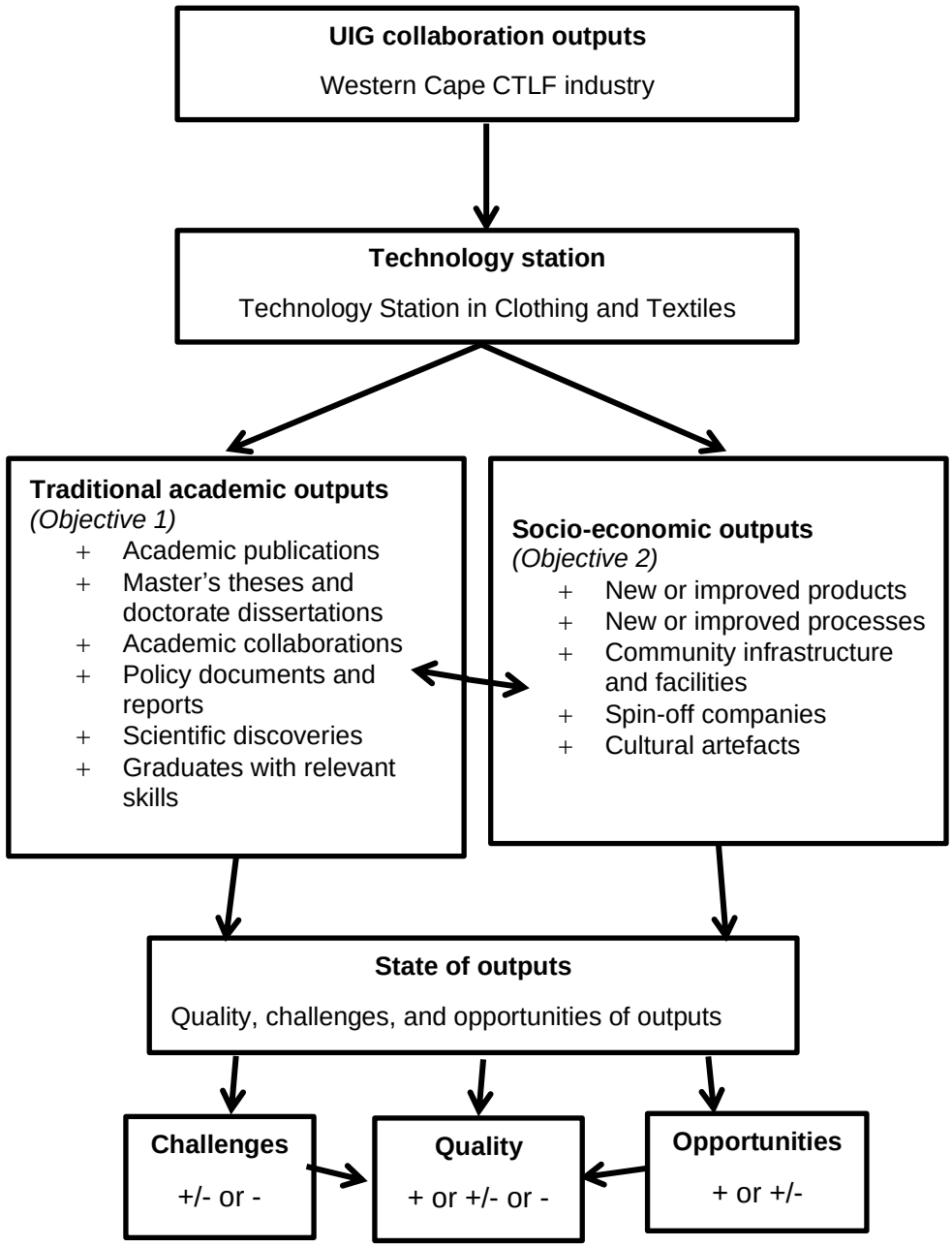


FIGURE 4.13: CONCEPTUAL FRAMEWORK

The success of the UIG collaboration outputs depends on certain intermediaries such as technology transfer centres or offices, university incubators and collaborative research centres (Villani, Rasmussen & Grimaldi, 2017). In South Africa, technology stations provide technology transfer infrastructure to support various industries and universities in creating innovative science, engineering, and technology (SET) solutions to support the government's socio-economic priorities (DST, 2018b). The Technology Station in Clothing and Textiles (TSCT) is currently the only technology station for the CTLF industry in the Western Cape (DST, 2018b). This study focuses on the CTLF industry, which is why the TSCT is a suitable technology station to study. The focus is based on this study's aim 'to investigate outputs from

UIG collaborations in the Technology Station in Clothing and Textiles (TSCT) of the Western Cape, South Africa'. Kruss and Visser's (2017) versions of outputs, traditional academic outputs, and socio-economic outputs are investigated from the TSCT to understand outputs from UIG collaborations. The outputs are based on the two objectives stated in Chapter 1. The two objectives are:

OBJECTIVE 1: To investigate traditional academic outputs (TAOs) from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

OBJECTIVE 2: To investigate socio-economic outputs (SEOs) from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

Each objective has criteria listed in the TAOs and SEOs boxes. The six TAOs include academic publications, master's theses and doctoral dissertations, academic collaborations, policy documents and reports, scientific discoveries, and graduates with relevant skills. The SEOs are five and include new or improved products, new or improved processes, community infrastructure and facilities, spin-off companies, and cultural artefacts.

The exploration of the outputs is to determine which outputs are being explored in the TSCT. The states of the outputs will show the availability of outputs (what outputs are published TAOs or new or improved SEOs). Then, based on the findings, the quality, challenges, and opportunities of the outputs from the TSCT will also be explored. For this study, opportunities would be favourable circumstances that could support furthering the TSCT in terms of STI either directly or indirectly. At the same time, challenges would be limitations to achieving the strategic objectives of the TSCT based on the triple challenges of poverty, inequality, and unemployment.

The state of the outputs will be used to analyse the quality of the TSCT outputs. If the outputs are marked with a plus (+) sign, it will indicate good quality, and a plus-minus (+/-) sign will indicate moderate quality, and a minus (-) sign will indicate low quality. Then the overall quality of the two output groups will be analysed to make conclusions about the outputs for the TSCT.

Studying UIG collaboration outputs in the TSCT presents an opportunity for innovation to be tracked. Therefore, knowing the technology station's outputs will improve UIG collaboration outputs in the Western Cape CTLF industry.

The conceptual framework above shows that understanding the UIG collaboration outputs, Technology Station in Clothing and Textiles (TSCT) outputs, and the state of the outputs will lead to the success of this study. This understanding will assist this study in contributing to the body of knowledge on UIG collaboration outputs in the Western Cape CTLF industry.

4.8 CONCLUSIONS

This chapter includes an overview of the NSI and the triple helix, a comparison of the NSI and triple helix, and the outputs of UIG collaborations. The NSI and the triple helix system are new knowledge or knowledge economy creators, acquirers, diffusers, and positioners to help South Africa achieve individual (role of each institutional sphere) and collective goals in UIG collaborations. The two types of outputs by Kruss and Visser (2017) were explored and used to create the conceptual framework. A standard gap was found in all the literature explored where limited studies focus on applying theories in the CTLF industry. The next chapter explains the research design and methodology used to gather the data for this study.

CHAPTER 5: RESEARCH DESIGN AND METHODOLOGY

"Be thankful for what you have; you'll end up having more. If you concentrate on what you don't have, you will never, ever have enough." ~ Oprah Winfrey

5.1 INTRODUCTION

The purpose of this chapter is to discuss the research design and research methodology used to conduct this study. The methodologies used for this study are outlined to respond to the research aims and objectives from Chapter 1. This study aimed to investigate outputs from UIG Collaborations in the Technology Station in Clothing and Textiles (TSCT) of the Western Cape, South Africa. The two objectives were:

OBJECTIVE 1: To explore traditional academic outputs (TAOs) from UIG collaborations in the TSCT, focusing on their quality, challenges and opportunities.

OBJECTIVE 2: To explore socio-economic outputs (SEOs) from UIG collaborations in the TSCT, focusing on their quality, challenges and opportunities.

After the research design and methodology, the operationalisation of this study will be tabulated and discussed. Then the quality of this study and various ethical issues will be discussed.

5.2 PHILOSOPHICAL WORLDVIEW

The philosophical view was explored to understand this study's research design and methodology. Saunders, Lewis, and Thornhill (2019:130) state that research philosophy is "a system of beliefs and assumptions about the developing knowledge" in a particular field. The authors state that there are five philosophical worldviews, and they are: positivism, critical realism, interpretivism, postmodernism, and pragmatism. This research took a pragmatic approach.

According to Saunders *et al.* (2019), the pragmatism view reconciles both objectivism and subjectivism. It considers theories, concepts, ideas, hypotheses, and research findings. Pragmatism research starts with a problem and aims to contribute practical solutions that inform future practice (Creswell, 2014; Saunders, Lewis & Thornhill, 2019). The worldview was deemed appropriate for this study because the focus is on outputs of the TSCT to report on quality, opportunities, and challenges of the TSCT.

5.3 RESEARCH DESIGN

Research design is a structured framework of how the research process would be conducted to solve a problem (Babbie, 2016). The research design was the plan used to conduct the research with the end product and logic of the research in mind (De Vos, Strydom, Fouché & Delport, 2005; Mouton, 2001). The case study research design was used to examine the in-depth complexities of what happened in a bounded system of people and is suitable for poorly understood or limited research knowledge (Clark & Creswell, 2015; Creswell, 2014; Leedy & Ormrod, 2015). This study used a case study research design because of the research philosophy, field discipline, and advantages associated with the research design.

This study had a pragmatic approach, an aim, and two objectives. In Chapter 1, Section 2, the problem was stated that some "form of collaboration needed to exist for the CTLF industry to improve". The justification section alluded that the research was necessary for innovation to be tracked. From exploring the literature and studying this study's theoretical framework, it was concluded that the case study research design is suitable for this study's research philosophy.

Yin (2018) states that case study research is found in many social science disciplines and among practising professionals. Studies that employ case studies in the CTLF industry are Foster and Yaoyuneyong (2014); Mbatha (2020); Mbatha and Mastamet-Mason (2021); Mbatha, Mastamet-Mason and Seda (2019); Sihlobo and Mbatha (2019; 2022). However, those specifically focused on UIG collaborations in the CTLF industry are Mbatha (2020) and Sihlobo and Mbatha (2019; 2022). The exploration of the various studies makes it suitable for this study to have used a case study research design.

The case study design has the following advantages (Tetnowski, 2015):

- Capturing complexities of a phenomenon;
- Having a more in-depth description of a phenomenon;
- Flexible research design that is easily combined with additional case studies; and
- Use of multiple sources of evidence.

The advantages mentioned above benefitted this study by fulfilling the aim and objectives of this study by investigating outputs. Yin (2018) states that case study research is a method of investigation to study a case (unit of inquiry) or cases. The goal is to understand the case, how it works and how it interacts with the real-world contextual environment. Yin (2018:32) also suggests two reasons to choose a case study: 1) The main research questions answer ‘how’ and ‘why’ questions, and 2) The focus of this study is a contemporary phenomenon.

This study focused on a contemporary phenomenon because it explores university-industry-government collaboration outputs in a minimally explored CTLF industry. This study has ‘how’ and ‘why’ questions. The main research questions are in Addendum A to C to show ‘how’ and ‘why’ questions. Case studies have a vast application and aim to investigate a social phenomenon such as an individual, group, institution and profession by combining multiple forms of data (Gillham, 2005).

There are also disadvantages to using case study research indicated by Rose, Spinks, and Canhoto (2015):

- Time-consuming research design;
- Selection bias – the researcher is the primary instrument of data collection and analysis;
- Universals cannot be found – knowledge is context-dependent;
- Findings cannot be statistically generalised;
- Difficulty in summarising case studies; and
- Lack of guidelines to compile a final report.

The researcher was time efficient by automating processes where possible, which would take time if done manually. The researcher also adhered to various researcher ethics (see Section 5.10). The researcher understood that the research was not based on finding universals or generalisations but on studying a case. The purpose of the current research is not to find universals but to study the case of the TSCT.

The researcher studied previous studies to summarise the case, compile a final report and reduce the disadvantages by using multiple data sources to draw a case. Yin (2018) states that case study research is found in many social science disciplines and practising professionals. Studies that employ case studies in the CTLF industry are Foster and Yaoyuneyong (2014); Mbatha (2020); Mbatha and Mastamet-Mason (2021); Mbatha, Mastamet-Mason and Seda (2019); Sihlobo and Mbatha (2019). However, those studies that specifically focused on UIG collaborations in the CTLF industry are by Mbatha (2020) and Sihlobo and Mbatha (2019). The researcher also used past research studies (Foster & Yaoyuneyong (2014); Kruss & Visser, 2017; Mbatha (2020)) as a basis to learn how to improve on the findings of this research. All these efforts lowered the potential disadvantages of the case study research design and helped answer this study's aim and objectives.

The research design forms the umbrella from which the research methodology will branch. The research methodology will be presented in the next section.

5.4 RESEARCH METHODOLOGY

Research methodology explains the methods, techniques and procedures used in the research design process (Babbie, 2016).

This study employed a qualitative methodology. Qualitative research allows the research problem to be studied for a deeper understanding of a new phenomenon, to analyse themes, and to conduct an inquiry reflexively (Clark & Creswell, 2015; Creswell, 2014). Maxwell (1992) (in Miles, Huberman & Saldaña 2014:273) suggests that for qualitative research to have a deep understanding, it should be:

- Descriptive – what happened in specific situations;
- Interpretive – what it meant to the people involved;
- Theoretical – the concepts, and their relationships, used to explain actions and meanings; and
- Evaluative – judgments of the worth or value of actions and meanings.

The researcher ensured the research was descriptive by studying specific situations within the TSCT, interpretive by collecting data, theoretical by basing the research on the theoretical framework, and evaluative by following particular steps to data analysis.

The qualitative methodology was suitable for this study because it enables credible, well-founded, reliable, and relevant data collection (Saunders et al., 2019). The research also explores experiences and perspectives for a single concept (Clark & Creswell, 2015). The single concept was 'outputs' in the TSCT to uncover themes found in the data. The next section will answer how the population was determined for this study.

5.4.1 Population

The population is defined as a small and similar or broad and diverse originating group where a subset of that group will be studied (Stewart & Cash, 2018). The population of this study consisted of 18 technology stations in South Africa. These are (DST, 2018b):

- Technology Station in Electronics (TSE);
- Metal Casting Technology Station (MCTS);
- Technology Station for Materials and Processing Technology (TSPMT);
- Product Development Technology Station (PDTS);
- eNTSA – Innovation Through Engineering;
- InnoVenton: Institute for Chemical Technology;
- Technology Station in Clothing and Textiles (TSCT);

- Agrifood Technology Station (ATS);
- Limpopo Agro-Food Technology Station (LATS);
- Technology Station in Chemicals (TSC) – Tshwane University of Technology (TUT);
- Technology Station in Chemicals (TSC) – Mangosuthu University of Technology (MUT);
- Reinforced and Moulded Plastics Technology Station (RMPTS);
- Institute for Advanced Tooling – Tshwane University of Technology (IAT-TUT);
- Institute for Advanced Tooling – Walter Sisulu University (IAT-WSU);
- Institute for Advanced Tooling – Stellenbosch University (IAT-SU);
- Adaptronics Advanced Manufacturing Technology Laboratory (AMTL);
- Process Energy and Environmental Technology Station (PEET); and
- Technology station in Rural Sustainable Development (TSRSD).

The Technology Innovation Agency (TIA) focuses on the priorities set out by the South African Department of Science and Technology (DST) in three areas (DST, 2019): the bio-economy strategy, Technology Stations Programme, and commercialisation. By advancing the three areas, TIA wants to align with broader national government socio-economic imperatives of poverty, inequality, and unemployment (DST, 2019). Focusing on the technology stations made this study relevant and aligned with national government issues. The selected population allowed this study an opportunity to use a suitable population to arrive at findings that addressed this study's aim and objectives.

5.4.2 Sample and sampling technique

A sample is a subset of a population to be studied (Stewart & Cash, 2018). Sampling means a subset is chosen to study out of the 18 technology stations mentioned in the previous section. Selecting a sample from a population was necessary to narrow the population from a broadly diverse group into a small, specific subset group (Stewart & Cash, 2018).

Purposive sampling was used in this study. The purposive sampling technique determines who or what to include in a sample based on sought-after characteristics (Kumar, 2011; Quinlan, Babin, Carr, Griffin, & Zikmund, 2015). The characteristic sought after for this study was a technology station specialising in clothing, textiles, leather, and footwear (CTLF) in a province where the CTLF industry is a driving industry.

The strategic province for this study was the Western Cape. The Western Cape is one of the central locations where the CTLF industry operates (CCTC, 2017; DTI, 2015; FP&M-SETA, 2014; Mbatha, 2018). While KwaZulu-Natal was viewed as a solid CTLF industry region, it has no clothing-related technology station, making it a suitable case to be studied in line with the set aims and objectives.

Of the 18 technology stations, the technology stations in the Western Cape were observed. In the Western Cape, there are four technology stations, namely, the Advanced Manufacturing Technology Laboratory (AMTL), Agri-food Technology Station (ATS), Technology Station in Clothing and Textiles (TSCT), and Institute for Advanced Tooling – Stellenbosch University (IAT-SU).

This characteristic was crucial in addressing this study's aim and objectives because the collaboration outputs explored were from the university, industry, and government (UIG). Only through the characteristics above-mentioned would UIG collaborations be acceptable.

The TSCT was the research institution chosen because it met these characteristics: It is a UIG, a technology station, and it is in the Western Cape.

5.5 SECONDARY DATA COLLECTION

According to Rouse (2016), data collection is a systematic approach to gathering information from various sources to get a complete picture of a phenomenon. Case study research employs multiple sources of information (Rose, Spinks & Canhoto, 2015; Yin, 2018). For that reason, secondary and primary data collection processes were used. This section will focus on secondary data, and the next section will focus on primary data.

Secondary data collection involved using pre-existing data to gain new insights different from the initially collected data (Daas & Arends-Tóth, 2012). The advantages of secondary data collection (Perez-Sindin, 2017; Saunders *et al*., 2019) were:

- Less time-consuming than primary data;
- Less expensive than primary data;
- Re-evaluating data allows for new insights;
- Longitudinal and comparative studies are easier to conduct; and
- Evaluation of the effectiveness of former studies is possible.

All the points mentioned above were used to choose document analysis as the measuring instrument. Document analysis systematically evaluates documents to increase understanding of a phenomenon (Zeegers & Barron, 2015). Document analysis was chosen to assist with the quality of the interview data. The document analysis assisted this study as a supporting mechanism by forming the basis for creating the interviews.

Milshinka, Pavlova, and Vishnevskiy (2019) used document analysis to form the basis for the research. They found 452 papers regarding industry foresight and 83 papers regarding trends in the CTLF industry. Reading the papers' abstracts allowed them to decide on 13 final papers

that link both insight and trends. Pavlova marks an example of document analysis in the international CTLF industry. In the South African CTLF industry, Mbatha (2020) mentioned that not using document analysis was a limitation in the author's study. This study used document analysis to avoid this limitation. Therefore, the disadvantages of secondary data collection (Perez-Sindin, 2017; Saunders *et al*., 2019) were identified as:

- Data that is not credible;
- Lack of latest and updated statistics, studies or reports; and
- Researcher does not have control over data quality.

Sources were chosen from UIG contributors to mitigate disadvantages. For credibility and quality of data, the researcher assumed that it should meet credibility and quality standards if it was acceptable to appear on a university, industrial or governmental website as original data. The researcher viewed documents found from 2010 to 2020 as the latest and updated. A total of 68 sources made up the secondary data collection of this study.

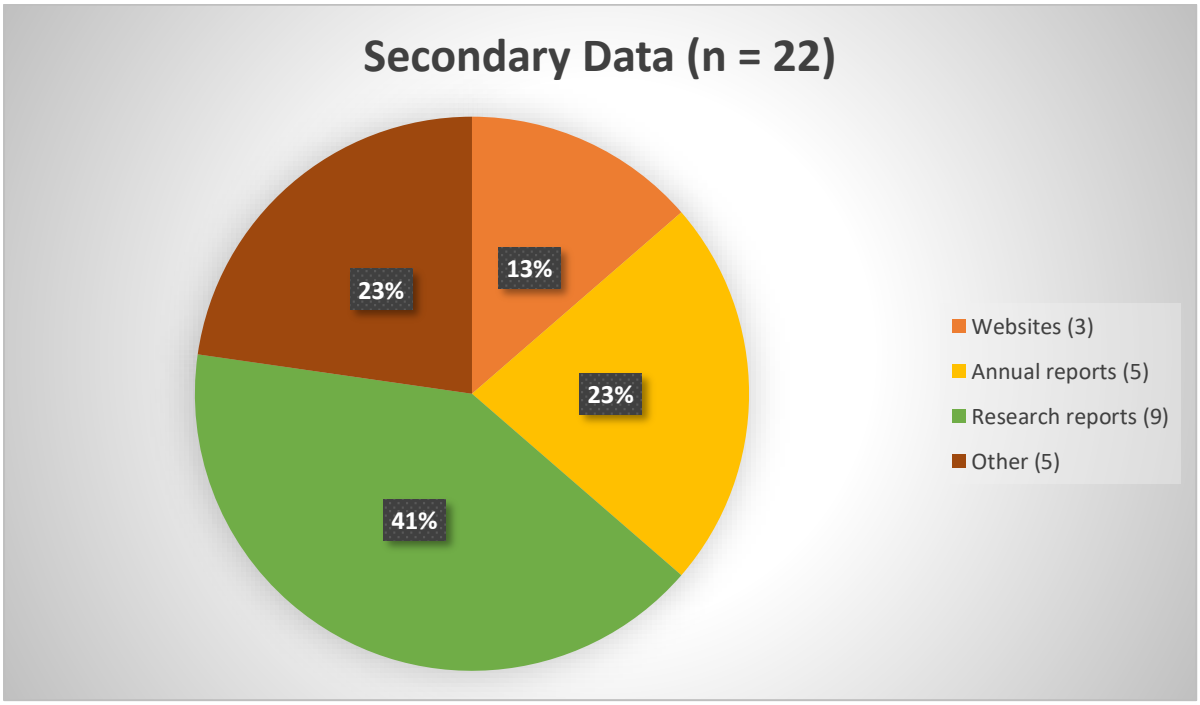


FIGURE 5.1: SECONDARY DATA COLLECTION BREAKDOWN

However, only 22 sources were taken into consideration for data analysis. Documentation that was irrelevant, duplicated, or indicated prospective plans was not considered. Figure 5.1 depicts the breakdown of all the secondary data collected for this study.

For the secondary data collection, "Technology Station in Clothing and Textiles" and "TSCT CPUT" were searched in the University of Pretoria worldcat.org search engine, Google Scholar, and Google. There was limited information on worldcat.org and Google Scholar.

Google had information related to the TSCT via their website, TIA website, CPUT website, company social media pages (Facebook and Instagram), employee social media pages (LinkedIn), and media profiles of the TSCT. For TIA, information was on the TIA and DST website and company social media page (LinkedIn).

The documentation for information on the TSCT and TIA was pdf documents, infographics, screenshots (photographs), blog posts, and media articles. Various data forms were used because not all information was available in pdf documents. Infographics provided summarised contextual data information. The pdf documents and infographics were suitable for traditional academic outputs. It was the output that proved hard to find or prove and needed gaps to be filled by interviews.

The blog posts and media articles assisted with socio-economic outputs. This information was easier to find and prove because there would be photographs proving socio-economic outputs, especially cultural artefacts. The socio-economic outputs were not primarily based on words but on products, processes, infrastructure, facilities, and cultural artefacts, all tangible photographable outputs.

In TIA pdf documents, socio-economic outputs would spotlight or highlight high-performing technology stations, so it was possible to see if TSCT did the same. The pdf documents, infographics, and photographs were downloaded, and screenshots were taken (not downloaded) of any relevant information (such as blog posts and media articles).

Folders named "TSCT" and "TIA" were created, and all the data was placed into the relevant folder. Subfolders also were created (such as CPUT, Engineering Faculty, Technology Stations Programme, and others in the TSCT folder; and TIA organisation, DST, Technology Stations Programme and others in the TIA folder). Once all data was captured, it was disassembled.

Both outputs created many questions because there were gaps in the information. The shortcomings were that sometimes information was missing or unavailable regarding specific outputs. The data answered many 'when' outputs began, occurred, or terminated questions but not the 'how' and 'why' questions. There were also follow-up questions needed for clarity because reporting was not transparent. Interviews were needed to clarify and ask questions

to fill in the gaps of missing information. Molebatsi (2015) used document analysis in a TIA study to collect data to form interviews, which is the same approach this study used.

5.6 PRIMARY INSTRUMENT DATA COLLECTION

Primary data for this study was new first-hand source data collected by the researcher to discover unique insights about a research problem (Quinlan *et al*., 2015).

According to Granot, Brashear, and Motta (2012), interviews are conducted when a researcher wants to observe the experience of individuals who make up an organisation. In-depth interviews explore experiences and the meanings attached to those experiences. Most of the questions used in an in-depth interview follow what the interviewee has said. Interviews were a suitable data collection method because the interviews filled the gaps and gave context where document analysis could not. Another reason for the choice of an interview was that UIG collaboration studies (such as Mbatha, 2020; Molebatsi, 2015; Nkosi, 2015) have used interviews and have had success with the data found.

Kvale (1996:88), quoted by Babbie (2016:313), suggests seven stages in completing the interview process and the first three are discussed below:

5.6.1 Thematising stage

The thematising stage was the clarifying of the interview purpose and concepts explored. The study's aim and objectives (see Chapter 3, Sections 3.2.1 and 3.2.2) determined this. The purpose of this study is in Section 1.7 of Chapter 1, and the conceptual framework is in Chapter 4, Section 4.8.

Questions on the traditional academic outputs and socio-economic outputs for the interview were designed from the two objectives.

5.6.2 Design and recruitment stage

During the design stage, the process of interviewing was established. It was the design of the interview. The designed interview addresses gaps in the document analysis, such as challenges and opportunities for outputs and why specific outputs have increased or decreased throughout the years. Then the actual conceptualising of the interview was done through the operationalisation table (see Section 5.8).

The researcher created an interview schedule (see Addendum D) to assist with the interviews. An interview schedule lists the questions, key points, and issues to ask participants (Quinlan et al., 2015). The interview schedule formed a checklist of steps to assist with the interview

flow and was based on Witzel and Reiter's (2012) steps to completing interviews (see Addendum A to C). Adapted steps were applied:

5.6.2.1 Introductory explanation and briefing

Introductory explanations and briefings formed the interview introduction (Witzel & Reiter, 2012). It was a way for the researcher and interviewee to be acquainted and develop rapport before the interview started. It also formed an additional reminder of the conditions for participating in this study and explaining the interview (Gillham, 2005).

5.6.2.2 Opening questions

The opening question was the first question at the beginning of the interview (Witzel & Reiter, 2012). This question allowed the interviewees to feel confident in answering questions and was a question the interviewees would know off the top of their heads. The study's demographical questions included three questions based on the interviewee, TSCT, and TIA (see Section A of Addendum A to C). The questions allowed the interviewees to talk about themselves and the company they work for, which were factors the interviewees could easily answer.

5.6.2.3 Core interview (substantive phase)

The substantive phase was the core of the interview, and the questions related to the focus of this study were asked (Gillham, 2005). The substantive phase of the interviews was based on open-ended contextual questions and dived more in-depth into the socio-economic aspects of outputs (see Sections B and C of Addendum A to C).

5.6.2.4 Exiting and debriefing

Exit and debriefing were the conclusions of the interview (Witzel & Reiter, 2012). The interviewees were thanked for their efforts and contributions. The interviewees were also allowed to share their final thoughts about their study participation experiences (Babbie, 2016; Gillham, 2005).

In the recruiting stage, the interviewees were contacted to do the interview and give explicit consent. The following respondents were recruited for this study:

- Head of the Technology Stations Programme;
- One of three managers of the Technology Stations Programme (TSP); and
- Manager of the Technology Station in Clothing and Textiles (TSCT).

The head of the Technology Stations Programme of all 18 technology stations and one of the managers of the Technology Stations Programme dealt with one-third (six of 18) of the technology stations, one of them being the TSCT. Then the manager of TSCT works with the TIA, CPUT, and other various industry and government institutions. The first two respondents were from TIA, while the third respondent was from CPUT TSCT. For TIA, the respondents were recruited through their customer service email (customerservice@tia.org.za) available from the TIA website (www.tia.org.za). When the researcher received no response to the email, the researcher phoned the customer service telephone to follow up. The researcher was then connected with various people from TIA to seek approval from the institution's CEO (see Addendum F) to conduct research. When the formal approval from the CEO came, the researcher gave the potential interviewees an information leaflet (see Addendum H to J) and consent form (see Addendum K) to sign and agree to the interview terms. The recruitment and conduction process took about one month for the head of the Technology Stations Programme and one of the managers.

For the TSCT respondent, the process of recruiting was lengthier. The TSCT forms part of CPUT and thus university regulations to conduct research are more formalised, with strictly followed procedures to conduct research. Through searching previous research reports, the details for the Deputy Vice-Chancellor (DVC) for research and secretary to the DVC were emailed about the research study. The wait to receive approval from the faculty took four weeks. As soon as CPUT approved that the researcher could interview a participant from the institution, the potential TSCT interviewee was contacted through their CPUT email. When the researcher did not receive a response, the researcher emailed the TSCT. Through the phone call, the researcher was directed to the TSCT interviewee and received a response. The TSCT interviewee signed the consent form, and the interview was scheduled for the following week. The stages from recruitment to the final interview took two-and-a-half months to finalise.

Interviewees were asked to keep their schedules open to allow ample interview process time (Seidman, 2006). The actual interview was to be an hour or less. However, the respondents were asked to keep an hour-and-a-half open because of the unpredictability of technology and potential technology failures. All interviews were for 1.5 hours or less.

5.6.3 Interviewing stage

Interviewing was the actual completion of the interview (Babbie, 2016). The interviews were conducted at an agreed location by the researcher and participant. The interviews were recorded to reference what was said later and assist with data analysis. The documents used assisted in supporting the information found by the interviews.

The procedure used to complete the interviews was online interviews. Google Meet was the videoconferencing application to conduct the interviews (Google, 2020). Google Meet (see Figure 5.2) allowed face-to-face video calls that simulated an in-person interview environment. This method was deemed suitable due to the COVID-19 pandemic and economic reasons. The South African COVID-19 pandemic regulations prohibited people from contact with other people, except those residing with them, and to keep a social distance of 1.5m (Department of Health, 2020). As restrictions and levels went down, people were encouraged to continue to practice social distancing to reduce the risk of infection (Department of Health, 2020).

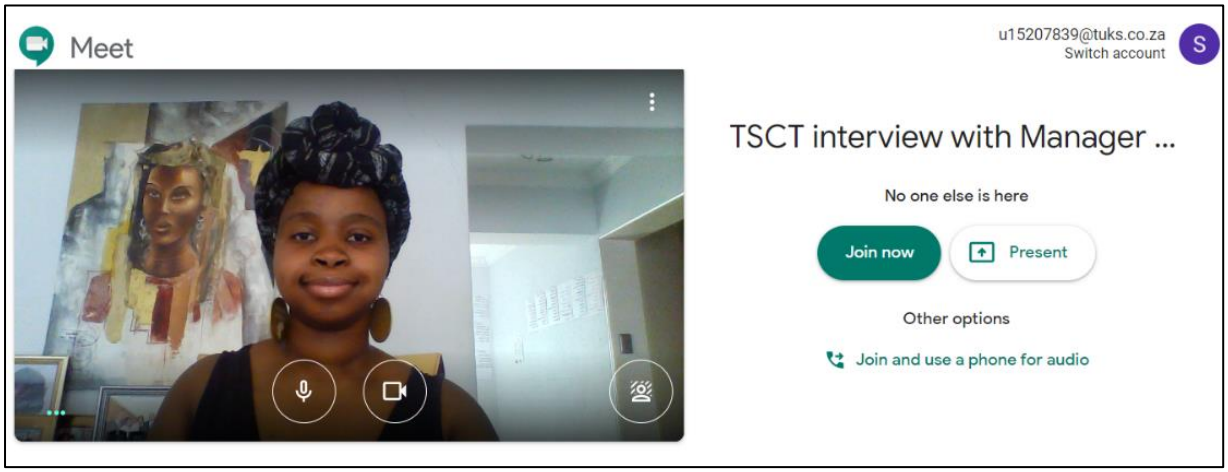


FIGURE 5.2: INTERVIEW SETTING OF THE RESEARCHER

According to Witzel and Reiter (2012), interviewees are usually more at ease and open to questions if they are interviewed in their chosen setting. The interviewees would be more comfortable sharing relevant information in a familiar setting. The requirement from the researcher was that space had to be private during the interview process to allow for better audio and proper tape recording and that there would not be any distractions, such as people moving in and out of the room.

The first interview was with the head of the TSP. It did not go as planned. As a contingency plan, Skype was used as an alternative option to Google Meet because the interviewee was familiar with the platform. However, it did not work because the recording was uploaded to the respondent's cloud. The recording was not received after recovery attempts (see Addendum J). Nevertheless, as discussed in the interview, the respondent sent agreed documents, which added value because they were not available online.

The second interview was with one of the managers for the TSP. The meeting was on Google Meet. However, the respondent opted not to reveal their face for the interview. The interview went well, and the visual and audio recording was possible.

The third and final interview was with the manager of the TSCT. The interview was on Google Meet. However, the platform was updated, and the record option had changed. The researcher had to record with another device, so the interview audio was recorded.

For all interviews, the questions were printed out (see Addendum A to C) and the schedule (see Addendum D). Notes were taken as respondents were talking to highlight specific points or jot down questions to ask. Using technology and online platforms for interviews proved challenging, but it was possible to use them for desired outcomes for fulfilling the requirements for this study. Using secondary and primary data options helped strengthen the data collection strategy.

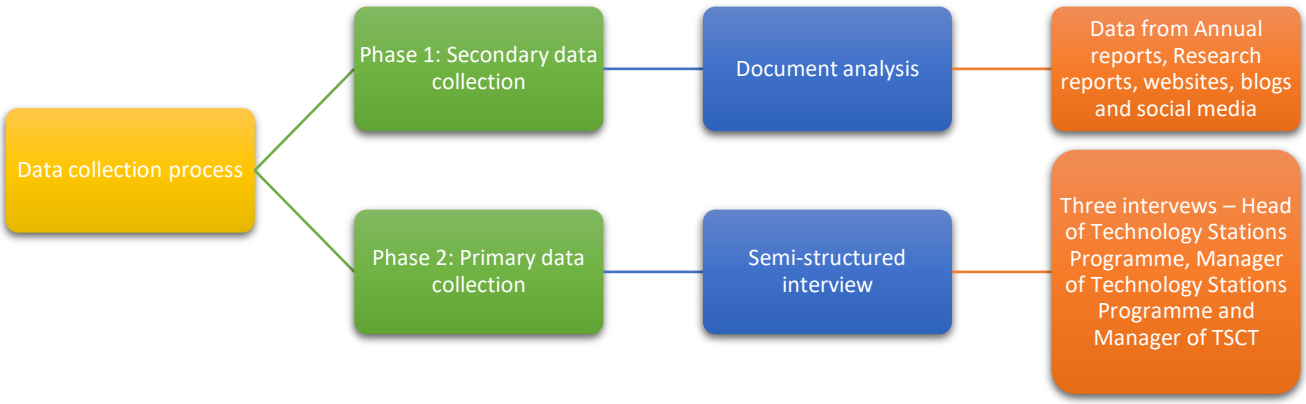


FIGURE 5.3: DATA COLLECTION OVERVIEW ADAPTED FROM NKOSI (2015:38)

Figure 5.3 summarises the data collection strategy for this study and depicts how the data collection processes took place from the measuring instrument development to the execution of the data collection. The next section will explain the data analysis procedure for this study.

5.7 DATA ANALYSIS

Data analysis is the logical reasoning behind all research to search for patterns identified in the data (Leedy & Ormrod, 2015). Analysing qualitative data is less prescriptive than quantitative data. Analysis relies on inductive reasoning processes indivisible into discrete, measurable variables (Leedy & Ormrod, 2015). For case studies, data is analysed thematically, using themes within data (Braun & Clarke, 2006; Clark & Creswell, 2015; Quinlan *et al.*, 2015). Themes organise and describe the data set in detail, allowing interpretation of various aspects of the research topic (Braun & Clarke, 2006; Maguire &

Delahunt, 2017). The thematic analysis could also be categorical aggregation when a researcher looks for a collection of instances from data to find issue-relevant meanings (Creswell, 2007). Maguire and Delahunt (2017) state that thematic analysis is proper because it is flexible and not tied to a specific theoretical perspective. Two themes are offered by Braun and Clarke (2006) and further cited by Maguire and Delahunt (2017): semantic themes and latent themes. Semantic themes are explicit meanings of the data. The researcher does not look beyond what the interviewee has stated or written (Braun & Clarke, 2006; Maguire & Delahunt, 2017).

For latent level themes, the underlying ideas, assumptions, conceptualisations and ideologies are identified and examined in the data to interpret and explain (Braun & Clarke, 2006; Maguire & Delahunt, 2017). Once outputs were identified, latent themes were searched to make sense of the data collected.

A computer-aided qualitative data analysis software (CAQDAS) was used to support the data analysis (Friese, 2012). The three most popular CAQDAS are MAXqda, ATLAS.ti, and QSR NVivo (Creswell, 2014). The CAQDAS used was the ATLAS.ti software. ATLAS.ti is a Windows-based program that organises text, graphic, audio, and visual data files with coding, memos, and findings into a study (Creswell, 2007; Creswell, 2014; Friese, 2012). This software was chosen because the University of Pretoria already owns a licence. Using the ATLAS.ti software reduced the possibility of human error and allowed for accurate data analysis of the case study (Friese, 2012). The researcher attended a YouTube training seminar on the programme hosted by ATLAS.ti software (ATLAS.ti – Qualitative Data Analysis, 2020), watched ATLAS.ti official tutorial videos (ATLAS.ti – Qualitative Data Analysis, 2020), and did further reading using a qualitative analysis ATLAS.ti book by Friese (2012).

According to Yin (2016b), five analytic phases followed to analyse data: compiling, dissembling, reassembling, interpreting, and concluding. Braun and Clarke (2006) have six phases of thematic analysis that offer an accessible and theoretically flexible approach to analysing qualitative data. Yin's (2016b) and Braun and Clarke's (2006) analytic phases will be combined for data analysis as they are interlinked and enhance the data analysis with different strengths. It is important to note that although the phases follow a sequence, they are not linear but dynamic, and certain phases were repeated to get optimum results.

5.7.1 Compiling (Phase 1: Familiarising yourself with your data)

Compiling is the proper sorting out of notes created during data collection to create an orderly database (Yin, 2016b). It is also the phase where researchers familiarise themselves with the data (Braun & Clarke, 2006).

Transcriptions are primary data. Transcribing is the writing out of the interview (Babbie, 2016). Transcribing was done with the aid of Google Docs, a subsidiary of Google, with the voice typing function. Lamptey (2020) states that Google Docs is an innovative and cost-effective method for data transcribing. The author also states that Google Docs is an excellent tool because it allows a person to voice type in the English language suited to that person's accent, which allows for better transcription. The researcher chose South African English to transcribe the data. The researcher played the tape recordings of the interviews, and the automated function on Google Docs listened to and transcribed the interview. The application did not pick up words or suggest an incorrect word in the sections. Pausing the tape recording was done, and the researcher corrected the error. This option assisted with the time-consuming aspect of transcribing interviews. This method was applied to the TSCT interview.

For the manager of the TSP, the interview was uploaded privately to YouTube because it was video content. Rice (2021) suggests that using YouTube is one of many adaptations to doing remote research during the coronavirus pandemic. YouTube, a subsidiary of Google, is a video-sharing platform that allows content to be uploaded privately, thus mitigating privacy and intellectual property risks. YouTube transcription was the least time-consuming alternative because YouTube automatically creates captions on videos if the option is enabled. The researcher then copied and edited the YouTube transcription.

Both primary and secondary data were compiled and were not searched for patterns or themes yet.

5.7.2 Disassembling (Phase 2: Generating initial codes and Phase 3: Searching for themes)

The data was disassembled after the compiling phase. Disassembling is the breakdown of the compiled database into smaller fragments (Yin, 2016b). These fragments are then assigned primary codes (Friese, 2012). Then a list is created of interesting facts about the data (Braun & Clarke, 2006). It was done through a note-making function on ATLAS.ti. Braun and Clarke (2006:19) suggest three points of advice for this phase:

- Code for as many potential themes as possible;
- Code extracts of data inclusively; and

- Code individual extracts of data in as many themes as they fit into.

The ATLAS.ti software was used to break down the data. All the data files, document analysis, and interview data were entered into the software to be read through and searched for overarching themes. The themes were based on the objectives of this study:

OBJECTIVE 1: To explore traditional academic outputs from UIG collaborations in the TSCT, focusing on their quality, challenges, and opportunities.

OBJECTIVE 2: To explore socio-economic outputs from UIG collaborations in the TSCT, focusing on their quality, challenges, and opportunities.

The codes assigned were “academic outputs” or “socio-economic outputs”. The researcher asked:

- Does the data contribute academically?
- Does the data contribute socially?
- Does the data contribute economically?

Then codes were assigned to the data through software functions.

5.7.3 Reassembling (Phase 3: Searching for themes and Phase 4: reviewing themes)

Reassembling is rearranging code fragments into various groups and sequences by representing data in a table, graph, or list (Friese, 2012; Yin, 2016b). In this phase, the researcher searched for themes and re-focus on the analysis at a broader level of themes rather than codes (Braun & Clarke, 2006). The two main outputs, traditional academic and socio-economic outputs, were subdivided. Traditional academic outputs were data about academic publications, master’s theses and doctoral dissertations, academic collaborations, reports and policy documents, scientific discoveries, and graduates with the necessary skills. Socio-economic outputs were data about new and improved products, new and improved processes, community infrastructure and facilities, spin-off companies and cultural artefacts.

The “academic outputs” code had six themes and the “socio-economic outputs” had five themes. Through ATLAS.ti, the information was available in list form (see Figure 5.4).

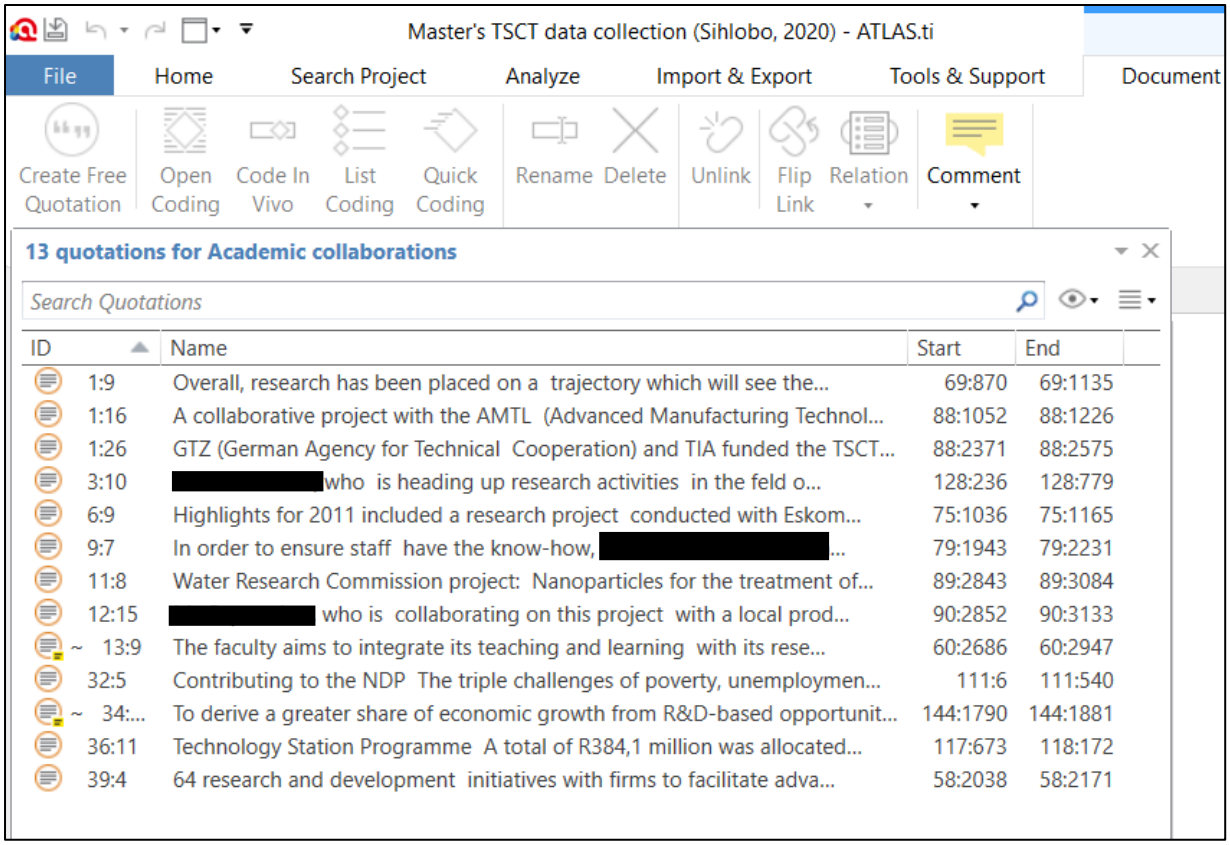


FIGURE 5.4: SAMPLE OF REASSEMBLING

As seen in Figure 5.4, the “academic collaboration” theme had a list of 13 quotations throughout the data. This was applied to all 11 themes for this study.

5.7.4 Interpreting (Phase 5: Defining and naming themes)

Interpreting creates a new narrative from the reassembled data and how data fit together (Friese, 2012; Yin, 2016b). A table format was the best-suited graphic representation of the data. The data needed a word-cloud presentation; a graph did not allow that. The table was used instead of the list because the information needed a matrix organisation.

At this point, themes were further refined to identify the essence of the themes (Braun & Clarke, 2006). The findings tables divided the themes into quality, challenges, or opportunities. The table was analysed to understand the presentation of the themes.

5.7.5 Concluding (Phase 6: Producing the report)

Concluding is drawing inferences from this study based on findings in data (Yin, 2016b). A report is written, and the final analysis of the final themes goes beyond the narrative but instead makes an argument regarding the data concerning the research objectives (Braun &

Clarke, 2006). The reporting stage is the sharing of the results. The reporting stage also addresses the research objectives of this study, which are in Chapters 6 and 7 of this study.

5.8 OPERATIONALISATION TABLE

Babbie (2016) states that operationalisation is developing operational definitions and specifying the operations involved in measuring a variable. Below is the operationalisation table, showing how the construct, dimensions, indicator, measuring instrument and data analysis all relate to the two objectives of this study. The following pages have a landscape layout to show the operational tables for this study.

TABLE 5.1: OPERATIONALISATION TABLE FOR TRADITIONAL ACADEMIC OUTPUTS

Construct	Dimensions	Indicator	Measuring Instrument		Data Analysis
			Document Analysis	**Interviews**	
Objective 1: To explore traditional academic outputs (TAOs) from UIG collaborations in the TSCT, focusing on their Quality, challenges and opportunities.					
UIG collaboration outputs	1. Traditional academic outputs (adapted from Kruss & Visser, 2017)	Academic publications	Documents with academic publication data such as conference proceedings, books, chapters within books and journal articles published within the TSCT from public websites and research reports. And publication data from the TIA reports.	Quality (Q): Please outline the nature of publications that have been produced by TSCT.	Adapted thematic analysis from Braun and Clarke (2006) and Yin (2018). It will be applied to both document analysis and interview data. Aspects of thematic analysis include: 1. Compiling (Phase 1) 2. Disassembling (Phase 2 and 3) 3. Reassembling (Phase 3 and 4) 4. Interpreting (Phase 5) 5. Concluding (Phase 6)
				Challenge (C): Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				Opportunity (O): Please discuss opportunities that exist for the TCST.	
		Master's theses and doctoral dissertations	Documents with master's theses and doctoral dissertations completed or published within the TSCT from public websites and research reports. And dissertation data from the TIA reports.	Q: Please discuss the nature of master's theses and doctoral dissertations produced by TSCT's staff.	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	
		Academic collaborations	Documents with academic collaborations data, such as collaborations on research projects with other researchers (academia), industry or government within the TSCT from public websites and research reports. And academic collaboration data from the TIA reports.	Q: Please discuss how the programmes of TSCT meet the needs of the clothing, textiles, leather, and footwear (CTLF) industry.	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	
		Policy Documents and Reports	Documents with policy documents and reports for the TSCT by the TSCT, TIA or CPUT. Documents include TIA performance plans, TIA reports and research reports.	Q: Please share the nature of reports that have been generated by TSCT? Q: Please explain the extent to which the TSCT is involved with policy-making within the CTLF industry.	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	
		Scientific discoveries	Documents reporting scientific discoveries made through various technologies or activities in the TSCT, and TIA reports and research reports.	Q: Kindly discuss how the new technologies or innovations produced by TSCT benefited the CTLF industry, TSCT, and the community?	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	
		Graduates with relevant skills	Documents related to alumni who benefitted from the TSCT. Documents related to alums using skills acquired from the TSCT.	Q: Please describe how the CTLF industry feels about the Quality of skills by graduates produced by TSCT?	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	

			Documents from includes testimonials, newspaper articles, websites, and research reports.	O: Please discuss opportunities that exist for the TCST.	

The construct of the operationalisation table is the university-industry-government collaboration outputs with the two dimensions of traditional academic outputs (see Table 5.1) and socio-economic outputs (see Table 5.2). The indicators are what is to be tested from the dimensions. In traditional academic outputs, there are six indicators (academic publications, master's theses and doctoral dissertations, academic collaborations, reports and policy documents, scientific discoveries, and graduates with relevant skills).

TABLE 5.2: OPERATIONALISATION TABLE FOR SOCIO-ECONOMIC OUTPUTS

Construct	Dimensions	Indicator	Measuring Instrument		Data Analysis
			Document Analysis	**Interviews**	
Objective 2: To explore socio-economic outputs (SEOs) from UIG collaborations in the TSCT, focusing on their Quality, challenges and opportunities.					
UIG collaboration outputs	1. Socio-economic outputs (Adapted from Kruss & Visser, 2017)	New or improved products	Documents relating to new or improved research products produced by the TSCT that led to economic insights or social improvement. Documents from websites, blogs, TIA reports and research reports.	Quality (Q): Kindly share new or improved tech-based products from TSCT that benefited the CTLF industry.	Adapted thematic analysis from Braun and Clarke (2006) and Yin (2018). It will be applied to both document analysis and interview data. Aspects of thematic analysis include: 1. Compiling (Phase 1) 2. Disassembling (Phase 2 and 3) 3. Reassembling (Phase 3 and 4) 4. Interpreting (Phase 5) 5. Concluding (Phase 6)
				Challenge (C): Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				Opportunity (O): Please discuss opportunities that exist for the TCST.	
		New or improved processes	Documents relating to new or improved research processes produced by the TSCT that led to economic insights or social improvement. Documents from websites, blogs, TIA reports and research reports.	Q: Kindly share new or improved processes from TSCT that benefited the CTLF industry.	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	
		Community infrastructure and facilities	Documents that refer to infrastructure and facilities that benefitted the community of the Western Cape Province. Documents found on social media, websites, testimonials, blogs, TIA reports and research reports.	Q: How has the TSCT equipment and facilities provided technology-based support and training to small and medium enterprises (SMEs)?	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	
		Spin-off companies	Documents refer to spin-off companies created from the TSCT. Documents found on websites, TIA reports and research reports.	Q: Kindly share if there are any spin-off companies generated from the activities of TSCT.	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	
		Cultural artefacts	Documents would be content of preserved artefacts that are indigenous to the Western Cape Province. Documents would be content found in photos, social media, websites, videos, documents, TIA reports, and research reports.	Q: Kindly share any artefacts from TSCT that benefited the CTLF industry or community.	
				C: Please discuss challenges you feel are hindering the TSCT from meeting its full potential.	
				O: Please discuss opportunities that exist for the TCST.	

For socio-economic outputs, there are five indicators (new and improved products, new and improved processes, community infrastructure and facilities, spin-off companies, and cultural artefacts). Then, three measures are tested for each indicator: quality, challenges, and opportunities. The measuring instruments are the main statements or questions used to create questions asked for the interviews and documents used for document analysis in terms of quality, challenges, and opportunities. Understanding the three measures will give insight into investigating outputs in the TSCT. The quality measure was based on the current activities within the TSCT that form the standard. For this study, *opportunities* are favourable circumstances that could support the furthering of the TSCT in terms of STI either directly or indirectly. At the same time, *challenges* are limitations to achieving the strategic objectives of the TSCT based on the triple challenges of poverty, inequality, and unemployment. The state of the outputs will analyse the quality of the TSCT outputs. According to Braun and Clarke (2006) and Yin (2018), everything was analysed thematically.

5.9 MEASURES OF TRUSTWORTHINESS (QUALITY OF THIS STUDY)

Lincoln and Guba (1985) suggest standards to study qualitative research in terms of trustworthiness and move away from the terms *validity* and *reliability*. Lincoln and Guba (1985) suggest four alternatives for assessing the trustworthiness of qualitative research: credibility, transferability, dependability, and confirmability.

Then in 1994, the authors added a fifth criterion, authenticity (Elo, Kääriäinen, Kanste, Pölkki, Utriainen & Kyngäs, 2014). Authenticity is similar to credibility. Credibility deals with the believability and accuracy of interviewees, while authenticity deals with reality and realness (Elo *et al.*, 2014). Authenticity refers to the extent to which researchers, impartially and faithfully, show a range of realities (Elo *et al*., 2014). For that reason, only four of the five measures of trustworthiness were used. The four measures of trustworthiness will be discussed below.

5.9.1 Credibility

Credibility is judged by the extent of respondent concordance, whereby the researcher takes findings to respondents of research for confirmation, congruence, validation, and approval (Kumar, 2011; Leedy & Ormrod, 2015). Trochim and Donnelly (cited by Kumar, 2011) state that credibility involves establishing the results of qualitative research as credible or believable from the respondent's perspective of the research. Researchers should identify trustworthy respondents and accurately describe why they are suited for this study (Elo *et al*., 2014).

The three interviewees were chosen based on their experience and expertise regarding the TSCT. The head of the Technology Stations Programme (TSP) deals with all 18 technology stations. In comparison, the manager of the TSP deals with six of the 18 technology stations, one of them being the TSCT. Then the manager of TSCT deals with the Technology Innovation Agency (TIA), a university and other various industry and government institutions.

Qualitative research studies explore people's perceptions, experiences, feelings, and beliefs, so respondents are perceivably the best judges in determining whether the research findings accurately reflect their opinions and feelings (Kumar, 2011). When the research report was compiled, the findings were sent to the interviewees to judge the research they provided to check accuracy. The interviewees were given a chance to view the research findings, given a chance to judge the credibility, and given a chance to confirm that the researcher kept to the research ethics.

Lincoln and Guba (cited in Creswell, 2007) suggest that techniques such as the triangulation of data sources, methods and researchers assist with achieving credibility. Triangulation is

achieved between complementary methods and data sources to produce converging conclusions; if not, the differences and their results are explained (Miles *et al.*, 2014). Triangulation of data sources was done using two data collection methods, primary (interviews) and secondary (documents) data collection. Triangulation allowed for a subjective and objective method to be used collectively to combat the disadvantages of each data collection method.

Miles *et al.* (2014:273) offer useful points that could be used when checking for credibility. These credibility checklist points were used as a checklist that was conducted throughout this study:

- Context-rich, meaningful, and 'thick' description of data;
- Findings are clear, coherent, and systematically related;
- Negative evidence is sought; and
- Rival explanations are considered.

All the processes followed when planning, collecting, analysing, and interpreting data were described with definitions and in detail. Credibility was applied throughout this chapter and all chapters of this study. The information presented in the findings chapter is divided into sections according to research outputs, and each output has been divided into document analysis and interview data. All these factors assist with making the findings clear, coherent, and systematically related.

Negative evidence is the non-occurrence of events in research (Lewis & Lewis, 1980). Not all evidence found in the research is necessary or relevant; thus, the researcher does not report everything. By not displaying all the information received through data collection, the researcher can summarise the case study, which combats a disadvantage of the case study research design. Embracing negative evidence tests rival explanations (Maxwell cited by Yin, 2018).

Rival explanations are alternative factors that accounted for the results observed in research other than what was expected (Yin, 2018). The rivals have been explained in the next chapter, as not all outputs produced the expected results regarding current quality. Observing rival explanations achieves credibility because it lessens the likelihood of the researcher's selection bias as a disadvantage to case study research. Broad statements were applied to more than one output for the document review, and thus findings were replicated. Another example is where interviewees spoke about something found in document analysis, thus creating replication.

This study's credibility was also upheld by verbatim transcription of the interviews and quoting document data (Clarke & Creswell, 2015). This study ensured reporting on what was said by the interviewee or written in the document without the researcher paraphrasing and weakening the data. The data was based on factual reporting, which made it more credible. Another way this study was credible was the citations and the reference list created to source literature from authors (Clarke & Creswell, 2015). Credibility meant original ideas had a traceable source that future researchers could check.

5.9.2 Transferability

Elo *et al.* (2014) refer to transferability as the degree to which the results of qualitative research can be generalised or transferred to other contexts or settings. Furthermore, the process adopted for others to follow and replicate must be thoroughly described (Creswell, 2007). Miles *et al*. (2014:274) offer valuable points that could increase transferability. These points were used as a checklist that was applicable throughout this study. The transferability checklist includes:

- Limits of sample selection specified in the report and examined generalisation to other settings and contexts;
- Sampling is theoretically diverse enough to encourage broader applicability when relevant;
- Any theories and their transferability are explicitly stated; and
- The report suggests settings where the findings could fruitfully be tested further.

The limitations section in the final chapter explicitly expresses the limitations of the sample. The sample being theoretically diverse for broader application is two-fold. Firstly, because there are 18 technology stations in total, it was assumed that the outputs applied to the TSCT could work for the other 17 technology stations. Secondly, on a smaller scale, the interviewees could be chosen for this study. The selection of three interviewees connected to the activities of the TSCT could allow for a broader study. The broadness of this study was in terms of the Technology Stations Programme.

This study's theories were explained in the theoretical perspective chapter to ensure this study's transferability. This study's methodology was described to ensure this study's transferability. Transferability was also applied using the ATLAS.ti software that allows efficient transfers of data as the program allows for data to be exported.

5.9.3 Dependability

Dependability is concerned with the stability of data over time and under various conditions (Elo *et al*., 2014). Miles *et al.* (2014:272) offer useful points that could be used to achieve dependability. The dependability checklist includes:

- Researcher's role and status within this study have been explicitly described;
- Data were collected across a full range of appropriate settings, times, and respondents, among others, as suggested by the research questions;
- Data quality checks have been made (for example, for bias);
- Multiple observers' accounts converge – in instances, settings, or times – when they might be expected to; and
- Forms of peer or colleague review are in place.

The points above were used as a checklist to increase dependability throughout this study. The role of the researcher was described in the information leaflets (see Addendum H and I) and throughout this chapter. The documents reviewed spanned ten years (2010 to 2020), thus making the data collected span across various times. The two main supervisors of this study did the quality checks. During this study's ethical approval, a team of reviewers checked if the interviews were acceptable for research. This statement serves to be relevant for multiple observer accounts converging and forms of peer or colleague review in place.

Dependability in qualitative research is established by an extensive and detailed record of the process to replicate (Elo *et al*., 2014). Dependability was applied in the verbatim transcription of the recordings of the interviews. It is because if the researcher had to listen to the tape recordings again after double-checking the interviews, the results should be the same.

5.9.4 Confirmability

Confirmability refers to the degree to which others can confirm or verify the results (Trochim & Donnelly in Kumar, 2011). Confirmability is concerned with objectivity and is only possible if researchers follow the process again (Elo *et al*., 2014). Alternatively, if the results are comparable, confirmability establishes the value of the data. Confirmability also means that there must be a similarity if two or more independent people evaluate the data's accuracy, relevance, or meaning (Elo *et al*., 2014). Miles *et al.* (2014:272) offer useful points that could be used when checking for confirmability. The confirmability checklist includes:

- Study's general methods and procedures are described explicitly and in detail;
- Actual sequence of how data were collected, processed, condensed/transformed, and displayed for specific conclusion drawing can be followed;

- Record of this study’s methods and procedures detailed enough to be audited by an outsider;
- Researcher has been explicit and as self-aware as possible about personal assumptions, values and biases, and affective states (and how they may have come into play during this study); and
- Study’s data are retained and available for re-analysis by others.

The methods and procedures were described throughout this chapter and in detail. The steps taken to collect the data were recorded and based on various authors' previous studies or research textbooks. Through peer analysis, the recording of study methods was achieved because it allowed an outsider to critically observe this study from an outsider's perspective. The researcher explicitly stated research limitations under the limitations section of the research in the final chapter. The study's data has been archived and available for re-analysis in line with the University of Pretoria’s duration for data storage.

In order to achieve confirmability in this study, the researcher documented data and analysis procedures throughout this study to make judgements about potential bias in the limitations of this study section.

5.10 ETHICS

Ethics is what is morally and legally right in the process of conducting research (Dantzker, Hunter & Quinn, 2018). Research ethics is concerned with working honestly, with integrity, ensuring safety and that no harm comes to anyone or anything (Quinlan *et al.*, 2015). The University of Pretoria granted ethical clearance to the Faculty of Natural and Agricultural Sciences Ethics Committee with the reference number NAS345/2019 (see Addendum E). There are two categories of stakeholders in ethical considerations, namely participant ethics and researcher ethics (Kumar, 2011; Leedy & Ormrod, 2015; Quinlan *et al.,* 2015). These are briefly discussed below.

5.10.1 Participant ethics

Joe, Raben, and Phillips (2017) state that participant ethics ensures that researchers apply ethically reflective tactics during the research process and that compromising factors are eliminated. Examples of participant ethics include confidentiality, informed consent, and voluntary participation (Joe *et al.,* 2017; Quinlan *et al.*, 2015:46). The processes to ensure participants' ethics are discussed below.

5.10.1.1 Confidentiality

Confidentiality is a guarantee made to participants by researchers that their contribution to the research project will be free from non-disclosure of specific information (Babbie, 2016; Dantzker, Hunter & Quinn, 2018; Quinlan *et al*., 2015). The names of the interviewees were not shared in this study, and the interviews were labelled “interview” to uphold confidentiality. In addition, any private information held by a non-disclosure agreement was not shared. The interviewees were made aware of the confidentiality conditions listed in the consent form of this study.

5.10.1.2 Informed consent

Informed consent is when research participants are formally made aware of participating in a research project (Leedy & Ormrod, 2015; Quinlan *et al.*, 2015). Interviewees were formally informed about their involvement in this study via email and an information leaflet. The email had an attached consent form for the interviewee to sign to participate in this study. An interview date, time, and place were set if they agreed to the terms and conditions. Before the interview commenced, the researcher reminded the interviewees of their contribution and how the results will be used. The information leaflets and consent forms of this study are in Addendum H to K of this study.

5.10.1.3 Voluntary participation

Voluntary participation is when participants are made aware of their contribution to the research and whether they will be compensated for participating (Dantzker *et al*., 2018; Leedy & Ormrod, 2015; Quinlan *et al.*, 2015). Voluntary participation was satisfied using the information leaflet (see Addendum H and I) and consent form (see Addendum K) given to this study's interviewees. The research respondents were informed that their contribution to the research is voluntary and without compensation in the attached information leaflet (see Addendum H and I) and consent form (see Addendum K). By not compensating the respondents, the respondents could not distort results by giving a social desirability bias. Social desirability is the tendency of respondents to report an answer in a way they deem to be more socially acceptable (Roulin, Bangerter, & Levashina, 2014). The respondents stood to benefit nothing materialistically, so their responses were not based on compensation. Respondents were also informed that they could withdraw from the research at any time. The withdrawal option allowed respondents to opt-out option should they feel they could no longer answer questions from the researcher. Interviewees were reminded of their voluntary participation on the day of the interview.

5.10.2 Researcher ethics

Researcher ethics are principles that should be considered by the researcher. The principles are integrity, harm, bias, and plagiarism (Quinlan *et al*., 2015). The processes this study employed to ensure researcher ethics are discussed below.

5.10.2.1 Integrity

The integrity of the research was achieved through the implementation of honest practices (Quinlan *et al.*, 2015) by following the University of Pretoria's (2018) Code of Ethics. Prewett (2022) states that research integrity is of high quality and ethical practice across the research process. Integrity includes planning and conducting research; the recording, reporting, and distributing of results; and applying the findings. The researcher applied this to this study by being professional, accountable, and responsible for the quality of the research throughout the whole study. Practical examples of this would be citing authors of work, referencing authors' work and upholding all participant ethics.

5.10.2.2 Protection from harm

The protection from harm ethics should protect the research participants from any harm related to their participation in this study (Joe *et al.*, 2017; Dantzker *et al*., 2018). In the information leaflet and consent form, the researcher had to mention the nature and extent of the risks and benefits associated with this study to inform interviewees of the possible harm or positive value the research could bring to their lives. This ethical principle also deals with the effects of the participation of participants in this study, such as their results being leaked or used for non-research purposes. In addition, the participant data collected from this study will be kept securely (Joe *et al.*, 2017; Dantzker *et al*., 2018). By concealing the identity of the interviewees, the researcher protects them from harm to their personal life, company or any other body that would want to attack their participation in this study. The University of Pretoria's (2018) Code of Ethics states that refraining from discrimination, abuse of supervisory authority, and sexual harassment are the responsibilities of researchers. These are the ways the researcher can protect interviewees from harm. The researcher upheld the participant's right to refuse to participate or withdraw from the research without any prejudice. The researcher always consulted interviewees should there be information that might reveal their identity to get their consent or use a pseudonym that protects their identity. There was a participant who felt uncomfortable with being on video call interview. The researcher allowed the video call to be recorded with audio only from the participant's side. Therefore, the researcher ensured and promoted the well-being of all affected by the research.

5.10.2.3 Avoiding bias

According to Dantzker *et al*. (2018) and Sarniak (2015), bias is the lack of objectivity. Bias means a researcher supports or unfairly opposes a person or thing. The researcher allows personal opinions to influence the fair judgment in this study. There was no prior expectation of results. Thus, no particular result was sought (confirmation bias). However, there is criticism for using interviews, as they could be biased. To eliminate bias, the researcher used document analysis to support or disqualify interview findings.

5.10.2.4 Plagiarism

Plagiarism is when information is extracted without acknowledging the source, and researchers pose the work as their own (University of Pretoria, 2020). For this study, all works of authors consulted have been cited and referenced according to the UP-EMS Harvard style. Furthermore, a plagiarism report is attached to prove that this study complied with the requirements to avoid plagiarism (see Addendum L).

The researcher followed all steps required by the University of Pretoria and the research fraternity (Department of Consumer and Food Sciences) to ensure scientific professionalism. Before chapters were sent for final approval by the supervisors, the researcher conducted a plagiarism test using Turnitin (see Addendum M for Turnitin declaration) to ensure that the research met professional, scientific requirements. Turnitin is an online plagiarism detection service available at the University of Pretoria's Blackboard Learn, a virtual learning environment and learning management system called ClickUp.

The researcher was competent in conducting assessments, moderating assessments and facilitation, and further drew from research experience to ensure that this research was professionally conducted.

5.11 CONCLUSION

The research design and methodology of this study make it possible to achieve the aim and objectives of this study. This study took on a case study approach and a qualitative research design. The two data collection methods used were semi-structured interviews and document reviews. The researcher self-administered the semi-structured interview. The document review information enhanced the results of the interviews for data analysis. ATLAS.ti software was used for data analysis, and efforts were made to retain the quality and ethics of this study. The following chapter will discuss the results of the methodology applied in this chapter.

CHAPTER 6: ACADEMIC RESULTS AND DISCUSSIONS

"Fashion is not something that exists in dresses only. Fashion is in the sky, in the street, fashion has to do with ideas, the way we live, what is happening." ~ Coco Chanel

6.1 INTRODUCTION

This chapter presents the results in terms of this study's research aims and objectives. This study aimed to investigate outputs from university-industry-government (UIG) collaborations in the Technology Station in Clothing and Textiles (TSCT) of the Western Cape, South Africa. The objectives of this study were:

OBJECTIVE 1: To investigate traditional academic outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

OBJECTIVE 2: To investigate socio-economic outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

This chapter will focus on OBJECTIVE 1, while OBJECTIVE 2 will be discussed in the next chapter. Sections 6.2 to Section 6.7 report the findings of the six traditional academic outputs. These outputs are academic publications, master's theses, and doctoral dissertations, academic collaborations, policy documents and reports, scientific discoveries, and graduates with relevant skills. Furthermore, everything is summarised in Section 6.7, where a figure will be presented based on the state of the traditional outputs, and the final chapter conclusion will be drawn in Section 6.8.

The first objective of this study was to investigate traditional academic outputs from UIG collaborations. This was in terms of quality, challenges, and opportunities found within the TSCT. The key in Figure 6.1 will form a basis for presenting the findings.

Key for findings	
Document analysis (n=22)	
TIA	Data from the Technology Innovation Agency (TIA) and Technology Stations Programme (TSP)
TSCT	Data from the Technology Station in Clothing and Textiles (TSCT) and Cape Peninsula University of Technology (CPUT)
Interview analysis (n=3)	
Interview 1	Interview data from the Head of the Technology Stations Programme
Interview 2	Interview with manager of Technology Stations Programme
Interview 3	Interview with manager of TSCT
General	
[ ]	Conceptualising the quote, researcher's own words
Words in italics	*e.g., Company A,* names have been changed for ethical reasons
	Colour for Quality
	Colour for Challenges
	Colour for Opportunities
	Colour for Data not found

FIGURE 6.1: KEY FOR FINDINGS

6.2 FINDINGS ON ACADEMIC PUBLICATIONS

The body of academic publications is academic research published in conference proceedings, journal articles, books, and chapters within books (Kruss & Visser, 2017). Table 6.1 highlights the document and interview findings for academic publications in the TSCT.

TABLE 6.1: FINDINGS FOR ACADEMIC PUBLICATIONS

State of outputs	Quotation from Document (n=23)	Quotation from Interview (n=3)
Quality	**TSCT 2016** – …paper, titled Ultrasonic welding – Innovative joining technology for sporttech application **TSCT 2017** – The research aspirations of CPUT are articulated in the RTI Blueprint and manifest themselves predominantly in seven research focus areas, namely:	**Interview 2** – "…[currently we look at the] "woman number of publications […] and the number of publications." **Interview 3** – "…based on the focus area of TSCT staff, for example – the most recent publication was looking at harmful substances in clothing and textiles...we selected baby clothing from various retailers, analysed them

	• Bio-economy & biotechnology • space science & technology • energy • climate change & environment • human & social dynamics (including service delivery) • economic growth & international competitiveness • design for sustainability **TSCT 2017** – …we managed to produce considerably more new knowledge – in the form of published research outputs – than in the previous year. **TSCT 2017**- …A renowned expert in technical textiles […] 62 publications in peer-reviewed accredited sources and two technology demonstrators. **TIA 2018/2019** – Support services provided by the technology stations […] research and development and technology demonstration and training.	and checked for harmful chemicals are in the type of product.”
Challenges		**Interview 1** – “HEIs are not positioning offerings and research to community needs.” **Interview 2** – “…a lot of researchers rushed to present their findings at conferences or to publish papers.”
Opportunities	**TIA 2017/2018** – To derive a greater share of economic growth from R&D-based opportunities and partnerships. **TSCT 2017** – …external research funding is also growing **TSCT 2017** – …is heading up research activities in the field of technical/smart textiles at CPUT […] has held an NRF C2 rating since 2015, and joined the Department of Clothing and Textile Technology this year.	**Interview 3** – “We currently have three researchers with doctorates in our department, doing more applied research in industry. Not to deliver publications but is to find a solution to a particular problem in the industry.”

6.2.1 Quality

The academic publication findings indicate that most of the publications are from the higher education institution (HEI) of CPUT, specifically the Faculty of Engineering. The findings corroborate the Human Sciences Research Council – Centre for Science, Technology and Innovation Indicators (HSRC-CSTII) (2019) because research is expected from HEI staff. The findings show that there was more academic research output than from students. Kruss and

Visser (2017) stated that public HEIs were established in diverse periods to meet specific economic and political purposes. From the findings, the TSCT was established to meet socio-economic purposes. The findings on the quality of academic publication output in this study suggest that TSCT meets the purpose. The findings also highlighted criteria that correlate with socio-economic issues in society. However, the findings suggest that more publications are possible and envisaged. The following section will highlight challenges that could be hindering the TSCT from reaching its full potential.

6.2.2 Challenges

The findings highlight that research done for academic publications is not focusing on the National Development Plan 2030, the triple challenges of poverty, inequality, and unemployment. The findings show that researchers are not thinking of academic publication implications but instead want to publish research based on preference and not on solving societal challenges. The findings refute Ranga (2012) because they do not support that triple helix systems could solve structural problems arising from the shift from an industrial society to a knowledge-based society. It means the findings suggest that a quantity over quality approach to researching has researched that of an industrial society instead of a knowledge-based society. However, the challenges were expressed by TIA, and seemingly, when the opportunities were explored, the TSCT acted.

6.2.3 Opportunities

The findings support Madue (2011) and HSRC-CSTII (2019) by validating the investment in research. The findings indicate that TSCT has the academic staff with the relevant skills to conduct research. Thus, the TSCT could develop a critical mass that will increase postgraduate research output. It supports the purpose of the Technology Stations Programme, as stated by the Department of Trade and Industry (2016). The findings indicate that the TSCT aims to align with industry needs and focus more on applied research than basic research, which will aid external research funding. It also supports Etzkowitz's (2008) and Etzkowitz and Zhou's (2018) laissez-faire triple helix model (TH II) because the industry is the driving force in the system.

6.3 FINDINGS ON MASTER'S THESES AND DOCTORAL DISSERTATIONS

Theses or dissertations are documents submitted in fulfilment of an academic degree (master's and doctoral), presenting the author's research and findings (University of KwaZulu-Natal (UKZN), 2019). Table 6.2 highlights the document and interview findings for master's theses and doctoral dissertations in the TSCT.

TABLE 6.2: FINDINGS FOR MASTER'S THESES AND DOCTORAL DISSERTATIONS

State of outputs	Quotation from document (n=23)	Quotation from interview (n=3)
Quality	**TSCT 2010** – GTZ (German Agency for Technical Cooperation) and TIA funded the TSCT's hosting of a visit of academic […] to supervise four MTech students. **TSCT 2015** – Clothing and Textiles lecturer […] is exploring the use of ultrasonic welding in the production of sports clothing for cyclists as part of her master's degree research… **TSCT 2016** – Exploration of ultrasonic welding, which forms part of *student* master's thesis, is important not only for the textile industry, but for the training of students enrolled in the university's clothing management programme	**Interview 3** – "…we currently in the clothing and textiles academic programme, we don't have master's and a doctoral qualification." **Interview 3 –** "…a student did a master's looking at workwear for women, they used the facilities of the technology station, for example the body scanner etc. to develop better fitting workwear for women." **Interview 3 –** "…a person did a master's in Quality focus on the textile industry from that perspective […] it does not necessarily say [master's in] 'clothing and textiles. It could be [a degree] in another discipline and they [students] would join us."
Challenges	**TSCT 2017** – …despite the challenges that we are currently experiencing in respect of throughput rates and supervision.	**Interview 2 –** "…some of the universities are phasing out textile courses." **Interview 2 –** "…a lot of people do studies, but they are not being applied." **Interview 2 –** "For all the professors and lecturers within that university there is an equipment usage policy where we say to them as much as we are set up to assist industry, we want 70% of the equipment to be used for every local project and 30% of the equipment, the expertise, and the skills to be made available for university staff and students." **Interview 3 –** "There has been a recalling of academic programmes." **Interview 3 –** "So the course we might run with them five years ago might not be relevant and might be something else going forward."
Opportunities	**TIA 2017** – To increase the number of high-level graduates and improve their representativity. **TSCT 2010** – Overall, research has been placed on a trajectory which will see the faculty position itself as a national leader in a number of priority areas, through robust global partnerships, leading to quality	**Interview 1** – "…strengthen existing capacity in HEIs departments in order to increase the experience, improve practices and competency levels." **Interview 2** – "…researchers […] putting on their master's and doctoral students on industry-related projects based on your needs or faculty."

	master's and doctoral programmes and high industrial impact. **TSCT 2017** – The faculty aims to integrate its teaching and learning with its research programmes and proactively pursue collaborative partnerships regionally, nationally and globally to create opportunities for socio-economic change aimed at solving regional and national. **TSCT 2020** – TEXTILES RESEARCH: …Our access to top-rated research, postgraduate students, industry experts and the latest equipment means that you have a complete knowledge-generating hub at your disposal.	**Interview 2 –** "…a lot of other universities […] are phasing out some of these textile courses." **Interview 2 –** "…they're [TSCT] trying to adapt to their curricula to make sure that it's updated or is in line with the industry […] to have one of the stronger […] textiles departments within the country." **Interview 3 –** "…a person did a master's in quality focus on the textile industry from that perspective. Another person may look at chemicals, like I said, harmful chemicals in textiles and write it from that perspective. It is not necessarily that it says, 'clothing and textiles', it could be in another discipline and that they would join us." **Interview 3** – "…in the process of getting to that [creating master's and doctoral studies] […] We're submitting almost on an annual basis, so we've just submitted a postgraduate diploma qualification for approval by the department, and I would assume by 2022 we would have a master's."

6.3.1 Quality

The findings indicate that the TSCT supports master's theses but at the capacity of academic collaboration and not through TSCT. The findings show that there is currently no clothing and textiles master's and doctoral programme available at the TSCT. It means that the institution the TSCT is a part of does not have these programmes. The findings support NSI (Grobbelaar, Tijssen & Dijksterhuis, 2017; Manzini, 2015; Morris & Einhorn, 2008; Organisation for Economic Co-operation and Development (OECD), 1997) but not the triple helix model (Etzkowitz, Dzisah, Ranga & Zhou, 2007; Etzkowitz & Leydesdorff, 2000; Etzkowitz & Ranga, 2010; Etzkowitz & Zhou, 2018) because the university is acting as a support and is not being entrepreneurial and driving collaboration.

6.3.2 Challenges

The findings indicate that the challenge with master's and doctoral programmes is that CTLF programmes are being phased out in South Africa. The findings also corroborate Milshina, Pavlova, and Vishnevskiy's (2019) view that the CTLF industry has a high degree of uncertainty. The findings show that the CTLF industry is constantly evolving, and universities choose to let go of study programmes. The findings support Mbatha (2020) that there is a mismatched curriculum for UIG R&D collaboration. The findings suggest that the TSCT could

be part of why South African research for master's and doctoral students is less than 10% (Department of Higher Education and Training, 2018).

6.3.3 Opportunities

The findings show that the TSCT took the challenges that exist in the CTLF industry and in academia to be in the process of creating master's and doctoral programmes. The findings corroborate Mbatha and Mastamet-Mason's (2021) findings that universities are trying to strengthen departments relevant to industry and the structural environment by solving issues within the country. Academic collaborations have strengthened this effort, and more information on the opportunities is in the following section.

6.4 FINDINGS ON ACADEMIC COLLABORATIONS

Academic collaborations are joint academic ventures by researchers of differing stature, funding status, and types of organisations (OECD, 1997). Table 6.3 highlights the document and interview findings for academic collaborations in the TSCT.

TABLE 6.3: FINDINGS FOR ACADEMIC COLLABORATIONS

State of outputs	Quotation from document (n=22)	Quotation from interview (n=3)
Quality	**TSCT 2010** – A collaborative project with the AMTL (Advanced Manufacturing Technology Laboratory) to develop engineering solutions for the clothing and textile industry was completed. **TSCT 2011** – Highlights for 2011 included a research project conducted with Eskom involving the evaluation of nanofibres for water treatment. **TSCT 2011** – Water Research Commission project: Nanoparticles for the treatment of industrial-scale effluents… **TSCT 2015 –** *Ms Abrahams*, who is collaborating on this project with a local sports clothing producer, has already identified weldable technical textiles that can be used to produce garments suitable for cycling... **TSCT 2017** – Innovator […] displays his patented AOEN bag (Wi-Fi Recharging bag) at the National Science Week exhibition. The project was a collaboration between the	**Interview 2** – "…[another technology station] […] had a partnership with industry and they set up a simulation facility at the technology station of a CPT [chemical processing technologies] plant […] and now they've also developed a three-year degree or qualification for CPT technologies […] students that come out of there are absorbed by companies." **Interview 2 –** "…professors and lecturers have access to all the equipment [under the] equipment usage policy […] 70% of the equipment is used by every local project and 30% of the equipment, the expertise and skills are made available for university and staff." **Interview 3 –** "…the TSCT venture with local and international partners...we do projects with retailers and manufacturers […] and try to engage with industry on a fairly regular basis to understand their needs." **Interview 3 –** "…we have a good relationship with a particular university in

	Technology Station Electronics (TSE) based at [the] Tshwane University of Technology and the Technology Station Clothing and Textile (TSCT) based at CPUT. **TSCT 2017** – principal of Atlantis Senior Secondary School who noted his willingness to accommodate the entrepreneurs as an incubator and TIA for supporting the Technology Station: Clothing and Textiles to extend its footprint. **TSCT 2018** – …H&M foundation visited the Clothing and Textile Technology Department at Cape Peninsula University of Technology to present the Global Change Award (worth EUR 1 million) to students and staff.	Germany, where we are able to bring a professor focusing on sizing." **Interview 3 –** "…the City of Cape Town, we particularly work with them, assisting them with development of the informal sector and engaging with them on that."
Challenges		**Interview 1 –** "Partners are inadequately capacitated to effectively achieve desired goals and objectives, as well as the required governance and management compliance standards." **Interview 2 –** "There is no acknowledgement of the Technology Stations Programme." **Interview 3 –** "We, unfortunately, have to tailor-make reporting to different people." **Interview 3 –** "Sometimes they [industry] share, sometimes they don't...they also see it as their competitive advantage."
Opportunities	**TIA 2017/2018** – To derive a greater share of economic growth from R&D-based opportunities and partnerships. **TSCT 2016** – The faculty aims to integrate its teaching and learning with its research programmes and proactively pursue collaborative partnerships regionally, nationally and globally to create opportunities for socio-economic change aimed at solving regional and national	**Interview 1 –** "A better enabling environment for [the] exploitation of R&D outputs of HEIs in partnership with other government agencies and entities." **Interview 3 –** "The people that join our department are coming from outside of the department."

6.4.1 Quality

The findings show that academic collaborations in the TSCT were a mix of formal and informal collaborations with universities, companies, SMEs, and other institutions throughout the years.

The findings corroborate Kruss and Visser (2017), stating that universities of technology have a scientific reputation in niche areas and tend to engage with large national firms and SMEs. The findings refute Sihlobo and Mbatha's (2019; 2022) reason that academic collaborations are unavailable because of a lack of government funding and CTLF industry funding. The findings support the laissez-faire triple helix model (Etzkowitz, 2003; 2008; Etzkowitz & Leydesdorff, 1998) because the industry is the driving force, thus government and university are supporting structures. This finding confirms the theory claim by the researcher of the Western Cape CTLF industry.

6.4.2 Challenges

The findings show that challenges exist more at a structural level for the Technology Stations Programme (TSP) than specifically for the TSCT. The directive for running technology stations comes from TIA, which inevitably comes from the Department of Science and Technology (now the Department of Science and Innovation). The findings support the legislative and mandate authority given to TIA by the Department (DST, 2010; 2017; 2018; 2019; DTI 2016; 2018; TIA, 2016; 2017; 2018; 2019; 2020a; 2020b). The major challenge the TSCT faces is working with various stakeholders with differing demands. The findings corroborate Mbatha's (2020) finding that competing interests between institutional spheres create challenges for effective collaboration. A competing interest is a challenge to the laissez-faire model because industry, university, and government are separate from each other, and institutional spheres interact modestly across strong boundaries (Etzkowitz, 2008; Etzkowitz & Zhou, 2018).

6.4.3 Opportunities

The opportunities for academic collaboration are partnering with various lecturers from various universities with different backgrounds. They come with different research expertise and disciplines to grow research and development. The findings corroborate with the OECD (1997) on academic collaboration. Other opportunities exist when collaborating with various government agencies and entities for regional and national change. It supports Mbatha (2020) and the legislative and mandate authority given to TIA by the department (DST, 2010; 2017; 2018; 2019; DTI 2016; 2018; TIA, 2016; 2017; 2018; 2019; 2020a; 2020b).

6.5 FINDINGS ON POLICY DOCUMENTS AND REPORTS

Policy documents and reports are official documents written to give information to a specific audience and for a specific purpose (Merriam-Webster, 2020). Table 6.4 highlights the document and interview findings for policy documents and reports that affect the TSCT.

TABLE 6.4: FINDINGS FOR POLICY DOCUMENTS AND REPORTS

State of outputs	Quotation from document (n = 22)	Quotation from interview (n = 3)
Quality	**TIA 2016** – The Technology Stations Programme has contributed towards the achievement of the DST [now DSI] and national objectives relating to technology innovation, enabling and support.	**Interview 2 –** "We report on the number of SMEs assisted […] the number of innovation products supported […] additional income so when the technology managed to get additional income […] we also report on the project from the technology stations in terms of TRL progression." **Interview 2 –** "…there's an economic impact assessment that then external companies then go and interview the clients that would have been assisted by all TIA programmes including the technology stations and then they tell us how we have done in terms of our economic impact indicators". **Interview 3 – "**We got to look at the aim of the stakeholder, for example, FP&M SETA, their focus is purely on training and human capital development, and when we report, we have to extract that information out when we report to them. They might not be interested in testing."
Challenges		**Interview 1 –** "Unco-ordinated ecosystem with duplicated national and regional initiatives." **Interview 2 –** "The [reporting] process is different for all the technology stations and it's different all the other programmes." **Interview 3 –** "We, unfortunately, have to tailor-make reporting to different people."
Opportunities	**TIA 2016** – Contributing to the NDP: The triple challenges of poverty, unemployment, and inequality require that government intensifies its efforts to drive initiatives that will lead to economic growth that is inclusive, equitable and leads to job creation and eradication of poverty. **TIA 2017** – The focus areas for FY2016/17 at an organisational level were to develop strategic plans for Strategic Technology Areas and Innovation Programmes linked to national priorities in collaboration with the relevant NSI stakeholders.	**Interview 1 –** "…identified initiatives that demonstrate the potential of the NSI to help address poverty, unemployment and inequality […] strengthening the NSI and various industry ecosystems in collaboration with key implementation partners across the innovation value chain." **Interview 1 –** "…the Technology Stations Programme […] aspires to introduce innovation and the use of technology more effectively, which requires a framework for benchmarking amongst the networks."

	TIA 2019/2020 – During FY2019/20, TIA will undertake assessments of all those SMMEs supported by TIA: the impact of Technology Stations Programme's support, growth in business, jobs, profitability, sustainability and location within private firms. Economic clustering and collaborations in bio-technology are essential in clarifying innovation and science, which are people-oriented. **TIA 2019/2020** – A cluster approach that is informed by the incubation development method can enable the exploration and hybrid models for speedy scientific and technology achievements which are transformational. **TIA 2019/2020** – The Government requires entities in the STI environment to render broad-based support to SMMEs, for example through walk-in support at technology stations. **TIA 2019/2020** – Furthermore, in the FIR, the technology stations' efforts will be focused on [the] diffusion of emerging technologies that will shape the realisation of the bio-economy to effectively integrate solutions […] to respond to poverty and inequality. **TIA 2019/2020** – For the FY2019/20, the technology stations will introduce technologies for transformative business applications into the programme to scale up the automation and data exchange in manufacturing technologies within the technology stations' network. **TIA 2020/2021** – The changing innovation landscape requires that TIA positions its technology station capabilities as part of a package of support in the National System of Innovation to promote the growth of collectives and small, medium, and micro enterprises; contribute towards innovation-led industrialisation processes; and foster inclusive development through an expanded spatial footprint and enhanced access for entrepreneurs throughout the country.	**Interview 2 –** "You're gonna have gaps in terms of just having a look at the technologies, just focusing on Technology Readiness Levels (TRLs) which is why the [TIA] organisation is trying to include the Business Readiness Levels (BRLs) as well as the MRL [Market Readiness Levels]."

	TSCT 2017 – CPUT is also beginning strategically to align itself to meet the challenges of the 4IR and 5IR, and further contribute towards achieving sustainable development goals and other relevant policy targets.	

6.5.1 Quality

The findings show that the TSCT does report. The reporting done is based on the stipulation of the Technology Stations Programme. The directive comes from the DSI, then filters to TIA and, ultimately, the Technology Stations Programme. The findings corroborate with the literature found on the TIA's legislative and policy mandates, strategic focus and performance measurement (DST, 2010; 2017; 2018; 2019; DTI 2016; 2018; TIA, 2016; 2017; 2018; 2019; 2020a; 2020b) and the reporting is also stakeholder dependent which leads to the challenges stated below.

6.5.2 Challenges

The findings on challenges indicate that reporting is stakeholder specific. The findings highlight reporting duplication, thus corroborating with Mbatha (2020) and Molebatsi (2015), due to the demands of various stakeholders. The findings also support Molebatsi's (2015) stance that there should be proper measures in place to capture outcomes and future decisions of the Technology Stations Programme and that the relationship between the strategic objectives of the Technology Stations Programme and the performance indicators used for impact assessment was not clear. The findings support the Department of Trade and Industry (2018) that the DST (now DSI) and the TIA explore opportunities to improve South Africa's economic competitiveness through science and technology.

6.5.3 Opportunities

The findings on opportunities corroborate with TIA's legislative and policy mandates, strategic focus, and performance measurement (DST, 2010; 2017; 2018; 2019; DTI 2016; 2018; TIA, 2016; 2017; 2018; 2019; 2020a; 2020b). These findings suggest that the future operating measures of the TSCT are in line with the TIA. Moreover, the TSCT is also aligned with its HEI.

6.6 FINDINGS ON SCIENTIFIC DISCOVERIES

Scientific discoveries are new inventions or innovations created by new or improved technologies to form products or processes from a successful scientific inquiry (Schickore, 2018).

TABLE 6.5: FINDINGS FOR SCIENTIFIC DISCOVERIES

State of outputs	Quotation from document (n=22)	Quotation from interview (n=3)
Quality	**TIA 2019/2020** – …In [the Technology Stations Programme] FY2017/18 41 enterprises securing commercial contracts because of interventions from the programme. **TSCT 2012** – CPUT now boasts the latest 3D design technology software for clothing product development. This cutting-edge technology is revolutionising clothing production by helping the industry to cut down on prototype costs. The software, which is housed at the Technology Station in Clothing and Textiles, allows a designer to develop a pattern on a CAD system and then develop a 3D simulation of a garment that can be shown on a virtual mannequin. **TSCT 2015 –** *Ms Abrahams*, who is collaborating on this project with a local producer of sports clothing, has already identified weldable technical textiles which can be used to produce garments suitable for cycling... **TSCT 2017** – …patented AOEN bag (Wi-Fi Recharging bag).	**Interview 3 –** "So, for example, one of the key drivers that we have here is around sustainability and based on that is how do we reduce chemicals and harmful chemicals within clothing or in textiles in general and it is an international trend at the moment." **Interview 3** – "There was a guy at Pretoria University, we assisted him in developing mosquito-repellent socks. So, he developed a chemical to repel mosquitoes, and we [the TSCT] made it into socks…" **Interview 3** – "…developing high-end innovative products for outputs, for example, smart-textiles, textiles that react to stimuli or senses in them."
Challenges	**TIA 2017** – To maintain and increase the relative contribution of South African researchers to global scientific output.	**Interview 1 –** "…outdated capital infrastructure." **Interview 2** – "…technologies that exist at universities and science councils […] are not getting to the market." **Interview 2 –** "For all the professors and lecturers within that university, there is an equipment usage policy where we say to them as much as we are set up to assist industry, we want 70% of the equipment to be used for every local project and 30% of the equipment, the expertise and the skills to be made

		available for university staff and students."
Opportunities	**TIA 2016** – Internationally, STI and related discoveries are recognised as future sources of economic growth with the potential to create new types of jobs, as well as new solutions to challenges like poverty, poor health and water shortages.	**Interview 3 –** "…we discovered that this [sizing] was a big problem and we then transfer that knowledge to industry. It led us to, for example, purchasing a 3D body scanner, then looking at using technology to then design products […] The 3D body scanner project is ongoing […] and there is "no South African size chart." **Interview 3 – "…**we are looking at developing our expertise in a particular economy...where we are able to develop products that are sustainable, assisting businesses with that. It is a very trendy international[ly], and it hasn't taken off well in South Africa yet. I think that is a great opportunity, going forward."
	TSCT 2015 – "This is an innovative way of melting synthetic fabric […] In terms of comfort, the seam is really fat, and there is less chafing on the skin […] Ultrasonic welding requires no needles, solvents, adhesives, mechanical fasteners, or other consumables." **TSCT 2017 –** "Textiles can be manipulated into various shapes with ease, and the fibres used in them are lightweight, which makes for a lighter, more fuel-efficient vehicle. Also, by reducing emissions, these textiles contribute to a healthier environment."	

6.6.1 Quality

The findings on scientific discoveries support the National Intellectual Property Management Office's (NIPMO) (2017) skills for successful scientific inquiry. These skills include a background in science and engineering, an understanding of R&D technology stages, intellectual property (IP) protection, and the ability to design IP for commercialisation and market and develop commercial relationships with partners. However, some skills could not be tracked, such as who the commercial local and international partners (probably due to trade secrets) were and the ability to negotiate complex transactions while meeting the Intellectual Property Rights (IPR) Act requirements.

6.6.2 Challenges

The findings on challenges support Frick, McKenna, and Muthama (2017) that the effectiveness of higher education and doctoral education is in question because scientific discovery does not equate to compassionate and creative scholars. The findings show that UIG collaborations, specifically the triple helix model (Etzkowitz, Dzisah, Ranga & Zhou, 2007; Etzkowitz & Leydesdorff, 2000; Etzkowitz & Ranga, 2010; Etzkowitz & Zhou, 2018) are not implemented for the success of the value chain of the CTLF industry. The findings refute Barnes (2018a; 2018b) that market access advantages, value chain capabilities, and success

of government industry policies and incentives will lead to success. The findings refute the success of the Technology Readiness Levels (TRLs) (TIA, 2018; 2019; 2020) because the maturity of technology does not equate to market success and commercialisation. However, the findings support that the inclusion of the Business Readiness Level (BRL) approach for enterprise development and the Market Readiness Level (MRL) for market and demand validation and feedback will assist with the challenges of the TRLs.

6.6.3 Opportunities

The findings support the direction of the future of the CTLF industry by Milshina, Pavlova, and Vishnevskiy (2019) that there are new methods to increase manufacturing efficiency for the CTLF industry. The findings also support the authors' idea that new technologies will replace traditional working environments. The findings support the dual objectives suggested for the South Africa CTFL industry for sustainability through lean production and a quick response supply chain model (Cape Clothing and Textile Cluster (CCTC), 2017). However, the findings do not provide solutions for the future of the CTLF industry since the COVID-19 pandemic. Thus, the Business of Fashion and McKinsey and Company (2020) refute suggestions of adapting to the new market environment by evaluating divestment and acquisition opportunities to strengthen their core and capture whitespaces that emerge from the reshuffle.

6.7 FINDINGS ON GRADUATES WITH RELEVANT SKILLS

Graduates with relevant skills are students who can transfer skills learned from an academic degree to the workplace environment and have competitive skills necessary for the industry (Ishengoma & Vaaland, 2016).

TABLE 6.6: FINDINGS FOR GRADUATES WITH RELEVANT SKILLS

State of outputs	Quotation from document (n = 22)	Quotation from interview (n = 3)
Quality	**TIA 2018/2019** – 124 students were afforded the opportunity to work on industry projects at [various] technology stations in the manufacturing and agro-processing sectors because of leveraged direct income.	**Interview 2 –** "…technology stations are meant to be that platform where students can get their training and work-integrated learning…and get some form of work experience…they [students] can be assisted to get technical skills." **Interview 2 –** "…because we realise the importance of having internships allocations to the technology stations, we've said to them [technology stations] when they budget on an annual basis, they can include provision for two interns
	TSCT 2010 – The Department of Science and Technology funded ten internships with the TSCT. **TSCT 2016 –** …students must be skilled in the latest technology. 'Rather	

	than just teach students about what's available now, we are looking ahead and advancing our students. Manufacturing advice – Audits and process improvements (productivity and quality). **TSCT 2017** – 26 Young Entrepreneurs from Atlantis […] screen-printing training programme […] helps these entrepreneurs to add value to their fabrics. **TSCT 2017** – The TSCT has been planting the seeds for job creation across South Africa through the Extending the Footprint (EGF) Project. The programme has shown that it is possible to train learners to manufacture their own school dress in one week. The training focuses on the basic clothing production methods used in an industrial environment. **TSCT 2018** – Subsidised services offered on the EGF project: • Human capital development – one day workshops, one week and two-week training sessions. • Product Development – Technical Drawings, pattern-making and grading services. • Product testing and analysis – Various fabric testing services. **TSCT 2018** – Small business participants under the banner of "Mothers Unite" an NPO based in Lavender Hill on the Cape Flats joined the Technology Station Clothing and Textiles on a 2-day programme "INTRODUCTION TO INDUSTRIAL SEWING MACHINE PRACTICE" ... **TSCT 2020 –** HUMAN CAPITAL DEVELOPMENT: The TSCT offers a menu of short learning programmes to the Clothing, Textiles, and related industry. All short learning programmes are governed by CPUT's Centre for Professional and Personal Development (CPPD) and its short course policy as well as the institutions quality management policy and procedure. **TSCT 2020** – The TSCT offers a menu of short learning programmes and has been appointed by the FP&M Seta as a host training provider, which allows	as a programme we still train two people". **Interview 3 –** "…a lot of the students might spend a year with us, some of them even eight months, before they finish their internship... companies recruit them to come work for them because of relevant experience. We are able to impart experience with the students under [the] supervised condition to be able to do various activities." **Interview 3 –** "Sometimes a company might say, we just need a workshop to impart specific knowledge...people coming in to do practical programmes...where although we are based in Cape Town, we might fly down to Durban to go to a training course with a *Fashion Retailer* because of a specific need they have. One advantage of that is...that we draw on expertise from someone in industry"

	the TSCT to offer learnership in conjunction with [the] qualifying firm. **TSCT 2020** – CPUT lecturers have contributed their own time and skills to assist disadvantaged individuals to empower themselves with marketable skills. TSCT, together with the City of Cape Town Enterprise Development Unit, has been visiting impoverished communities around the Peninsula, informing them about the support they could provide.	
Challenges		**Interview 2 –** "Department of Science and Innovation had what was called setup which was the Science Engineering Technology Industry Internship Program […] so that programme was dedicated or specifically focused on having interns […] where they were just getting work experience at the technology station […] and then that programme stopped…" **Interview 3 –** "We discovered that, especially with COVID-19 […] that if we can relate the training in a home language instruction, it will be better." **Interview 3 –** "For example, we did a lot of online teaching, via Blackboard or via those mediums. We thought we will be able to do that for the SMME sector, but we also discovered that many of our SMMEs didn't have access to computers, they struggle with [cellphone] data" **Interview 3 –** "So the course we might run with them five years ago might not be relevant and might be something else going forward."
Opportunities		**Interview 2 –** "…we are trying to drive them [technology stations] to work for the future. We're trying to make sure that they will accommodate future jobs." **Interview 3 –** "For example, we are now teaching students how 3D technology works, then in a year or two students will be going out here [TSCT] also with that type of knowledge using it in industry." **Interview 3 –** "Rather than having to make people understand English or Afrikaans we will use the medium that they are familiar with."

		Interview 3 – "Currently developing an online short course. We even have inquiries from Botswana and Namibia."

6.7.1 Quality

The findings show that technology stations should enable students to get technical skills and work-integrated learning. The findings are evident in two of the four areas of employability Jacobs (2018) suggests. These include technical competencies and life skills for a globalised knowledge economy. The findings corroborate the findings of the DTI (now DTCI) about the DST (now DSI) and the roles of technology stations. The findings show that TSCT produces graduates with relevant skills, thus refuting Tilson-Scoble (2017) that HEIs produce too many graduates with general CTLF degrees, with very few people with high-level specialist skills. However, the findings supports Tilson-Scoble (2017) that there should be a transitional period where employers train graduates for company positions as it will help to build their knowledge and skills in shaping them into productive employees. It also supports Etzkowitz and Leydesdorff (2000) and Spinoglio (2015) that graduates bring knowledge to their new jobs.

The findings show that human capital development is a strength of the TSCT, ranging from SMMEs to large companies, individuals, and disadvantaged communities. The focus is on short training programmes or workshops for skills training that can be applied immediately in the CTLF industry. The findings corroborate HSRC-CeSTII (2019) that HEIs should provide graduates with industry-relevant skills. The findings show that the government also funds internship opportunities. The findings show that government funding plays a key role when it comes to students and graduates, which corroborates Mbatha's (2020) claim that government funding drives collaboration. The findings also confirm that government is the driving force at the national level, which then confirms that the triple helix model in operation at the national level is the statistical model. It also supports Mbatha's (2020) claim.

6.7.2 Challenges

The findings show that an internship programme discontinued at the department level filters down the TIA and affects programmes like the Technology Stations Programme and the TSCT. It supports Christie's (2016) claim that publicly funded institutions are not providing the required training due to skills gaps and shortages at a technical and managerial level. The findings show that internships decreased from ten internships to two internships, but the TSCT has managed to grow their community footprint.

The findings show that in human capital development, the challenge has been making courses available in the language of instruction. The findings also show that challenges exist with online instruction, as not all students have access to resources to further education. The findings corroborate Mbatha's (2020) finding that curricula mismatches exist. However, the findings refute the UIG collaboration technology issue based on social needs. The societal basis supports Tilson-Scoble's (2017) acknowledgement of the disparity between CTLF industry needs and HEI provision, and bridging the gap would take an alignment of the expectations of students, educators, and employers. The findings show that challenges are linked to Jacobs's (2018) two areas of employability. These are higher-order cognitive skills (acquiring knowledge and understanding through thought, experience, and the senses) and metacognitive (thought process) strategies. The findings support Mbatha (2020) and Jacobs (2018) in that there should be a CTLF industry cultural shift to combat the industry's challenges.

6.7.3 Opportunities

The findings show that TSCT aims to align their curriculum with industry needs. The findings support the DST's (2016) (now DSI) role of technology stations by solving industry problems and ensuring industry requirements are incorporated into curricula for students to meet industry needs. The TSCT is for industry and also for the community, as well as catering to international markets. The findings support the directorate of Mbatha (2020) to a sustainable CTLF industry. The findings also support Jacobs's (2018) focus on curricula development and learning outcomes to prepare graduates for the CTLF industry because knowledgeable graduates add value, feed innovation, and enable global competitiveness.

6.8 CONCLUSION

The Sections in 6.2 to 6.7 covered the following findings: academic publications, master's theses and doctoral dissertations, academic collaborations, policy documents and reports, scientific discoveries, and graduates with relevant skills. The findings found these traditional academic outputs' quality, challenges, and opportunities. Thus, finding the state of the academic outputs in the TSCT. The conclusions and final ratings (+ or +/- or -) for each output with reasons will be explored in the final chapter (see Chapter 8). The next chapter (see Chapter 7) will highlight socio-economic output findings to get the state of TSCT socio-economic outputs.

CHAPTER 7: SOCIO-ECONOMIC RESULTS AND DISCUSSIONS

"'For I know the plans I have for you,' declares the LORD, 'plans to prosper you and not to harm you, plans to give you hope and a future.'" ~ Jeremiah 29:11

7.1 INTRODUCTION

This chapter presents the results in terms of the research aims and objectives of this study. This study aimed to investigate outputs from university-industry-government (UIG) collaborations in the Technology Station in Clothing and Textiles (TSCT) of the Western Cape, South Africa. The objectives of this study were:

OBJECTIVE 1: To investigate traditional academic outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

OBJECTIVE 2: To investigate socio-economic outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

This chapter is a continuation of the previous chapter and will focus on OBJECTIVE 2. Sections 7.2 to Section 7.6 will report the findings of the five socio-economic outputs. These outputs are new and improved products, new and improved processes, community infrastructure and facilities, spin-off companies, and cultural artefacts. Furthermore, everything is summarised, where a figure will be presented based on the state of the traditional outputs, and the final chapter conclusion will be drawn in Section 7.7.

The second and last objective of this study was to investigate socio-economic outputs from UIG collaborations. This was in terms of quality, challenges, and opportunities found within the TSCT. To present the findings the key found in Figure 7.1 will form a basis to present the findings.

Key for findings

Document analysis (n=22)

TIA	Data from the Technology Innovation Agency (TIA) and Technology Stations Programme (TSP)
TSCT	Data from the technology station in Clothing and Textiles (TSCT) and Cape Peninsula University of Technology (CPUT)

Interview analysis (n=3)

Interview 1	Interview data from the head of the Technology Stations Programme
Interview 2	Interview with manager of Technology Stations Programme
Interview 3	Interview with manager of TSCT

General

[ ]	Conceptualising the quote, researchers' own words
Words in italics	*e.g., Company A,* names have been changed for ethical reasons
	Colour for Quality
	Colour for Challenges
	Colour for Opportunities
	Colour for Data not found

FIGURE 7.1: KEY FOR FINDINGS

7.2 FINDINGS ON NEW AND IMPROVED PRODUCTS

New and improved products are products that contribute to intellectual property (licences, patents, copyright, and trade secrets, among others) and can be commercialised for socio-economic benefits (Kruss & Visser, 2017). See Table 7.1 for the findings of new and improved products.

TABLE 7.1: FINDINGS FOR NEW AND IMPROVED PRODUCTS

State of outputs	Quotation from document (n = 22)	Quotation from interview (n = 3)
Quality	**TIA 2016/2017** – 64 research and development initiatives with firms to facilitate advancing the products/services to market for commercialisation. **TIA 2017/2018** – …34 knowledge-based products and 1 571 competitive improvements were developed... **TIA 2017/2018** – …98 new knowledge products being developed; this is an increase of 53% from the FY2016/17, which saw 64 knowledge products developed. **TIA 2018/2019** – Support services provided by the technology stations span from the prototyping or piloting stage up until pre-commercialisation and include testing and analytical services; rapid prototyping and manufacturing; consultation, technology audit and feasibility study; process or product improvements; applied development, engineering and design.	**Interview 3** – "There was a guy at Pretoria University, we assisted him in developing mosquito-repellent socks. So, he developed a chemical to repel mosquitoes, and we [the TSCT] made it into socks…" **Interview 2** – "…so after some men have gone through a circumcision event […] the band-aid that they were using was actually sticking and causing pain and things like that, so he [a researcher] developed something where it would reduce the infections after the circumcision." **Interview 3** – "…developing high-end innovative products for outputs, for example, smart-textiles, textiles that react to stimuli or senses in them."
	TSCT 2010 – Adaptation of a sewing machine for the physically disabled; produced a working model. **TSCT 2010 –** Milling machining of new patterned shaping wheels for the ultrasonic welding machine. **TSCT 2010 –** Design and manufacture of an adjustable stand for a sewing machine. **TSCT 2010 –** Design and manufacture of a fabric inspection machine used in the clothing and textile industries. **TSCT 2010 –** Clamping device for layers in order to cut them into pieces which are exactly the same size. **TSCT 2010 –** Design and manufacture of a lifting device for rolls of the material of a minimum of 35kg and a maximum of 50kg, and transport of the material around the factory. **TSCT 2010 –** Re-engineering of an existing magnet guide to enable the	

	operator to ensure the stitches are straight and of good quality. **TSCT 2010 –** A device to measure the usage of a zipper, counting the opening and closing frequency cycles for failure to occur. **TSCT 2012** – CPUT now boasts the latest 3D design technology software for clothing product development. This cutting-edge technology is revolutionising clothing production by helping industry to cut down on prototype cost. The software, which is housed at the Technology Station in Clothing and Textiles, allows a designer to develop a pattern on a CAD system and then develop a 3D simulation of a garment that can be shown on a virtual mannequin. **TSCT 2017** – …patented AOEN bag (Wi-Fi Recharging bag).	
Challenges		**Interview 1** – "…uncertain and insufficient investment capital to support a growing demand." **Interview 1 – "…**government does not readily purchase locally produced goods." **Interview 1 – "…**access to pilot manufacturing and techno-economic evaluations for product scale-up and market entry." **Interview 1 – "…**commercialisation managers practitioner programme is not regulated or certified – in-take numbers are limited to available funding and reducing the ability to scale up the market entrance for new products." **Interview 3** – "…the model we had with the TIA that they didn't want to fund us, their funding was sort of reducing, we said how can we earn some money for yourself. And that meant we started servicing large companies who were paying clients for what we did."
Opportunities	**TIA 2019/2020** – …a total of 100 technologies and knowledge innovation products such as prototypes, patents, technology demonstrators and technology transfer packages are targeted to be supported from these facilities. This is against an	**Interview 3** – "A person to the age of 35 can apply if they have an idea, then they can apply for this if it is successful and feasible, they can come to the technology station, and the technology station would help them develop the product. From developing a prototype to be able to take it up to the market. So, it's basically holding their hand and

	estimate of 91 being realised in FY2018/19. **TSCT 2015** – Clothing and Textiles lecturer…is exploring the use of ultrasonic welding in the production of sports clothing for cyclists as part of her master's degree research. **TSCT 2017** – "Textiles can be manipulated into various shapes with ease, and the fibres used in them are lightweight, which makes for a lighter, more fuel-efficient vehicle. Also, by reducing emissions, these textiles contribute to a healthier environment," **TSCT 2020** – PRODUCT DEVELOPMENT: Turning ideas into reality. With our comprehensive range of product development software, equipment and skills, our product development department offers an advanced service to both start-ups and established businesses.	getting them to develop a viable prototype which they are able to take into the market." **Interview 3** – "On another level, SMME can come to us. We can assist them to develop a product which they can sell." **Interview 3** – "…we are looking at developing our expertise in a particular economy...where we are able to develop products that are sustainable, assist businesses with that."

7.2.1 Quality

The findings on new and improved products support the dual objectives suggested for South Africa in the CTFL sector to boost the competitiveness of products and sustainable industry growth by the Cape Clothing and Textile Cluster (CCTC, 2017). Therefore, there is evidence of deepening lean production practices to maximise efficiency and a Quick Response supply chain model to create a competitive advantage over international competition around flexibility and speed-to-market. The findings support the strategic focus of the Technology Innovation Agency (TIA) (DST, 2018a; 2018b) to provide customer-centric technology development funding and support. The findings also support the core goal of the Technology Stations Programme (TSP) to improve industry competitiveness by applying specialised knowledge and technology (DST, 2018a; 2018b). The findings support Kruss and Visser (2017) because the new or improved products contribute to intellectual property (licences, patents, copyright, and trade secrets) and could be commercialised for socio-economic benefits.

7.2.2 Challenges

The findings on challenges affect the TIA strategic focus (DST, 2018b) of developing an effective and efficient internal environment to execute the strategy. The findings show that challenges for new and improved products are aligned with a decrease in funding. It is a challenge because Mbatha (2020) found that UIG collaborations are driven mainly by government funding. The findings support that the TSCT was allocated grant funding from the

TIA ZAR 3.4 million in 2015/2016, ZAR 3.6 million in 2016/2017, and ZAR 3.7 million in 2017/2018. (The increments of funding per financial year are decreasing. From 2015/2016 to 2016/2017 = R200 000 increase. From 2016/2017 to 2017/2018 = R100 000 increase.) The findings also supported the decrease in product testing in 2014, 2 789 analyses and tests were conducted for SMMEs, 1 250 for 2016 and 489 for 2018.

7.2.3 Opportunities

Opportunities exist for the TSCT to grow their footprint in new economies. The findings support the Business of Fashion and McKinsey and Company (2020) that members of the CTLF industry must adapt to the new market environment to strengthen their core. The findings also support the authors' stance that the CTLF industry should be strategic in identifying financial leverage, divestitures, and acquisition opportunities. The CTLF industry must also identify strategic partners, increase earnings, and create operational and financial stability. The findings support an initiative of the TIA called the Youth Technology Innovation Programme (YTIP), which assists young innovators in accessing risk funding, mentorship, and business skills support (TIA, 2020a). Such opportunities for business development growth in the CTLF industry support the direction of the future of the CTLF industry to Milshina, Pavlova, and Vishnevskiy (2019) that there are new technologies and global trends for the CTLF industry.

7.3 FINDINGS ON NEW AND IMPROVED PROCESSES

New and improved processes are processes that contribute to intellectual property (licences, patents, copyright, and trade secrets, among others) and can be commercialised for socio-economic benefits (Kruss & Visser, 2017). See Table 7.2 for the findings on new and improved processes.

TABLE 7.2: FINDINGS FOR NEW AND IMPROVED PROCESSES

State of outputs	Quotation from document (n = 22)	Quotation from interview (n =3)
Quality	**TSCT 2010** – Process innovation project funded by the provincial government of the Western Cape to improve the processes of the following businesses: Farbe Sport, African Nature, KVM Manufacture, Cape Mohair, AC Clothing, Darkie Velotex Cycling Wear, Glow Gear, Duchess Uniforms **TIA 2018/2019** – Support services provided by the technology stations spans from the prototyping/piloting stage up until pre-commercialisation and includes testing and analytical services;	**Interview 3** – "…for a product analysis, a company comes to us, a client brought the garment back, and they ask us why this fabric is failing. We can run a number of tests and give them a report back to say...test your fabric before you make it up [before it becomes a problem], rather than when you have the problem." **Interview 3** – "A close facility that allows them to test their products quickly. We pride ourselves in the turnaround time, where we say [in] 48

	rapid prototyping and manufacturing; consultation, technology audit and feasibility study; process or product improvements; applied development, engineering and design; technology demonstration and training. **TSCT 2020** – MANUFACTURING ADVISORY SERVICES: Through our process of establishing a baseline, evaluation, implementation and re-evaluation, we will assist you in implementing effective, measurable quality and productivity improvements in your company. **TSCT 2020** – TEXTILES TESTING AND SPECIFICATIONS DEVELOPMENT: The laboratory provides product testing and analysis service to the clothing, textiles, and related industries.	hours, we will be able to test your product. It depends on the type of test."
Challenges	**TSCT 2015 –** Traditional sewing is still a popular method of joining materials but has disadvantages such as discontinuous joints, which produce perforated seams and sewing thread deteriorating with time, and sewing speed limitations	**Interview 1 – "…**insufficient investment capital to support a growing demand." **Interview 2** – "When somebody goes to the technology stations, we don't ask the data to have a baseline […] we found a lot of guys could tell that there's a lot of improvement, but they couldn't tell us exactly." **Interview 3 –** "One example, we worked with a factory that had a reject rate, we measured it, and they didn't realise it, but their reject rate was 95%. That means every single garment had to be fixed up...It's about taking systems where they're able to everyday measure what their quality is, how they measure their performance. And when they know what that is, you can measure it and correct it."
Opportunities	**TSCT 2015** – …the machine will revolutionise SA's clothing industry, helping to produce better-sized garments for a diverse consumer base…the portable scanner uses infrared technology to measure, generating up to 44 different measurements in a few seconds, with a set-up time of only 30 minutes. **TSCT 2015** – This is an innovative way of melting synthetic fabric […] In terms of comfort, the seam is really fat, and there is less chafing on the skin […] Ultrasonic welding requires no needles,	**Interview 3 – "…**[improve businesses] quality system and improving their productivity […] I will use an example, maybe they produce ten garments an hour and you look at their production system […] you are able to produce 15 garments an hour and that improves their productivity and bottom line their profit.".

	solvents, adhesives, mechanical fasteners, or other consumables.	

7.3.1 Quality

The findings show that the TSCT is exploring new and improved processes. The findings show the support of the Western Cape government for new and improved processes. The findings prove that the Western Cape government values the CTLF industry and supports literature on the Western Cape CTLF industry (Bizcommunity, 2019; CCTC, 2017; CDI, 2019; CTFC, 2019a; CTFC, 2019b; Wesgro, 2021; Western Cape Government, 2014). It also supports the laissez-faire triple helix model (TH II) because the Western Cape CTLF industry role players are more active than South African CTLF. Moreover, as much as there is more interaction between spheres, strong boundaries exist between the spheres.

7.3.2 Challenges

The challenges with processes were that processes outside the TSCT are general and not specialised. The findings support the DST (now DSI) views of the role of technology stations as a provider of specialised infrastructure aligned with the focus of technology stations. Furthermore, technology stations are a provider of specialist knowledge and skills to improve innovation and new products and process development (DTI, 2016:74). However, the findings refute the provisions from the public perspective because the findings indicate that the public was uninformed of the processes in the TSCT. The findings refute Süli's (2019) necessity for process modifications from the public's perspective. These include additional workforce requirements, developing a training plan, processing failure modes and effects analysis, establishing capability requirements, developing control plans and work instructions, and identifying assembly processes. Thus, value was created but not easily measurable or explainable. The findings then refute TIA (2018) and Villani, Rasmussen, and Grimaldi (2017) that technology transfer happens from specialised knowledge and innovative technologies.

7.3.3 Opportunities

The findings highlight that the TSCT may have solutions to the future of the Western Cape and South African CTLF industry. The findings support Mbatha (2020), who found categories less explored by industry. These categories are speed to markets, logistics of CTLF, e-business, marketing strategies, sourcing of raw materials, labour productivity, emerging markets, Quick Response, policies affecting the CTLF industry and technology in the CTLF industry. The findings also support the goal of the Technology Stations Programme (DST,

2018b) to improve the industry's competitiveness through the application of specialised knowledge and technology.

7.4 FINDINGS ON COMMUNITY INFRASTRUCTURE AND FACILITIES

Community infrastructure represents the physical systems of businesses or nations, such as transportation (air, water, road, and rail), communication, sewage, water, and electric systems vital to a country's economic development (Chappelow, 2019). Community facilities are buildings that offer health and emergency services, social and cultural public services, civic services, social services, education services, or parks and recreation services in a country (CSIR, 2012). See Table 7.3 for the findings of community infrastructure and facilities.

TABLE 7.3: FINDINGS FOR COMMUNITY INFRASTRUCTURE AND FACILITIES

State of outputs	Quotation from document	Quote from interview
Quality	**TIA 2017** – TIA, through its network of 18 technology stations and eight Technology Platforms, provides access to expertise and high-end infrastructure for the development of technologies. These facilities provide technical engineering and scientific support to innovators, entrepreneurs, SMMEs and large industry companies that require research, analytical and testing services to either validate or progress their technologies through the value chain. **TIA 2018/2019** – The programme provides technology innovators in targeted industries/communities with sophisticated state-of-the-art equipment, infrastructure and knowledge/expertise in specialised fields through the technology stations that would not otherwise be available to commercialise their innovations.	**Interview 2 –** "For all the professors and lecturers within that university, there is an equipment usage policy where we say to them as much as we are set up to assist industry, we want 70% of the equipment to be used for every local project and 30% of the equipment, the expertise and the skills to be made available for university staff and students." **Interview 3 –** "…with SMMEs, to get them to understand the importance of testing, 'why they need to test' and 'why they need to analyse'." **Interview 3 –** "We gave support to SMMEs to help them launch their product into the market to improve their capabilities. For example, imparting new skills to them and from the testing side we were able because our laboratories are accredited."
	TSCT 2013 – Technology platform: Specialised machines are available for use by SMMEs on an appointment basis. A satellite platform, the Fashion Technology and Innovation Centre has also been established in partnership and within the premises of the Cape Town Fashion Council (www.ctfc.co.za) **TSCT 2014** – The TSCT assisted *a client* with creating customised patterns, helped her to improve the production process, and put her in touch with suppliers in the industry. From working	**Interview 3 –** "Quite a number of small businesses that come here as start-ups and eventually they develop, sometimes they come with an idea. For example, one of the businesses, the lady graduated as a chemical engineer, then she couldn't find help as a chemical engineer then she decided to go in the clothing industry, so we helped train and set her up and currently she employs 13 people."

	with only two schools, *the client* now boasts a staff of ten and supplies ten schools with uniforms and sportswear. “I call the TSCT, my big brother. They have held my hand throughout the process of establishing my business,” she said. **TSCT 2017** – The TSCT developed a six-hour pull-on skirt programme, which enables the SMMEs to gain enough basic skills to develop and sew a basic pull-on skirt which they can make to sell. The main objective is to transfer knowledge through university resources to empower disadvantaged communities.	
Challenges	**TSCT 2015 –** Traditional sewing is still a popular method of joining materials but has disadvantages such as discontinuous joints, which produce perforated seams and sewing thread deteriorating with time, and sewing speed limitations	**Interview 1 – “…**uncertain and insufficient investment in Capex-High-End Infrastructure.” **Interview 2 –** “TIA doesn't do well even the tech stations programme is we don't pay our success stories […] we are not measuring our impact […] There isn't anybody that has the time to go out to a point where they can have enough data to say this is the actual impact of the technology stations.” **Interview 3 –** “We inherited a body scanner from the CSIR, and it allowed us to do size studies, but we found this a bit problematic that it was a fixed unit...you couldn’t move it, and it was difficult to bring people to the technology station to measure them. **Interview 3 –** “All universities have three main focus areas, one is teaching and learning, research and community engagement and they seem to neglect the community engagement part of it.” **Interview 3 –** “For example, the designer walks into a fabric shop and they buy something and say they want 100% linen, and they are given a piece of fabric and it’s 100% polyester. They don’t know so they come to us, and they check it, and we will see.”
Opportunities	**TIA 2017/2018** – Plans are underway to increase the operating capacity of the technology infrastructure and align these closer to industry. **TIA 2018/2019** – Aims to enable academia and industry to take part in technology transfer and development by	**Interview 3 – “**All universities have three main focus areas, one is teaching and learning, research and community engagement and they seem to neglect the community engagement part of it. So, our role straddles the research and community engagement.”

	facilitating their interaction and reducing barriers to market access via subsidised services offered by the 18 technology stations located across the country.	**Interview 3** – "…we purchased a portable unit, which allowed us to move the body scanner...to where the potential samples are. Let's say, for example; you want to move it to Durban. That process is ongoing."

7.4.1 Quality

The findings show that TSCT uses community infrastructure and facilities to run the operations of the TSCT, thus supporting Spinoglio (2015) that universities should provide a supportive environment with access to necessary infrastructure. The TSCT's HEI and members of the CTLF industry use the infrastructure. The findings support the objective operational measures of the Technology Stations Programme (DST, 2018b; TIA, 2016) for socio-economic impact. The findings support Centres of Excellence's five key performance areas (DST, 2019): research/knowledge production, education and training, information brokerage, networking, and service rendering. The usage policy for the TSCT reflects that industry is the driving force in the system (Etzkowitz, 2008; Etzkowitz & Zhou, 2018) because they are the sphere that benefits most. Thus, confirming the laissez-faire triple helix model (TH II) again.

7.4.2 Challenges

The findings show that the CTLF industry in the Western Cape, and possibly the rest of South Africa, still subscribes to traditional infrastructure and facilities. The findings show that some infrastructures in the TSCT are incompatible for national use should services be needed nationwide. The findings show that challenges exist regarding initiatives to be developed through the Textiles and Clothing Centre of Excellence (TCCoE) (DTI, 2010): South African garment sizing database utilising 3D body scanner technology, Computer-Aided Design (CAD) using 3D scanner data, processing capabilities of new natural fibres, non-woven products and fibre reinforced composites through new technologies, and technologies in garment designing. The findings show that lack of funds is the cause of not supporting changes in industry requirements. Ultimately, the findings also show that the community is unaware of the infrastructure and facilities of the TSCT.

7.4.3 Opportunities

The findings highlight opportunities to invest in the rest of South Africa. It means increased community development. This supports TIA's (2020a) improvement strategy for the 2015 to 2020 period:

- Enhance the ability to support SMMEs through the Technology Stations Programme (TSP);

- Implement an effective regional strategy;.
- Improve operational efficiencies and reputation (in terms of turnaround times); and
- Promote a Culture of innovation.

However, the findings refute 2020 to 2025 strategic cycle factors that support the TIA for becoming a rapidly maturing global environment (TIA, 2020b) because the TSCT has not matured in the global market.

7.5 FINDINGS ON SPIN-OFF COMPANIES

Spin-off companies are new small and medium enterprises (SMEs – formally, informally or non-VAT registered businesses or start-up ventures (Small Enterprise Development Agency (SEDA), 2016)) created by a parent company. See Table 7.4 for the findings of spin-off companies.

TABLE 7.4: FINDINGS FOR SPIN-OFF COMPANIES

State of outputs	Quotation from document (n = 22)	Quotation from interview (n =3)
Quality	**TIA 2016** – Technology Station Clothing and Textiles (TSCT) – Cape Peninsula University of Technology 14 SMEs managed to secure contracts through the intervention of the technology station, including Sweet-Orr and Move Pretty. **TIA 2019/2020** – …the Technology Stations Programme has achieved an impact of an economic multiplier of 3.7. Audited data from FY2015/16 to FY2018/19 reveals that an average of 2 413 SMMEs were assisted each year. In FY2017/18 alone, 34 knowledge-based products and 1 571 competitive improvements were developed, with a further 41 enterprises securing commercial contracts because of interventions from the programme.	**Interview 3 – "**Our focus is to assist SMMEs and develop prototypes**."**
	TSCT 2014 – Small business owner […] is making her mark in the clothing and textile industry thanks to support from CPUT […] owns a Khayelitsha-based school clothing manufacturing company, is just one of many small business owners who have been given a lifeline by the university's TSCT. Based at the Bellville campus, the TSCT provides	

	innovation support and training to the clothing and textile industry. **TSCT 2020** – SMME SUPPORT AND DEVELOPMENT: The TSCT provides innovation support to the clothing and textiles industry to become more competitive. Besides providing assistance to established businesses, we strategically aim to be a catalyst in the development of new SMMEs in all provinces. Industry growth and improvement is our number one priority.	
Challenges	**TIA 2019/2020** – There are key weaknesses that prohibit commercialisation for entrepreneurs who are serviced by the government via enabling incubators and accelerators; this is attributable to: i. Encouraging entrepreneurship by recognising international talents / overseas-based skills and exposure. ii. Developing new industries: IP-knowledge driven and new scientific exploitation. The IP Survey has reflected the commercialisation aspect (i.e., 7-2-1 sharing) to be weak for public-funded development. iii. Ecosystem for innovative enterprises to be built next to top universities. iv. Community/Municipality and youth development-based programmes towards underserved municipalities as guided by the Institute of Race Relations comfort/deprivation index measures. v. Governance and Management: big business involvement requires trust, not the "red tape" lengthy processes that do not provide value.	**Interview 1 –** "…no international soft-landing programmes for local start-ups and SMMEs to enable export market access in new and emerging markets to promote entrepreneurial thinking and culture at the HEIs." **Interview 1 –** "…no public institutionalised technology-based incubators that are market-led." **Interview 2 –** "…technology alone is not going to make a business successful or is not going to make a business attractive to the next funder." **Interview 3 –** "…the person with the [mosquito repellent] socks, he basically started a spin-out company, although he was based at the University of Pretoria, he started his spin-out company from there."
Opportunities		**Interview 2 –** "…bulk of the people in SMEs and individuals included [in the Technology Stations Programme] come from TSCT." **Interview 3** – "We currently have three researchers with doctorates in our department, doing more applied research in industry. Not to deliver publications but is to find a solution to a particular problem in the industry."

7.5.1 Quality

The findings show that the TSCT does not have spin-off companies but assists individuals in making companies in the form of SMEs. The findings show that the TSCT is not in the position to achieve an integrated triple helix model (Compagnucci & Spigarelli, 2018; Gutiérrez-Fuentes, 2015; Morrar, Hamand & Arman, 2018), such as the Sweden Textile Fashion Centre (Textile Fashion Centre, 2020) and the Hong Kong Research Institute of Textiles and Apparel (HKRITA, 2018). Thus, the Western Cape and the South African CTLF industry cannot have proper socio-economic development. The findings support Worku's (2018) claim that entrepreneurs start businesses as means of living and not to solve socio-economic issues. The findings support TIA's (2020b) terms of measuring commercialised innovations because the focus is on the following:

- The number of technologies developed;
- The number of technologies successfully diffused for inclusive development; and
- The total value of funding leveraged (based on the value of signed agreements entered with third parties).

Emphasis is more on individual technologies than on business ventures.

7.5.2 Challenges

The findings indicate the reason for the lack of entrepreneurship, which affects spin-off companies: The focus of the TSCT is community engagement and not entrepreneurship. It means that the TSCT is not in line with the third mission of economic development of universities (Bogoro, 2015; Ranga, 2012; Ranga & Etzkowitz, 2013). The findings indicate an external spin-off company that arose for research purposes from the TSCT, showing that spin-off companies could be created through academic research, specifically, a technology station, instead of the industry. However, the TSCT has not benefitted. Concluding that since South Africa publicly funded IP start-up companies in 2011 (NIPMO, 2017), the TSCT has not benefitted. Therefore, that is a challenge. Also, from the TIA (2018), the TSCT is not partaking in socio-economic benefits such as new or improved companies or industries leading to new jobs and wealth and reduced environmental impact.

7.5.3 Opportunities

The findings show that the TSCT has assisted hundreds of SMMEs but has not applied the knowledge and skills to start a company from the TSCT. The TSCT is missing out on the spin-off companies' benefits stated by Nottingham Trent University (2020). Research spin-off companies have the potential to create: new collaborations with organisations and

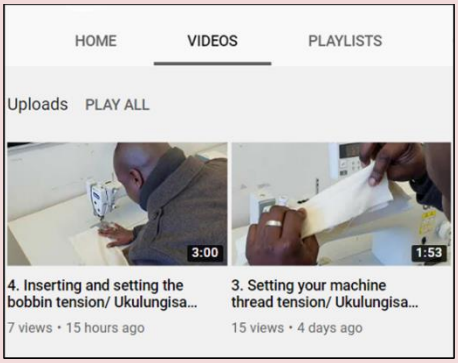
businesses, new jobs, money going back into the local economy and money to fund further research. The findings show that TSCT focuses on applied research, which is TRL level 3 of 9 of TIA's Technology Readiness Levels (TRLs). However, TRL 7 to 9 is where revenue generation and job creation happen (TIA, 2019). There is an opportunity for the TSCT to improve to get to higher levels of TRL and work on Business Readiness Levels (BRLs) and Market Readiness Levels (MRLs).

7.6 FINDINGS ON CULTURAL ARTEFACTS

Designs and creative works that are non-textual outputs (images, performances, artefacts, and designs). These works result from original, systematic investigation to gain new knowledge and understanding, leading to new or substantially improved insights (Council of Higher Education, 2005:15; Madue, 2011:162). See Table 7.5 for the findings of cultural artefacts.

TABLE 7.5: FINDINGS FOR CULTURAL ARTEFACTS

State of outputs	Quotation from document	Quotation from Interview
Quality	 **FIGURE 7.2: ARTEFACT ON TSCT WEBSITE (TSCT, 2020A)**	**Interview 3** – "We also noted that, especially with our sewing mechanic, the guy who is in the video, he could basically give the instructions in isiXhosa. Rather than having to make people understand English or Afrikaans, we use the medium that they are familiar with."

	 **FIGURE 7.3: ARTEFACT ON TSCT YOUTUBE CHANNEL (TSCT, 2020B)**	
Challenges		**Interview 2 –** "With every disclosure, whether it's a copyright or registered design or a patent […] we've looked at industry and this thing does not exist anymore." **Interview 2 –** "Disclosure or even registered designs is not necessarily something that is qualified by the Technology Stations Programme, but the programme should be able to determine if there is there's something new there that can be disclosed." **Interview 3 –** "I wouldn't say we have done a lot of artefacts. Our focus is rather on prototype development […] that is more of what we have been doing, rather than, you know, particular artefacts in a[n] academic sense."
Opportunities		**Interview 2 –** "If the research was done using publicly funded funds, they [NIPMO] will help you file through their technology transfer offices." **Interview 3 –** "…currently looking at [isi]Zulu, as a potential because we looked at where the areas are where the industry is...in the KwaZulu-Natal area there's big clothing industry. And if we can relate the training in a home language instruction, it will be better. I think it is something that has made a significant difference to people." **Interview 3 –** "We are also embarking on a project since last year on what we call fashion tourism...Where communities find what is unique in that environment, assisting them to develop products that they could potentially sell to tourists but is of a clothing nature...something about Cape Town or something about an area you live in."

		Interview 3 – "…a lot of discussions going on at the moment, around artefacts or creative outputs, alternatives rather than publications, where, for example, if you have developed a prototype or innovation, that you also get credit for it. I think that we [are] pushing a lot that discussion that there [are] alternate ways in which an academic can get credit."

7.6.1 Quality

The findings showed that cultural artefacts are available on the TSCT YouTube and website. The findings support Luo and Dong (2017) because the TSCT generated unique ''culturally-oriented products'' with distinct national features to maintain regional ethnic characteristics and cultural integrity – the availability of videos and other resources in isiXhosa. The findings also support Adinolfi *et al*. (2018) and Bada (2013) regarding the importance of cultural preservation because the artefacts represented improved insights but refute the authors' new insights suggestion.

7.6.2 Challenges

The findings show that the formalisation of a cultural artefact is not guaranteed. The findings correlate with the National Intellectual Property Management Office (NIPMO) (2017), that design and copyright protection are available in South Africa. The findings highlight what Mbatha (2020) found about the mismatched curricula between the UIG collaboration actors. Specifically, that industry and government are ahead of the TSCT. The TSCT is trying to catch up with the technology being implemented by the industry and creating a gap. The findings show that if the TSCT focuses on cultural artefacts, the TIA may not be of significant assistance and must consult a third-party such as NIPMO.

7.6.3 Opportunities

The findings show that the TSCT should tap into the uniqueness of South Africa, specifically the Western Cape. Focusing on cultural diversity will allow the fashion tourism venture to grow. The findings show new ways of academic credits through creative outputs, allowing cultural artefacts to be considered academically accepted outputs. The opportunity supports the Craft Design Institute (CDI) that craft and design are mutually inclusive and part of a broader creative sector because the CDI was able to move from being a Western Cape institution to serving South Africa. The findings show that TSCT is in the accreditation process for cultural artefacts, creating an opportunity for research growth and research output.

7.7 CONCLUSION

The Sections 7.2 to 7.6 covered the following findings: new and improved products, new and improved processes, community infrastructure and facilities, spin-off companies, and cultural artefacts. The findings found these socio-economic outputs' quality, challenges, and opportunities. Thus, finding the state of the socio-economic outputs in the TSCT. The conclusions and final ratings (+ or +/- or -) for each output, with reasons, will be explored in the next and final chapter (see Chapter 8).

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

"Improvise. Become more creative. Not because you have to, but because you want to. Evolution is the secret for the next step." ~ Karl Lagerfeld

8.1 INTRODUCTION

This chapter presents the conclusions and recommendations of this study. The main aim of this study was: To investigate outputs from UIG Collaborations in the Technology Station in Clothing and Textiles (TSCT) of the Western Cape, South Africa. The previous chapter proved that. The conclusions and recommendations for this study will be based on these two objectives. This study had two objectives:

OBJECTIVE 1: To investigate traditional academic outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

OBJECTIVE 2: To investigate economic and social outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities.

The objectives were analysed based on the findings presented in the previous chapter of this study, and conclusions will be drawn regarding the findings. The review of the research process took place, the limitations discussed, and possible recommendations offered. Then finally, recommended future studies are discussed.

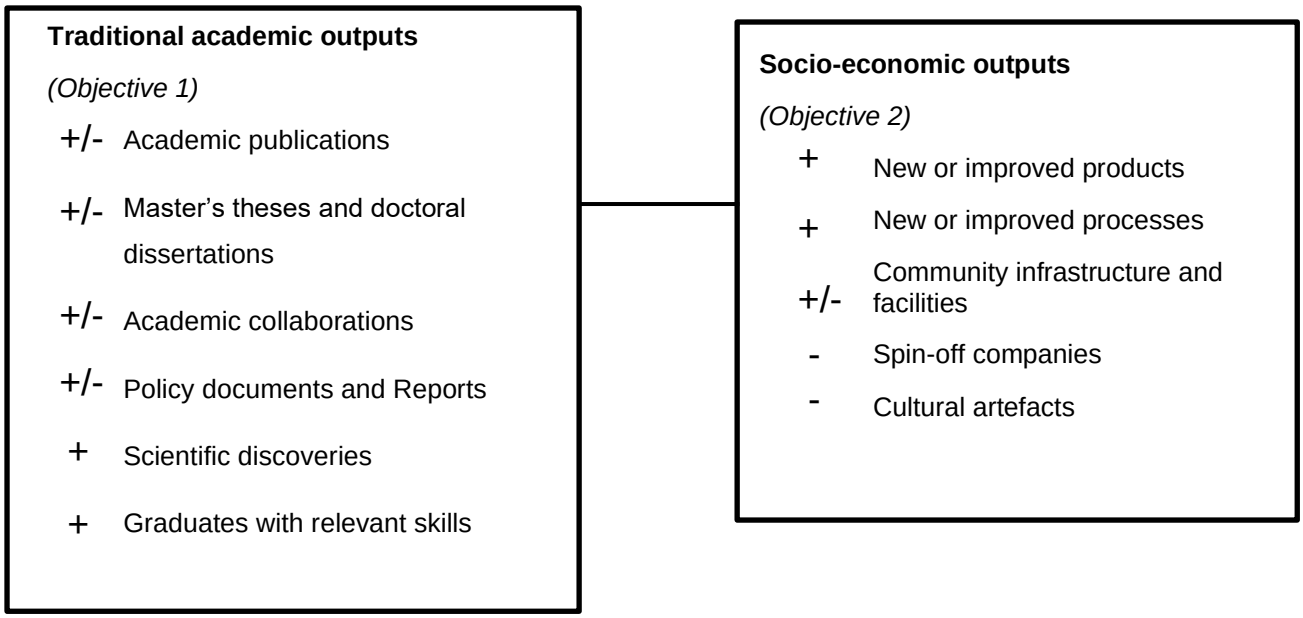


FIGURE 8.1: STATE OF OUTPUTS FOR THE TSCT

Figure 8.1 shows the state of the outputs for the TSCT. Outputs with good quality have a plus (+) sign, outputs with moderate quality have a plus-minus (+/-) sign and outputs with low quality have a minus (-) sign. Sections 8.2 and 8.3 will expand on and provide conclusions for the current results for Objective 1 and Objective 2.

8.2 CONCLUSIONS OF OBJECTIVE 1: TRADITIONAL ACADEMIC OUTPUTS

8.2.1 Academic publications conclusions

The academic publications at the TSCT are of Moderate (+/-) quality. The reason for this is the competency of the staff hired within the TSCT and the university. Over the years, the staff have produced publications to further their research journeys. The findings corroborate with the literature of this study and Kruss and Visser (2017) that UoTs are less inclined to publish, and that academia publishes more than students. However, the publications are not from the master's and doctoral students and will be discussed below.

8.2.2 Master's theses and doctoral dissertations conclusions

The state of the master's and doctoral studies is Moderate (+/-) quality. The TSCT does not offer programmes; however, the staff does supervise master's and doctoral students, which shows partial contribution to the contribution of master's and doctoral graduates. Master's and doctoral graduates are supposed to demonstrate specialist and crucial knowledge to demonstrate expertise (South African Qualifications Authority (SAQA), 2012) in the CTLF

industry. Without a programme, these advanced scholar skills cannot be produced by the TSCT.

8.2.3 Academic collaborations conclusions

Academic collaborations have Moderate (+/-) quality. The academic collaborations within the TSCT are about 70% for the socio-economic benefit and 30% for academic purposes. It means that collaboration focuses on industry application and not academic research. Confidentiality and competitive advantage reasons could hinder the TSCT from expanding on their research as companies do not want their trade secrets out in the open. The TSCT should investigate asking companies to use their findings with confidentiality in mind in the contract clause. It will allow the use of their data for other research purposes. It would then mean that sound policies and reporting measures should be in place.

8.2.4 Policy documents and reports conclusions

Moderate (+/-) quality was the rating given to the state of policy documents and reports. The TSCT has little control regarding policy documents and reporting because it depends on the stakeholder. The effects of policies will be known when the period is over. For example, in 2030, it will be known if the TSCT contributed to the National Development Plan and Sustainable Development Goals. However, the TSCT has not taken the initiative to report fully in the capacity they have. The TSCT currently uses Facebook as its primary medium of public communication.

8.2.5 Scientific discoveries conclusions

Good (+) quality was the rating given to the state of scientific discoveries in the TSCT. There have been significant scientific discoveries within the TSCT. Some stemmed from research, others from researching on behalf of companies or entrepreneurs. However, the originality of the discoveries is questionable as most discoveries come from pre-existing factors. In other words, the discoveries are new to the Western Cape CTLF industry, South African CTLF industry, and not necessarily the world.

Comparing the results from the TSCT to studies observed internationally (Lugoda, Dias & Morris, 2015; Milshina, Pavlova & Vishnevskiy, 2019; Rahemtulla, Hughes-Riley & Dias, 2019; Satharasinghe, Hughes-Riley & Dias, 2019), the CTLF is not on par yet with CTLF trends. It could be that the TSCT could only guide entrepreneurs or researchers if there is something worth protecting.

The TSCT focus is not on patents or protected research but on assisting people. Only through scientific enquiry at the National Intellectual Property Management Office (NIPMO) would an

entrepreneur or researcher know that there is a scientific discovery worth protecting. However, some of the scientific inquiry skills could not be tracked, such as who the commercial local and international partners (probably due to trade secrets) were and the ability to negotiate complex transactions while meeting requirements of the Intellectual Property Rights (IPR) Act. In addition, scientific discoveries do not promise relevant skills among researchers, compassionate scholars, or graduates.

8.2.6 Graduates with relevant skills conclusions

The state of graduates with relevant skills is Good (+) quality. Currently, graduates from the TSCT are community individuals (who are attending workshops, short courses) and national diploma-holding graduates. The TSCT is at an advantage because it regularly communicates with CTLF industry role players and thus can improve curricula. The TSCT has also done well by encouraging graduates to apply skills by offering internships within the TSCT that lead to a successful employment rate after the graduate has finished the internship. However, the TSCT falls short again with the lack of postgraduate degrees to produce graduates at higher levels with relevant skills. By the TSCT not having postgraduate degrees, the graduates cannot thoroughly add value, feed innovation, and enable global competitiveness (Jacobs, 2018).

8.2.7 Summary of traditional academic outputs

Most traditional academic outputs (TAOs) have moderate quality, and two have good quality. It means that the TSCT has not fully explored challenge mitigation proposed by triple helix systems such as bettering student and researcher training, creating more and better jobs, and ensuring sound and sustainable economic growth (Ranga, 2012). Sihlobo and Mbatha (2019; 2022) found that much encouragement is needed to motivate universities of technology (UoTs) to partake in research forms of linkages as they have more institutions that could have the capabilities to do so. It is the case with the TSCT and confirms Kruss and Visser's (2017) findings that research is not fully explored at UoTs. Thus, TAOs are not fully explored in the TSCT, which operates from a UoT background. The more involved the UIG collaborators, the more successful the outputs. The moderate state of the outputs shows that more work is needed to strengthen UIG collaborations. The university is the greatest contributor to academic outputs, and if it is operating at a moderate state, it cannot contribute effectively to UIG collaborations. Hence, challenges in higher education, R&D, competitiveness, and the labour market will continue to persist.

In conclusion, OBJECTIVE 1: To investigate traditional academic outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities was achieved.

8.3 CONCLUSIONS OF OBJECTIVE 2: SOCIO-ECONOMIC OUTPUTS

8.3.1 New and improved products conclusions

The new and improved products have Good (+) quality. The TSCT has a track record of assistance regarding products from the Western Cape and the rest of South Africa. Products in the TSCT contributed to improved products for competitive reasons, and clients of TSCT initiated most products. The TSCT has not fully benefitted from new and improved products from research as this would improve scientific discovery and current processes. However, the decrease in funding is affecting the output of the TSCT. It then means the TSCT must search for alternative ways to grow their output footprint.

8.3.2 New and improved processes conclusions

The new and improved processes have Good (+) quality. Again, the TSCT has a track record of assistance regarding products from the Western Cape and the rest of South Africa. The TSCT has managed to assist many companies; however, when TIA evaluates the companies, the companies cannot reiterate how the TSCT has assisted them. It means there is a communication breakdown. It would mean that the processes set in place may not be sustainable. The lack of sustainability would be because if there were future issues, the companies would not know if there were issues unless they have a constant relationship with the TSCT. The public possibly negates the necessity for specialised knowledge and innovative technologies. The public tends to reach out for assistance to improve a current process, but if a current process is ‘working’ for them, they may not understand the value of specialised services.

8.3.3 Community infrastructure and facilities conclusions

The community infrastructure and facilities of the TSCT have Moderate (+/-) quality. The TSCT meets short-term needs and goals and is satisfactory to the running of the technology station. However, the infrastructure and facilities do not consider sustainable measures such as those Cho (2014) mentions, which is that UIG R&D collaborations improve the ability of a university to become an entrepreneurial university. The findings indicated that the community is uninformed about developments in the CTLF industry and is unaware of TSCT services.

The findings also indicated that specialised infrastructure and facilities are not easily replicated. The shelf-life of infrastructure is short-lived because of the changing requirements of the CTLF industry. The findings support Worku (2018) that entrepreneurs start businesses as means of living and not to solve socio-economic issues, which could explain why the community negates or is unaware of the value of specialised services.

8.3.4 Spin-off companies' conclusions

No spin-off company was found at the TSCT. It means this output is at Low (-) quality. The TIA supports commercialisation because they invested ZAR 155,5 million towards a commercialisation project portfolio where inventions generated ZAR 8,3 billion and created over 14 000 jobs. It means the TIA supports innovations, and if the TSCT could leverage this type of success with a spin-off company, great things could be expected. The TSCT's approach to running the TSCT could affect them in the long term if they do not consider restructuring. It means they are not solving socio-economic issues and are in line with the third mission of being an entrepreneurial university.

8.3.5 Cultural artefacts conclusions

The cultural artefact output at TSCT is Low (-) quality. The TSCT has not figured out how to use cultural artefacts as a means for the Western Cape to be sought for specific speciality designs and create a new international market for uniqueness. The findings show that the Craft Design Institute is a better-suited institution for cultural artefacts because the institution focuses on developing and promoting the Western Cape craft and design sector. However, the focus is not on the CTLF industry. It means there is untapped potential. It is not always a matter of awareness, but it is worth the work. Cost, knowledge, and time play a role in cultural artefacts; all three are necessary for the success of cultural artefacts. The TSCT should ask itself if it wants to create artefacts for future generations to enjoy and learn about various cultures or protection of creative works to avoid infringements or stolen creative works.

8.3.6 Summary of socio-economic outputs

For the socio-economic outputs (SEOs), two outputs have Good (+) quality, two outputs have Low (-) quality, and one output has Moderate (+/-) quality. According to Kruss and Visser (2017), universities of technology have higher frequencies of socio-economic outputs than traditional academic outputs. With the Technology Station in Clothing and Textiles (TSCT) at a university of technology, it was explored that this is accurate. It is accurate under the consideration of the outputs with 'Good' quality (2 of 6 for TAOs – 33%; 2 of 5 for SEOs – 40%). However, for TSCT's case, TAOs are mostly Moderate-Good, whereas the SEOs are Good-Moderate-Low. The nature of the SEOs shows there are disparities between UIG collaborators. It means that collaboration is implemented thoroughly in some areas or poorly in other areas. If the government's outlook could change, there could be better collaboration through funding and policymaking.

In conclusion, OBJECTIVE 2: To investigate socio-economic outputs from UIG collaborations with the TSCT in terms of quality, challenges, and opportunities was achieved.

8.4 RECOMMENDATIONS OF THIS STUDY

In the following sections, the researcher offers advice to the affected stakeholders.

8.4.1 Technology Innovation Agency (and government agencies and departments)

The Technology Innovation Agency (TIA) and potentially other government agencies require policy reform that limits red tape. The findings of this research present the TIA with an opportunity to improve its reporting and policy documents. The TIA is selling itself short by not reporting its success stories. The TIA also should improve policies to measure the impact of all the services they provide. They should investigate having an Impact Management Team to measure the effectiveness of programmes. As an entity, more awareness is required, and attention should be paid to the significant work done by the organisation. Thus, the TIA should allow for more recognition.

The TIA should improve on measuring the technology stations programme (TSP) for each technology station differently according to the station's capabilities. Instead of having a one-size-fits-all approach, each technology station's result and output should be individualised. The TIA should investigate having a public report on the highlights or success stories of the TSP and any other programme. So, when they file a final report, they can explore more of the technology station’s highlights. The TIA could also delegate specific national, African, and international objectives to enforce technology innovation to enable and support the technology station.

Sponsorship requirements in agreements are required. For example, the Department of Science and Innovation stipulates that it must be mentioned as a sponsor on official documents. The government should use mechanisms to assist in bridging gaps between industry and HEIs (HSRC-CeSTII, 2019). Then industry will attract highly skilled personnel, and HEIs will produce graduates relevant to industry needs.

8.4.2 Technology Stations Programme (and other government programmes)

With only 18 technology stations available, there could be an opportunity to add more technology stations. For example, the TSCT only deals with about half of the CTLF industry. It focuses on clothing and textiles, and it would be great to have another technology station focusing on leather and footwear or improve on the offering the technology station offers. Technology stations are also unavailable in all 26 public HEIs, which presents an opportunity for the programme to grow. The TSP could also branch out more and impact more people, with each station being in an area of speciality. For example, a marine technology station near ocean-bearing locations. Alternatively, if there are similar industries, dual technology stations should cater to those fields.

8.4.3 Technology Station in Clothing and Textiles (and other technology stations)

The Technology Station in Clothing and Textiles (TSCT) should grow its digital media footprint, specifically social media. It was not until the pandemic that the TSCT realised the importance of social media. As with studying other technology stations, they were more active on social media platforms. The TSCT should investigate the marketing of the TSCT to increase the awareness and exposure of the technology station. If it were not for the suggested master's study, the researcher would have never known that the TSCT existed. In addition, targeting their approach to a younger audience will assist them in recruiting more youth. They should also concentrate their efforts on social media used by youth. Social media could also have professional benefits, such as having a LinkedIn business page.

There is a tie between Good (+) socio-economic outputs versus Low (-) socio-economic outputs. It shows a stark contrast between outputs the TSCT concentrates on and those that need more attention. The difference highlights the almost 30% under-utilisation of the CTLF industry, with the biggest under-utilisation stemming from insufficient demand (B&M analysts, 2020; Stats SA, 2020b). The model the TSCT is operating under is driven by industry. Community infrastructure and facilities form the middle ground and could assist the TSCT in improving the low quality of cultural artefacts, inevitably creating a spin-off company.

The TSCT's altruistic approach (showing unselfish concern for the welfare of others) could apply a corporate social responsibility (CSR) business strategy to form a spin-off company. CSR is a business model that helps a firm be accountable socially to itself, its stakeholders, and the public. It will lead the TSCT to be on the way to contribute to the third mission of economic development of universities (Ranga, 2012; Ranga & Etzkowitz, 2013). The TSCT could adopt a CSR strategy for entrepreneurship.

This study could have benefitted from an interview with someone from the research department in the TSCT to gain better insights into the academic outputs. Moreover, a survey of previous graduates or community members involved with the TSCT would determine if their perception of the TSCT is as positive. Such a survey could have provided ways for the TSCT to improve to better suit their future students and community.

8.4.4 Universities

This recommendation is specifically for higher education institutions looking to add new master's and doctoral studies or improve on the current studies, specifically in the CTLF industry. In the researcher's experience, 'people perish because of lack of knowledge'. A university could have a great course but fail to motivate students to study further. These students' questions should be answered by the course:

- Why must I study further?
- Will my study be funded?
- Why should I study with you?
- What are the benefits of studying with you?
- After studying with you, what will happen?

The TSCT is looking to focus more on outcomes or non-traditional academic methods for obtaining qualifications. An outcome (coursework) based evaluation master's with a mini-thesis may be more feasible as a one-year option full-time and a two-year option part-time (or extended). Then for more profound research-based outcomes, have a two-year master's with a complete thesis. The beauty of dissertation degrees is that they are research focused and not necessarily dependent on a module curriculum. Thus, research is done with improvement in mind.

Depending on their interest, they are then developing a doctoral programme if necessary. The Sweden Textiles Institution, specifically the University of Borås in Sweden, is currently in a positive triple-helix of government, industry, and university without a doctoral programme. However, the Hong Kong Research Institute of Textiles and Apparel, part of The Hong Kong Polytechnic University, has a doctoral programme. One of TSCT's research strengths is 3D body scanning technology, and maybe the TSCT could partner with universities such as a polytechnic university.

Another approach is an international degree. Ghent University in Belgium has a two-year master's programme called the International Master of Science in Textile Engineering (Keystone Master Studies, 2022). The first semester is studied at Ghent University, then the second at the Polytechnical University of Valencia in Spain (Keystone Master Studies, 2022). For the third semester, the student chooses between the University of Borås in Sweden or the Kyoto Institute of Technology in Japan (Keystone Master Studies, 2022). During the fourth and final semester, the student does a thesis at one of the partner universities (Keystone Master Studies, 2022). Awarding scholarships or bursaries for studying, especially with a unique international degree, to five students (whether to the public or current students) could change the master's and doctoral scenario in South Africa.

In terms of the content of the degrees, the TSCT should align itself with:

- Industry requirements and needs;
- HEI's aim of integrating its teaching and learning with its research programmes; and
- TIA's expectations from the TSCT in terms of the Technology Stations Programme.

The TSCT should also pursue collaborative partnerships regionally, nationally, and globally to create opportunities to solve regional and national issues for socio-economic change. The TSCT is not an academic department and should investigate collaboration opportunities and not necessarily become an academic department.

8.4.5 CTLF industry

The COVID-19 pandemic created difficulties for the Western Cape CTLF and South African CTLF industries. The South African CTLF industry is competing with the penetration of the international CTLF industries. The emphasis is placed on competitive advantage and innovation. The findings present practical ways or measures that could be put into place to assist the CTLF industry on the journey of recovery. The CTLF industry cannot survive without government and university efforts to get the economy back on track, and the industry requires radical transformation. In the past, Research and Development (R&D) investments were used to combat the recession and economic recovery in first-world countries (Etzkowitz & Zhou, 2018; Ranga, 2012). It will make the industry a forerunner in contributing to significant technological innovation (Milshina, Pavlova & Vishnevskiy, 2019).

The findings also present that more measures are needed in place for South Africa to stop having a reactive or defensive approach to the CTLF industry. Currently, the South African industry mimics or tries to assimilate thriving CTLF industries abroad. The South African CTLF industry should consider tailor-making the CTLF industry, even if it completely changes its approach. Ideally, South Africa should be a frontier country for the CTLF industry and for the rest of the world to follow suit regarding the innovations presented. However, South Africa could learn from the successes of various first-world countries that worked collaboratively to advance.

Another area of improvement is fashion tourism. Improving fashion tourism will make the Western Cape, specifically Cape Town, the higher-ranked fashion capital of the world. Bada (2013) stated that fashion tourism in Africa depends on developing a separate framework for fashion tourism with better marketing, security and consistent promotion efforts. Adinolfi, Tichaawa and Banda (2018) stated that there is insufficient research; however, fashion tourism has the potential for socio-economic development. The authors further stated that fashion tourism could potentially shape a city's image. The TSCT investing in fashion tourism will economically improve the City of Cape Town and Western Cape Province and attract international consumers and collaborations.

8.4.6 Quality measuring instrument

The researcher realised that a basic quality criterion (Low-Moderate-Good) was not enough to judge outputs. It would be beneficial to relate qualities with numerical measures and add other qualities for nuances and better understanding. Figure 8.2 shows the proposed quality standard for outputs.

FIGURE 8.2: OUTPUT QUALITY STANDARD BY SIHLOBO 2023

Poor quality (- -) outputs = 0% – 19% indicate non-existent outputs. These outputs represent blind spots or oversight by the institution because they are necessary but have not been considered by the institution.

Low quality (-) outputs = 20% – 39% indicates that outputs have not been explored. These are outputs that have been partially explored and have the potential to make a difference if attention were given to them. For example, if there are five services to be provided, only two services are provided.

Moderate quality (+/-) outputs = 40% – 59% indicates that outputs are operating at a basic level of intention or purpose. This means if five services should be provided to the public, three to five services are being provided.

Good quality (+) outputs = 60% – 79% indicates that there is a track record for the functioning of the output. The output is a regional (provincial) leader and has the potential to be a national leader.

Great quality (+ +) outputs = 80% – 99% indicate that a national leader has the potential to be a global leader and has received national recognition.

Excellent quality (+ + +) outputs = 100% indicates that the output is a pioneer output in the continent, is one-of-a-kind and is a global leader. Various international institutions and organisations come for expertise that the output possesses.

8.5 LIMITATIONS OF THIS STUDY

According to Olufowote (2017:3-4), the limitation section is where researchers can write and address significant problems in this study. Researchers apply themselves to think critically about the implications of this study's limitations for future research studies. Limitations present an opportunity to develop new working habits, which assist with completing this study. For this study, limitations were found in various areas of this study, which will be discussed below.

8.5.1 COVID-19 pandemic

Due to the pandemic, there were many approvals and research progress delays. There was a lack of access to resources due to having to work remotely on this study and not being able to use the resources available from the University of Pretoria, such as a computer, Wi-Fi, library, storage, and a research environment. During this study, the researcher's laptop broke beyond repair and research was halted until an arrangement could be made. The pandemic also forced the researcher to change the primary data collection method from in-person to online interviews to suit the pandemic regulations. However, the shift assisted with the financial implications and limited the costs of research funds.

Conducting the interviews during the pandemic's peak did not allow for the activities of the TSCT to be truly reflected. Also, the researcher did not experience the services offered by the TSCT. The development of a longitudinal study framework would provide more insight into the actual running of the TSCT.

This study only interviewed the respondents once to assess their perspectives of the TSCT. The development of a longitudinal study framework would provide more insight into the actual running of the TSCT. A post-pandemic study should be done to evaluate whether the TSCT has adapted, improved, and recovered from pandemic disruption, thus investigating if post-pandemic transformation occurred.

8.5.2 UIG without the 'I' is just UG

The apparent relationships were between the university and the government because the researcher spoke to people representing these spheres. However, industry relations were based on the interviewers' perceptions and not on Industry personnel. This study could have benefited from an interview with a CTLF industry organisation to see if the TIA or TSCT meet the industry's standards.

8.5.3 Public sector

The TIA is a state-owned enterprise, meaning the government has control. The TSCT operates in a public university of technology. This study only included employees connected to government organisations.

The TIA also represents one of 198 state-owned enterprises. Furthermore, this study offers limited knowledge on whether other enterprises will yield the same results. This study also left out the private sector. Therefore, the research cannot be generalised for the private sector of South Africa.

8.6 FUTURE STUDIES

Future studies are based on the findings and conclusions that remain unanswered or not studied. The researcher could not study further due to time, resources, and the level of this study conducted. The researcher found it beneficial to study academic and socio-economic outputs; however, separately studying the outputs allows for deeper research. As the TSCT was a sample of a population of other technology stations, it can be assumed that it could work for other stations. Future studies include:

- Investigating UIG collaboration socio-economic outputs in the <u>(insert technology station (TS) name)</u> –
    - The technology stations include:
        - Technology Station in Electronics (TSE);
        - Metal Casting Technology Station (MCTS);
        - Technology Station for Materials and Processing Technology (TSPMT);
        - Product Development technology station (PDTS);
        - eNTSA – Innovation Through Engineering;
        - InnoVenton: Institute for Chemical Technology;
        - Agrifood technology station (ATS);
        - Limpopo Agro-Food technology station (LATS);

    - technology station in Chemicals (TSC) – Tshwane University of Technology (TUT);
    - technology station in Chemicals (TSC) – Mangosuthu University of Technology (MUT);
    - Reinforced and Moulded Plastics technology station (RMPTS)
    - Institute for Advanced Tooling – Tshwane University of Technology (IAT-TUT);
    - Institute for Advanced Tooling – Walter Sisulu University (IAT-WSU);
    - Institute for Advanced Tooling – Stellenbosch University (IAT-SU);
    - Adaptronics Advanced Manufacturing Technology Laboratory (AMTL);
    - Process Energy and Environmental technology station (PEET); and
    - technology station in Rural Sustainable Development (TSRSD).

- Investigating academic collaboration outputs in the (insert technology station name)
    - TSE;
    - MCTS;
    - TSPMT;
    - PDTS;
    - eNTSA;
    - InnoVenton: Institute for Chemical Technology;
    - ATS;
    - LATS;
    - TSC – TUT;
    - TSC – MUT;
    - RMPTS;
    - IAT-TUT;
    - IAT-WSU;
    - IAT-SU;
    - AMTL;
    - PEET; and
    - TSRSD.

There is a potential for 34 future studies. Other potential studies could be based on the effects of TIA's specialised programmes. Future studies could include:

- The effectiveness of the TIA programmes: The (insert name of programme)
    - Programmes include:
        - Technology Stations Programme;

- Youth Technology Innovation Programme;
- Innovation Skills Programme;
- Global Cleantech Innovation Programme; and
- Innovation for inclusive development.

There is a potential for five future studies. Another potential study could be based on the impact the COVID-19 pandemic had on TIA programmes. The future study is:

- Investigating the impact and effectiveness COVID-19 had on TIA programmes

Previous studies have focused on UIG collaborations in the CTLF industry of South Africa and forms of UIG collaborations in South African CTLF university academia. This study has contributed to new knowledge and filling a gap in research regarding the outputs from the TSCT.

UIG collaborations are under-researched in the CTLF discipline (Mbatha, 2020; Mbatha & Mastamet-Mason, 2021; Mbatha, Mastamet-Mason & Seda, 2019; Sihlobo & Mbatha, 2019; 2022). There is a possibility that the research findings from this study could be of importance to Africa and internationally, as the CTLF industries are topical issues.

The above-suggested studies could also fill a gap in South African research. Exploration of these studies would benefit government, industry, and universities in transforming the triple challenges transformation of poverty, unemployment, and inequality into wealth and prosperity, entrepreneurs and employment, and equality and peace.

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ADDENDUM A: INTERVIEW 1

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

ETHICAL REFERNCE NUMBER:

NAS345/2019

INTERVIEW QUESTIONS SCHEDULE FOR THE HEAD OF TECHNOLOGY STATIONS PROGRAMME (TSP) AT THE TECHNOLOGY INNOVATION AGENCY (TIA)

Section A: Demographical Questions – Technology Innovation Agency (TIA)

1. **Please introduce yourself and the office you hold. – Please explain your role in TIA? And the Technology Stations Programme?**
2. **Could you please provide a brief overview of TIA?**
3. **Could you please outline the purpose of the Technology Stations Programme (TSP)?**
4. **Please share why you think the Technology Stations Programme is important for South Africa? Specifically, the Technology Station in Clothing and Textiles (TSCT)?**

Section B: traditional academic outputs

According to Kruss and Visser (2017), Traditional Academic outputs (TAOs) are outputs that have effectively measurable results in the long term as the impact can be seen. This output regards individuals who have published work such as academic publications, Masters and PhD theses (dissertations), academic collaborations, reports and policy documents, scientific discoveries as well as graduates who have necessary skills.

1. **One of the objectives of Technology Stations Programme is to** *Contribute to higher education institutions (HEIs) being more responsive to the needs of the industry*. **Please discuss how the Technology Stations Programme have achieved this objective.**
2. **Please share the outputs achieved from this objective. (Academic publications, master's theses and doctoral dissertations, academic collaborations, policy documents and reports, scientific discoveries and graduates with relevant skills)**

3. **According to TIA reports, the "TSP has contributed towards the achievement of the DST and national objectives relating to technology innovation, enabling and support." How would you say the TSCT has applied this in terms of academia?**
4. **TIA aims to contribute to the NDP in terms of the triple challenges of poverty, unemployment and inequality. What are the academic efforts in place within the Technology Stations Programme to assist with this?**
5. **Technology Stations provide diverse support through the collaboration with various strategic partners, industry engagements and co-investments. Several projects have also been implemented in collaboration with other stakeholders and the NSI. In your opinion, how have the TSCT collaborations benefited the Technology Stations Programme?**

Section C: economic and social outputs

Socio-Economic outputs are outputs that benefit a country's economy and society only if outputs are converted into marketable and consumable products. Socio-Economic outputs are new or improved products and processes, community infrastructure and facilities, spin-off companies and cultural artefacts that depend on the country or region that is being addressed (Kruss & Visser, 2017).

1. **One of the objectives of Technology Stations Programme is to** *Enable industry, SMEs in particular, to benefit from the specialised knowledge and innovative technologies of the universities***, please discuss how the Technology Stations Programme have achieved this objective.**
2. **Kindly share the Economic outputs achieved from this objective.**
3. **Kindly share the social outputs achieved from this objective.**
4. **Also, in the 2017/2018 financial year, 41 enterprises secured commercial contracts because of interventions from the programme. What does it mean for the Technology Stations Programme if TSCT secures contracts?**
5. **According to TIA, the Technology Stations Programme "provides access to expertise and high-end infrastructure for the development of technologies." Please share how TSCT's infrastructure has led to the development of new technologies.**
6. **TIA also states that "these facilities provide technical engineering and scientific support to innovators, entrepreneurs, SMMEs and large industry companies". Please share how the TSCTs facilities have supported the various individuals or organisations mentioned. Innovators? Entrepreneurs? SMMEs? Large industry companies?**
7. **Artefacts are non-textual designs such as images, videos or creative works that result from original, systematic investigation to gain new knowledge and understanding which lead to new or substantially improved insights. What qualifies as a design or disclosure for TIA?**
8. **The TIA reports mention that the Technology Stations Programme provides support services that span from the prototyping/piloting stage up until pre-commercialisation. How has the support provided by TSCT benefit the community? Technology Stations Programme?**

9. **One of your reports highlights the TSCT because the technology station (TS) managed to secure 14 SMEs contracts through the intervention of the TS, including Sweet-Orr and Move Pretty. How does securing contracts by the TSCT, benefit the Technology Stations Programme?**
10. In TIA reports, there were key weaknesses mentioned that prohibit the commercialisation for entrepreneurs who are serviced by the government via enabling incubators and accelerators.
    a. Please share challenges that the TSCT face with encouraging entrepreneurship by recognising international talents / overseas-based skills and exposure.
    b. Please share the challenges that TSCT faces with developing new industries.
    c. Please share the challenges that TSCT faces with developing ecosystems for innovative enterprises to build the next top university.
    d. Please share the challenges the TSCT faces with developing Community/Municipality and youth development-based programmes.
    e. Please share the challenges the TSCT faces with Governance and Management in terms of big business involvement required trust, not the “red tape” lengthy processes that do not provide value.

Section D: Closing questions

1. **Please discuss the challenges that TIA faces regarding the Technology Stations Programme and TSCT in particular. – Ask for academic outputs and socio-economic separately.**
2. **Please discuss opportunities you think exist for Technology Stations Programme and the TCST in particular?**

ADDENDUM B: INTERVIEW 2

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

ETHICAL REFERNCE NUMBER:

NAS345/2019

INTERVIEW QUESTIONS SCHEDULE FOR THE MANAGER OF THE TECHNOLOGY STATIONS PROGRAMME OF THE TECHNOLOGY INNOVATION AGENCY

Section A: Demographical Questions

5. Please introduce yourself and the office you hold.
6. Please share what makes the Technology Station in Clothing and Textiles (TSCT) important to the technology station Programme?

Section B: traditional academic outputs

According to Kruss and Visser (2017), Traditional Academic outputs (TAOs) are outputs that have effectively measurable results in the long term as the impact can be seen. This output regards individuals who have published work such as academic publications, master's theses and doctoral dissertations, academic collaborations, reports and policy documents, scientific discoveries as well as graduates who have necessary skills.

6. One of the objectives of Technology Stations Programme is to *Contribute to higher education institutions (HEIs) being more responsive to the needs of the industry***.** Please share with us how the Technology Station in Clothing and Textiles (TSCT) have achieved this objective.

7. Please highlight the traditional academic outputs (academic publications, master's theses and doctoral dissertations, academic collaborations, policy documents and reports, scientific discoveries and graduates with relevant skills) achieved from the above objective.

8. In TIA reports, there were various proxy indicators mentioned. I will ask about them and would like for you to explain for each one, how the TSCT has achieved them…
    a. The first one is… *"To derive a greater share of economic growth from R&D-based opportunities and partnerships."* Please share with us how the Technology Station in Clothing and Textiles (TSCT) have achieved this.

b. The second one is… *"To increase the number of high-level graduates and improve their representivity."* Please share with us how the Technology Station in Clothing and Textiles (TSCT) have achieved this.
c. The third one is… *"To maintain and increase the relative contribution of South African researchers to global scientific output."* Please share with us how the Technology Station in Clothing and Textiles (TSCT) have achieved this.
d. The fourth one is… *"To accelerate inclusive development through scientific knowledge, evidence and appropriate technology."* Please share with us how the Technology Station in Clothing and Textiles (TSCT) have achieved this.

9. According to TIA reports, the *"TSP has contributed towards the achievement of the DST and national objectives relating to technology innovation, enabling and support."* How would you say the TSCT has applied this in terms of academia?
10. TIA aims to contribute to the NDP in terms of the triple challenges of poverty, unemployment and inequality. What are the academic efforts in place within the Technology Stations Programme to assist with this?
11. Technology Stations provide diverse support through the collaboration with various strategic partners, industry engagements and co-investments. Several projects have also been implemented in collaboration with other stakeholders and the NSI. In your opinion, how have the TSCT collaborations benefited the Technology Stations Programme?
12. The Department of Science and Technology funded ten internships with the TSCT. How do the internships funded by the DST (or now DSI) for the TSCT benefit to graduates having relevant industry skills?

Section C: Socio-economic Outputs

Socio-Economic outputs are outputs that benefit a country's economy and society only if outputs are converted into marketable and consumable products. Socio-Economic outputs are new or improved products and processes, community infrastructure and facilities, spin-off companies and cultural artefacts that depend on the country or region that is being addressed (Kruss & Visser, 2017).

11. One of the objectives of Technology Stations Programme is to *Enable industry, SMEs in particular, to benefit from the specialised knowledge and innovative technologies of the universities***,** please discuss how the TSCT have achieved this objective.
12. Kindly share the Socio-Economic outputs achieved from the above objective.
13. In the 2019/2020 financial year, *a total of 100 technologies and knowledge innovation products such as prototypes, patents, technology demonstrators and technology transfer packages are targeted to be supported from the Technology Stations Programme*. This is against an estimate of 91 being realised in FY2018/19.
    a. Please share how TSCT products have contributed to the Technology Stations Programme.
    b. Please share how TSCT products will contribute to Technology Stations Programme.

14. In the 2017/2018 financial year, *34 knowledge-based products and 1 571 competitive improvements* were developed. Please share how TSCT improvement processes have contributed to the Technology Stations Programme.
15. Also, in the 2017/2018 financial year, 41 enterprises secured commercial contracts because of interventions from the programme. What does it mean for the Technology Stations Programme if TSCT secures contracts?
16. According to TIA, the Technology Stations Programme *"provides access to expertise and high-end infrastructure for the development of technologies."* Please share how TSCT's infrastructure has led to the development of new technologies.
17. TIA also states that *"these facilities provide technical engineering and scientific support to innovators, entrepreneurs, SMMEs and large industry companies".* Please share how the TSCTs facilities have supported the various individuals or organisations mentioned. Innovators? Entrepreneurs? SMMEs? Large industry companies?
18. TIA further states that these individuals or organisations *"require research, analytical and testing services to either validate or progress their technologies through the value chain."* How has the TSCT provided support?
19. The TIA reports mention that the Technology Stations Programme provides support services that span from the prototyping/piloting stage up until pre-commercialisation. How has the support provided by TSCT benefit the community? Technology Stations Programme?
20. One of your reports highlights the TSCT because the technology station (TS) managed to secure 14 SMEs contracts through the intervention of the TS, including Sweet-Orr and Move Pretty. How does securing contracts by the TSCT, benefit the Technology Stations Programme?
21. In TIA reports, there were key weaknesses mentioned that prohibit the commercialisation for entrepreneurs who are serviced by the government via enabling incubators and accelerators.
    a. Please share challenges that the TSCT face with encouraging entrepreneurship by recognising international talents / overseas-based skills and exposure.
    b. Please share the challenges that TSCT faces with developing new industries.
    c. Please share the challenges that TSCT faces with developing ecosystems for innovative enterprises to build the next top university.
    d. Please share the challenges the TSCT faces with developing Community/Municipality and youth development-based programmes.
    e. Please share the challenges the TSCT faces with Governance and Management in terms of big business involvement required trust, not the "red tape" lengthy processes that do not provide value.
22. *Artefacts are non-textual designs such as images, videos or creative works that result from original, systematic investigation to gain new knowledge and understanding which lead to new or substantially improved insights.* What qualifies as a design or disclosure for TIA?

Section D: Closing questions

3. Please discuss the challenges that TIA faces regarding the explained traditional academic outputs TSCT in particular.
4. Please discuss the challenges that TIA faces regarding the explained socio-economic outputs TSCT in particular.
5. Please share opportunities that you feel may exist relating to traditional academic output from TCST.
6. Please share opportunities that you feel may exist relating to socio-economic output from TCST.

ADDENDUM C: INTERVIEW 3

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

ETHICAL REFERNCE NUMBER:

NAS345/2019

INTERVIEW QUESTIONS SCHEDULE FOR THE TECHNOLOGY STATION IN CLOTHING AND TEXTILES (TSCT)

Section A: Demographical questions

7. Please introduce yourself and the office you hold.
8. Could you please provide a brief overview of the TSCT?
9. In your view, what makes the TSCT is important to the South Africa clothing and textiles industry?

Section B: traditional academic outputs

According to Kruss and Visser (2017), Traditional Academic outputs (TAOs) are outputs that have effectively measurable results in the long term as the impact can be seen. This output regards individuals who have published work such as academic publications, master's theses and doctoral dissertations, academic collaborations, reports and policy documents, scientific discoveries as well as graduates who have necessary skills.

13. Your reports reveal that over the years the TSCT has made many academic collaborations. Could you please outline the nature of publications (journal articles, books or book chapters and conference proceedings) that have been produced by TSCT's staff.
14. On your website, your research speciality is textiles and to quote you have, *"access to top-rated research, postgraduate students, industry experts and the latest equipment means that you have a complete knowledge-generating hub at your disposal"*. Please discuss the nature of master's theses and doctoral dissertations that have been produced through TSCT's staff.
15. In 2017 as a faculty of Engineering, postgraduate student numbers grew despite having challenges with throughput rates and supervision. Was the TSCT affected by this?
16. Please explain how the research done at the TSCT is relevant to this statement*: "Our national and international partnerships are a key aspect of our strategic positioning*

within the research landscape and a significant driver of our research reach and relevance."

17. In the faculty of Engineering at CPUT*, "an extensive strategy was refined in 2016 to ensure research and innovation in the faculty were aligned with key institutional and national focus areas".* Could you please explain the extent to which the TSCT is involved with policy-making within the CTLF industry?
18. According to your TSCT intro video on YouTube, the TSCT works with CPUT, FP&M SETA, the City of Cape Town and TIA. How do you make your reporting stays true to TSCT values? Please share the nature of reports that have been generated by TSCT?
19. *"The TSCT was established to provide innovation support to the clothing and textile industry to become more competitive."* Kindly discuss how the new scientific discoveries (technologies or innovations) produced by TSCT has benefited academia?
20. Human Capital Development is a major role played by the TSCT. Please discuss how the short course programmes of the TSCT meet the needs of the Clothing, Textiles, Leather and Footwear (CTLF) industry?
21. Dr Hovgaard made this statement*, "students must be skilled in the latest technology. 'Rather than just teach students about what's available now, we are looking ahead and advancing our students"* How is the TSCT making sure that students are graduating with relevant skills?

Section C: socio-economic outputs

Socio-Economic outputs are outputs that benefit a country's economy and society only if outputs are converted into marketable and consumable products. Socio-Economic outputs are new or improved products and processes, community infrastructure and facilities, spin-off companies and cultural artefacts that depend on the country or region that is being addressed (Kruss & Visser, 2017).

23. At TSCT, you pride yourselves in product development by *"turning ideas into reality. With our comprehensive range of product development software, equipment and skills…"* Kindly share how new or improved tech-based products from TSCT benefit CTLF industry.
24. Shalton Mothwa displayed his patented AOEN bag (Wi-Fi Recharging bag) at the National Science Week exhibition, how did the TSCT benefit from this collaboration?
25. At TSCT you provide textiles testing and specifications development, and your website states that *"the laboratory provides product testing and analysis service to the clothing, textiles and related industries.* Kindly share how new or improved processes from TSCT that benefit the CTLF industry.
26. There was a *"Process innovation project funded by the Provincial Government of the Western Cape to improve the processes of…businesses: Farbe Sport, African Nature, KVM Manufacture, Cape Mohair, AC Clothing, Darkie Velotex Cycling Wear, Glow Gear, Duchess Uniforms."* How did TSCT contribute to the process innovation project?
    a. What did the TSCT learn from the process innovation project?
27. Please discuss how technological additions such as the 3D body scanner assist the TSCT in revolutionising SA's clothing industry?
    a. Are there any other technological additions that could be useful in revolutionising the TSCT further?

28. The TSCT provides manufacturing advisory services. Furthermore, the TSCT conducts baseline, evaluation, implementation and re-evaluation services to assist the companies in implementing effective, measurable quality and productivity improvements. What has been the major benefit of offering these services to companies?
    a. Are the services listed above, available to the general public?
    b. What does the TSCT mean when it refers to 'companies'?
29. How has the training TSCT provides to small and medium enterprises (SMEs) or SMMEs benefited the CTLF industry?
30. Ms Ngoma…started her business called Queen Bee's. Kindly share if there are any other spin-off companies generated from the activities of the TSCT.
31. According to your reports, CPUT lecturers contribute their own time and skills to assist disadvantaged individuals empowering themselves with marketable skills. How has this community training provided by the TSCT benefited the CTLF industry?
32. According to your website, the TSCT has *"been planting the seeds for job creation across South Africa through the Extending the Footprint (EGF) Project."* How has the training provided at the TSCT contribute to job creation?
33. Through exploring your YouTube channel, it was discovered that you had posted videos of useful machine instructions in isiXhosa. How does having such an output benefit the community?
34. How does the TSCT plan on improving on this output?
35. Does the TSCT plan to have other outputs such as these?
36. *Artefacts are non-textual designs such as images, videos or creative works that result from original, systematic investigation to gain new knowledge and understanding which lead to new or substantially improved insights.* Now, with the definition in mind, kindly share any artefacts from TSCT that benefited the CTLF industry.

Section D: Closing questions – Challenges and opportunities

7. Please discuss the challenges that the TSCT faces regarding the explained traditional academic outputs.
8. Please discuss the challenges that the TSCT faces regarding the explained socio-economic outputs.
9. Please share opportunities that you feel may exist relating to traditional academic output from TCST.
10. Please share opportunities that you feel may exist relating to socio-economic output from TCST.

ADDENDUM D: INTERVIEW SCHEDULE

INTERVIEW SCHEDULE FOR INTERVIEWS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

ETHICAL REFERNCE NUMBER:

NAS345/2019

1. **Login into Google Meet 10 minutes before the interview starts**
    a. Check if the camera is working
    b. Check if the sound is working
2. **When interviewee logs on:**
    a. Greet the person and thank them for joining you
    b. Check that all is working
    c. Read the de-brief/ final consent
3. **De-brief/ final consent**

    a. I will be interviewing you today based on the outputs in the Technology Station in Clothing and Textiles;

    b. The interview will take around an hour to complete and is divided into three sections. Before we start, I would like to remind of ethical considerations for doing this study;

    c. Please note that there is no compensation for your participation. Your participation in this research is completely voluntary. You have the right to withdraw at any point during the interview, for any reason, and without any prejudice. I will also be voice recording this interview to reference what was said at a later stage;

    d. The interview is confidential, meaning that your personal information will not be used in the final research and publications. If you would like clarity in certain questions, please do not hesitate to stop me to elaborate. If you consent, we may proceed with the interview.

    e. Do you consent to taking part in this study?

    f. *When the interviewee answers YES, you may begin*.
4. **Conduct interview**
    a. Section A:

b. Section B: TAOs
c. Section C: SEOs
d. Section D: Closing Questions

5. Ask interviewee if he/she has questions for you

a. Thank person for contribution
b. End interview

ADDENDUM E: ETHICS APPROVAL LETTER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences
Ethics Committee

E-mail: ethics.nas@up.ac.za

04 June 2020

ETHICS SUBMISSION: LETTER OF APPROVAL

Miss ST Sihlobo
Department of Consumer and Food Sciences
Faculty of Natural and Agricultural Science
University of Pretoria

Reference number: NAS345/2019
Project title: Investigating Outputs from University-Industry-Government Collaborations in the Technology Station in Clothing and Textiles

Dear Miss ST Sihlobo,

We are pleased to inform you that your submission conforms to the requirements of the Faculty of Natural and Agricultural Sciences Research Ethics committee.

Please note the following about your ethics approval:

- Please use your reference number (NAS345/2019) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.
- Please note that ethical approval is granted for the duration of the research (e.g. Honours studies: 1 year, Masters studies: two years, and PhD studies: three years) and should be extended when the approval period lapses.
- The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.
- **Applications using Animals:** NAS ethics recommendation does not imply that AEC approval is granted. The application has been pre-screened and recommended for review by the AEC. Research may not proceed until AEC approval is granted.

Post approval submissions including application for ethics extension and amendments to the approved application should be submitted online via the Ethics work centre.

We wish you the best with your research.

Yours sincerely,

Chairperson: NAS Ethics Committee

ADDENDUM F: SIGNED PERMISSION REQUEST FORM

APPROVAL TO CONDUCT RESEARCH AT TIA

I hereby acknowledge that I have been informed about the nature of the research project, the benefits and how data will be handled and presented through this research project. I am aware that the results of the study will be confidentially processed into a research report. I acknowledge and approve that the research project be conducted with affected UP staff complement. I have had sufficient opportunity to ask questions and of my own free will declare myself informed about the research project.

Principal Investigator's name: SINQOBILE SIHLOBO

Principal Investigator's signature: Sihlob

Date: 2020-08-12

CEO's name: Patrick Krappie

Authority or Role:

CEO's signature: DocuSigned by: BA0D8598D9054AD...

Date: 27-Aug-20 | 16:38:40 SAST

ADDENDUM G: PERMISSION LETTER FROM CPUT

Office of the Deputy Vice Chancellor:
Research, Technology Innovation & Partnerships
Bellville Campus
P O Box 1906
Bellville 7535
Tel: 021-9596242
Email: PHAHOD@cput.ac.za

21 September 2020

Miss Sinqobile Sihlobo
Student no 15207839
MSc Clothing Management
University of Pretoria

Dear Miss Sihlobo

RE: PERMISSION TO CONDUCT RESEARCH AT CPUT

The Institutional Ethics Committee received your application entitled: "*INVESTIGATING OUTPUTS FROM UNIVERSITY-INDUSTRY-GOVERNMENT COLLABORATIONS IN THE TECHNOLOGY STATION CLOTHING AND TEXTILES*" together with the dossier of supporting documents.

Faculty Ethics Committee Approval Date: 1 September 2020.

Faculty Ethics Committee Approval Reference No: 2020FEREC-STD-044

Permission is herewith granted for you to do research at the Cape Peninsula University of Technology.

Wishing you the best in your study.

Sincerely

Dr David Phaho
Deputy Vice-Chancellor: Research, Technology, Innovation & Partnerships
Cape Peninsula University of Technology | #WeAreCPUT

t: +27 (0) 21 959 6242 | e: dvcresearch@cput.ac.za w: www.cput.ac.za
PO Box 1906 Bellville 7535 | Symphony Way, Bellville, Cape Town, South Africa

ADDENDUM H: INFORMATION LEAFLET 1

INFORMATION LEAFLET AND INFORMED CONSENT FOR THE TECHNOLOGY

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

ETHICAL REFERNCE NUMBER:

NAS345/2019

INNOVATION AGENCY (TIA)

Project Title: Investigating Outputs from University-Industry-Government Collaborations in the Technology Station Clothing and Textiles

Degree: MConsumer Science: Clothing Management

Principal investigator: Miss Sinqobile T.L. Sihlobo, Department of Consumer and Food Sciences, University of Pretoria

Supervisor: Mr Sipho Mbatha, Department of Design Studies, Tshwane University of Technology

Co-Supervisor: Prof Thomas W. Thurner, Faculty of Informatics and Design and Faculty of Health and Wellness Sciences, Cape Peninsula University of Technology.

Dear Research participant,

You are kindly invited to participate in a research study that forms part of the completion of my MConSci: Clothing Management degree. This information leaflet will help you to decide whether you would like to participate in this study. Before you agree to take part, you should fully understand what is involved. If you have any questions that this leaflet does not fully explain, please do not hesitate to ask the research personnel.

What is this study about?

The focus of this study is to gain an understanding, through your experiences, about the state of research collaboration outputs in the Technology Innovation Agency (TIA) Technology

Stations Programme (TSP) to improve, amongst others, research collaborations within the Clothing, Textiles, Leather and Footwear (CTLF) industry. The outputs that are going to be explored are based on Kruss and Visser (2017) ***traditional academic outputs*** (academic publications, Dissertations, academic collaborations, reports, policy documents, scientific discoveries and graduates with relevant skills) and ***socio-economic outputs*** (new or improved products and processes, community infrastructure and facilities, spin-off companies and cultural artefacts).

What will you be required to do in this study?

If you decide to take part in this study, you will be required to respond to interview questions relating to the current state, challenges and opportunities of research collaboration outputs in the Technology Stations Programme. The interview is expected to last for approximately an hour.

Risk and discomfort involved in this study

In the interview you will be sharing information regarding your activities within the TIA. This process means that you will have to recall and share processes and actions taken regarding the above stated Technology Stations Programme, which could be viewed as putting your competitiveness at risk. All measures that will be taken to mitigate any loss of competitiveness will be discussed under the “How will confidentiality and anonymity be ensured in this study?” section below.

Potential benefits of this study

The TIA will be emailed the research report in PDF format so that it can be used to improve their outputs for research collaboration strategies. The TIA will improve its understanding of research collaboration outputs with universities, CTLF industries, and government agencies. Furthermore, the TIA will improve its understanding of the available government support to promote research collaboration as well as understanding how to strengthen research quality and output.

What are your rights as a participant in this study?

Your participation in this study is entirely voluntary. You have the right to withdraw at any stage without any penalty or future disadvantage whatsoever. You do not even have to provide the reason/s for your decision. Note that you are not waiving any legal claims, rights, or marks because of your participation in this research study.

Will you receive any financial compensation or incentive for participating in this study?

Please note that there will be no financial compensation or incentives for participating in this study.

Has this study received ethics approval?

This study has received ethics approval from Research Ethics Committees of the Faculty of Natural and Agricultural Sciences, University of Pretoria, telephone number: 012 420 4356 (Ethical Reference Number: NAS345/2019).

Information and contact person

The principal investigator is Miss S.T.L Sihlobo, who can be contacted on her cellular phone at 076 038 1945 and emailed at ssihlobo1@gmail.com. If you would like to contact the supervisor, Mr S. Mbatha he can be contacted during his office hours at (012) 382 6078 or on his cellular phone at 081 448 5385 and emailed at MbathaS@tut.ac.za. Should you have any questions regarding the ethical aspects of this study, you can email the Faculty of Natural and Agricultural Sciences Ethics Committee, University of Pretoria at ethics.nas@up.ac.za.

How will confidentiality and anonymity be ensured in this study?

All information that you give will be kept strictly confidential. Research reports, presentations and articles in scientific journals will not include any information that may identify you. All the "raw" data that you provide during this study will be handled confidentially. This means that access to your "raw" data will be strictly limited to the researcher, the supervisors of this study and the designated examiners (appointed by the University of Pretoria). All of these role players have implied declarations of confidentiality built into their appointments. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. As funders of the research, the National Research Foundation will have access to data that would have no identifiable information traceable to any of your departments. After data have been interpreted, the findings will be sent back to you for confirmation that all the confidentiality and anonymity promises have been adhered to and that the interpretation is a fair reflection of what has been shared. The raw data, the data sheets and any other material that run the potential risk of connecting you to the data will be digitally archived at the Faculty of Natural and Agricultural Sciences Ethics Committee of the University of Pretoria.

A final word

Your cooperation and participation in this study will be greatly appreciated. Please sign the informed consent form below if you agree to participate in this study, in which case you will receive a copy of the signed informed consent from the researcher.

CONSENT TO PARTICIPATE IN THIS STUDY

I hereby confirm that I am an adult of at least 18 years of age; I have been adequately informed by the researcher about the nature, conduct, benefits and risks of this study. I have also received, read and understood the above written information. I am aware that the results of this study will be anonymously processed into a research report. I understand that my participation is voluntary and that I may, at any stage, without prejudice, withdraw my consent and participation in this study. I have had sufficient opportunity to ask questions and of my own free will declare myself prepared to participate in this study.

Research Participant's name: _____

Research Participant's signature: _____

Date: _____

Principal Investigator's name: _____

Principal Investigator's signature: _____

Date: _____

ADDENDUM I: INFORMATION LEAFLET 2

ETHICAL REFERNCE NUMBER:

NAS345/2019

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

INFORMATION LEAFLET AND INFORMED CONSENT FOR THE TECHNOLOGY STATION IN CLOTHING AND TEXTILES (TSCT)

Project Title: Investigating Outputs from University-Industry-Government Collaborations in the Technology Station Clothing and Textiles

Degree: MConsumer Science: Clothing Management

Principal investigator: Miss Sinqobile T.L. Sihlobo, Department of Consumer and Food Sciences, University of Pretoria

Supervisor: Mr Sipho Mbatha, Department of Design Studies, Tshwane University of Technology

Co-Supervisor: Prof Thomas W. Thurner, Faculty of Informatics and Design and Faculty of Health and Wellness Sciences, Cape Peninsula University of Technology.

Dear Research participant,

You are kindly invited to participate in a research study that forms part of the completion of my MConSci: Clothing Management degree. This information leaflet will help you to decide whether you would like to participate in this study. Before you agree to take part, you should fully understand what is involved. If you have any questions that this leaflet does not fully explain, please do not hesitate to ask the research personnel.

What is this study topic?

The focus of this study is to gain an understanding, through your experiences, about the state of research collaboration outputs in the Technology Station in Clothing and Textiles (TSCT) to improve, amongst others, research collaborations within the Clothing, Textiles, Leather and Footwear (CTLF) industry. The outputs that are going to be explored are based on Kruss and Visser (2017):

- ***traditional academic outputs*** (academic publications, Dissertations, academic collaborations, reports, policy documents, scientific discoveries and graduates with relevant skills) and
- ***socio-economic outputs*** (new or improved products and processes, community infrastructure and facilities, spin-off companies and cultural artefacts).

What will you be required to do in this study?

If you decide to take part in this study, you will be required to respond to interview questions relating to the current state, challenges and opportunities of research collaboration outputs in the TSCT. The interview is expected to last for approximately an hour.

Risk and discomfort involved in this study

In the interview, you will be sharing information regarding your activities within the TSCT. This process means that you will have to recall and share processes and actions taken regarding the above-stated TSCT, which could be viewed as putting your competitiveness at risk. All measures to mitigate any loss of competitiveness will be discussed under the *"How will confidentiality be ensured in this study?"* section below.

Potential benefits of this study

The TSCT will be emailed the research report in PDF format so that it can be used to improve their outputs for research collaboration strategies. The TSCT will improve its understanding of research collaboration outputs with universities, CTLF industries and government agencies. Furthermore, the TSCT will improve its understanding of the available government support to promote research collaboration as well as understanding how to strengthen research quality and output.

What are your rights as a participant in this study?

Your participation in this study is entirely voluntary. You have the right to withdraw at any stage without any penalty or future disadvantage whatsoever. You do not even have to provide the reason/s for your decision. Note that you are not waiving any legal claims, rights or marks because of your participation in this research study.

Will you receive any financial compensation or incentive for participating in this study?
Please note that there will be no financial compensation or incentives for participating in this study.

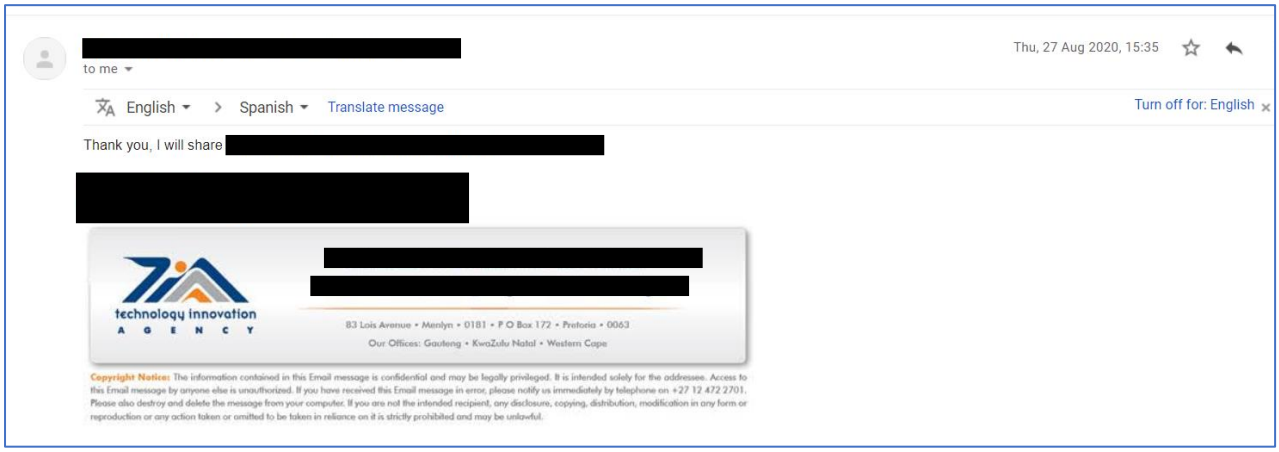
Has this study received ethics approval?
This study has received ethics approval from Research Ethics Committees of the Faculty of Natural and Agricultural Sciences, University of Pretoria, telephone number: 012 420 4356 (Ethical Reference Number: NAS345/2019).

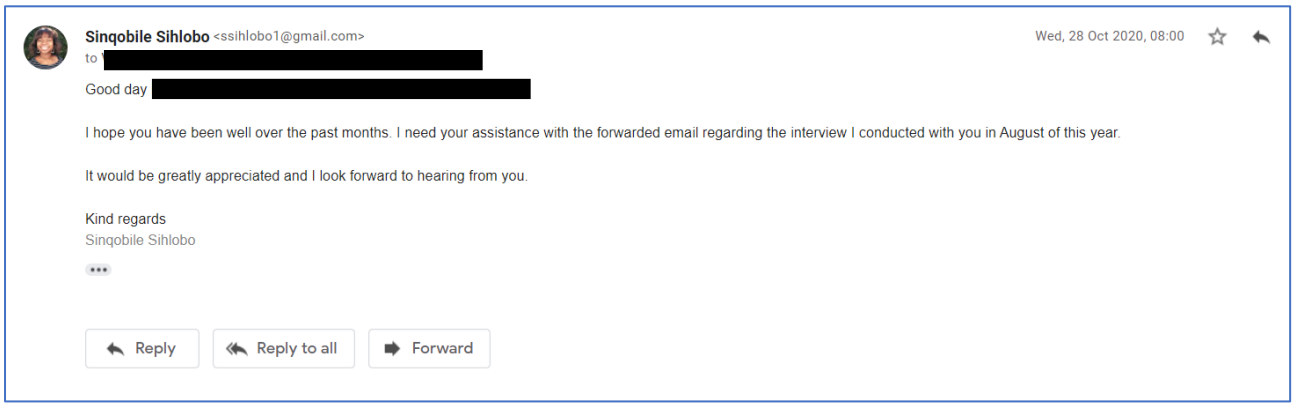
Information and contact person
The principal investigator is Miss S.T.L Sihlobo, who can be contacted on her cellular phone at 076 038 1945 and emailed at ssihlobo1@gmail.com. If you would like to contact the supervisor, Mr S. Mbatha he can be contacted during his office hours at (012) 382 6078 or on his cellular phone at 081 448 5385 and emailed at MbathaS@tut.ac.za. Should you have any questions regarding the ethical aspects of this study, you can email the Faculty of Natural and Agricultural Sciences Ethics Committee, at the University of Pretoria at ethics.nas@up.ac.za.

How will confidentiality be ensured in this study?
All information that you give will be kept strictly confidential. Research reports, presentations and articles in scientific journals will not include any information that may identify you. All the "raw" data that you provide during this study will be handled confidentially. This means that access to your "raw" data will be strictly limited to the researcher, the supervisors of this study and the designated examiners (appointed by the University of Pretoria). All of these role players have implied declarations of confidentiality built into their appointments. Any information that is obtained in connection with this study and can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. As funders of the research, the National Research Foundation will have access to data that would have no identifiable information traceable to any of your departments. After data have been interpreted, the findings will be sent back to you. It will be for confirmation that all the confidentiality promises have been adhered to, and the interpretation is a fair reflection of what has been shared. The raw data, the data sheets and any other material that run the potential risk of connecting you to the data will be digitally archived at the Faculty of Natural and Agricultural Sciences Ethics Committee of the University of Pretoria.

A final word
Your cooperation and participation in this study will be greatly appreciated. Please sign the informed consent form below if you agree to participate in this study, in which case you will receive a copy of the signed informed consent from the researcher.

ADDENDUM J: INTERVIEW 1 RECOVERY





ADDENDUM K: CONSENT FORM

CONSENT TO PARTICIPATE IN THIS STUDY

I hereby confirm that I am an adult of at least 18 years of age; I have been adequately informed by the researcher about the nature, conduct, benefits and risks of this study. I have also received, read and understood the above-written information. I am aware that the results of this study will be anonymously processed into a research report. I understand that my participation is voluntary and that I may, at any stage, without prejudice, withdraw my consent and participation in this study. I have had sufficient opportunity to ask questions and of my own free will declare myself prepared to participate in this study.

Research Participant's name: _____

Research Participant's signature: _____

Date: _____

Principal Investigator's name: _____

Principal Investigator's signature: _____

Date: _____

ADDENDUM L: PLAGIARISM DECLARATION

UNIVERSITY OF PRETORIA

FACULTY Natural and Agricultural Sciences

DEPARTMENT Consumer and Food Sciences

The Department Consumer and Food Sciences places specific emphasis on integrity and ethical behaviour with regard to the preparation of all written work to be submitted for academic evaluation.

Although academic personnel will provide you with information regarding reference techniques as well as ways to avoid plagiarism, you also have a responsibility to fulfil in this regard. Should you at any time feel unsure about the requirements, you must consult the lecturer concerned before you submit any written work.

You are guilty of plagiarism when you extract information from a book, article or web page without acknowledging the source and pretend that it is your own work. In truth, you are stealing someone else's property. This doesn't only apply to cases where you quote verbatim, but also when you present someone else's work in a somewhat amended format (paraphrase), or even when you use someone else's deliberation without the necessary acknowledgement. You are not allowed to use another student's previous work. You are furthermore not allowed to let anyone copy or use your work with the intention of presenting it as his/her own.

Students who are guilty of plagiarism will forfeit all credit for the work concerned. In addition, the matter can also be referred to the Committee for Discipline (Students) for a ruling to be made. Plagiarism is considered a serious violation of the University's regulations and may lead to suspension from the University.

For the period that you are a student at the Department Consumer and Food Sciences , the under- mentioned declaration must accompany all written work to be submitted. No written work will be accepted unless the declaration has been completed and attached.

I (full names) Singobile Thokozani Loyiso Sihlobo

Student number 15207839

Subject of the work VBR 890

Declaration

1. I understand what plagiarism entails and am aware of the University's policy in this regard.
2. I declare that this Dissertation (e.g., essay, report, project, assignment, dissertation, thesis etc) is my own, original work. Where someone else's work was used (whether from a printed source, the internet or any other source) due acknowledgement was given and reference was made according to departmental requirements.
3. I did not make use of another student's previous work and submitted it as my own.
4. I did not allow and will not allow anyone to copy my work with the intention of presenting it as his or her own work.

Signature 

ADDENDUM M: PLAGIARISM REPORT

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Natural and Agricultural Sciences

TURNITIN DECLARATION

Full names of student	SINQOBILE THOKOZANI LOYISO SIHLOBO
Student number	15207839
Degree	MCONSUMER SCIENCE: CLOTHING MANAGEMENT
Department	CONSUMER AND FOOD SCIENCE

Declaration by student:

I declare that I have used Turnitin according to University's policy in this regard.

SIGNATURE OF CANDIDATE: Sihlob

I declare that I have seen and am satisfied with the Turnitin reports.

NAME OF SUPERVISOR: Dr Sipho Mbatha

SIGNATURE OF SUPERVISOR:

Date: 18 April 2023