University-industry-government research and development collaborations in public higher education institutions in South Africa

Sinqobile Sihlobo [a] and Sipho Mbatha [b*]

[a] Department of Consumer and Food Sciences, University of Pretoria, South Africa
[b] Department of Design Studies, Tshwane University of Technology, South Africa
*Corresponding author email: mbathas@tut.ac.za

Abstract

This paper explores the university, industry and government (UIG) research and development (R&D) collaborations that academia in South African higher education institutions (HEIs) with clothing-related programmes engage in. In the research on which the paper is based, Fashion, Consumer Science, Textiles and Clothing Management academia were purposively sampled to gather data regarding the UIG R&D collaborations. Data collection was conducted through an online questionnaire. Descriptive statistics were employed to analyze data and present results in figures and graphs. Findings show that majority surveyed academia had never been involved in UIG R&D collaborations with any government levels, the clothing, textiles, leather and footwear (CTLF) industry or other clothing related organizations. The paper concludes that the ability of surveyed academia to produce 'relevant' new knowledge may be limited due to under developed UIG R&D collaborations. The likelihood of the surveyed clothing-related programmes producing graduates with 'relevant skills' for a changing world may also be negatively impacted.

Keywords: HEIs; clothing-related programmes; triple helix; clothing industry; SDGs 2030; AU Agenda 2063

Introduction

The triple helix (TH) on university-industry-government (UIG) collaborations indicates that relevant new knowledge is produced through research and development (R&D) collaborations, thereby improving socio-economic development in a country (Guiliani and Arza 2008; Bartels and Koria 2014; Patra and Muchie 2018). In such UIG collaborations, R&D activities are largely performed by academia at universities (Bogoro 2015; Patra and Muchie 2018). In line with the third mission (economic development) of universities, academia is expected to form part of various UIG R&D collaborations. The literature on UIG R&D collaborations focusing on academia predominantly deals with the global north context, and not the global south. This starves Africa of relevant new knowledge as the continent attempts to achieve the United Nation's Sustainable Development Goals (SDGs) 2030 and African Union (AU) Agenda 2063.

The current researchers sought to explore and describe UIG R&D collaborations in South African public higher education institution (HEIs) with academia with clothing-related programmes (henceforth referred to as academia) engage in the TH framework. In this paper, academia is defined as public HEIs with the following degrees or diploma programmes: Fashion Design, Consumer Science, and Textiles and Clothing Management. In this paper, public HEIs are South African public Traditional Universities (TradUs), Comprehensive

Universities (CompUs) and Universities of Technology (UoTs). The TradUs are previously-advantaged research HEIs that grant academic degrees in a variety of subjects, provide both undergraduate and postgraduate education, and are committed to research as a central part of their mission (Prime 2015). The UoTs, previously known as Technikons, offer mainly diploma and certificate courses and emphasize innovative problem-solving and career-directed courses with experiential learning forming part of the courses (Oxford University Press South Africa 2015). A CompU is a combination of UoTs and TradUs and offers a wide range of disciplines through degrees and diploma programmes (Mgqibela 2008). Kruss and Visser (2017) advise that industry and government need to understand university collaboration to improve their UIG collaborations, generation of new knowledge and transfer of new knowledge to industry.

Empirical findings focusing on UIG R&D collaborations from the context of academia are nonexistent. This identified gap provided grounds for the paper to explore UIG R&D collaborations from the context of academia. The following are the research questions that the paper sought to answer:

i. What are the forms of UIG R&D collaborations that academia is involved in?
ii. Which government levels do academia collaborate with within the UIG collaborations?
iii. What are the UIG collaborations between academia and clothing-related organizations?
iv. What is the frequency of UIG collaborations between academia and the CTLF industry?

To explore the above questions, this paper describes role-players in UIG R&D collaborations from the context of South African CTLF industries. The forms of UIG R&D collaborations found through a literature review are first discussed. This is followed by the presentation of methods and findings leading to the conclusions drawn from this paper.

Literature review

Overview of the triple helix model of innovation

Ranga and Etzkowitz (2013) posit that the elements of the TH model of innovation can be identified in the works of Lowe (1982) and Sabato and Mackenzi (1982). Years later, the TH was introduced as a model for innovation by Etzkowitz and Leydesdorff at a workshop held in Amsterdam (Etzkowitz, 1993; Etzkowitz and Leydesdorff, 1995; Leydesdorff and Etzkowitz, 1996). The TH model of innovation represented a shift from a dyad system (industry and government) into a triadic system (university, industry and government). More recently the TH model of innovation has evolved to encompass a quadruple system (university, industry, government, and society) as introduced by Carayannis and Campbell (2009). Throughout all its forms (statist model, laissez-faire model, integrated model, and the quadruple model), the TH model of innovation encourages open innovation and transformation of each actor (Etzkowitz and Leydesdorff 2000; Singer and Petereka 2012). The discussions about collaborations are grounded on the above overview of the TH model of innovation.

South African CTLF role-players and possible R&D collaborators

Porter's diamond model theory advises that for a country to develop and sustain competitive advantage, it should have effective supporting industries or institutions as well as research institutions in sophisticated disciplines (Porter, 1990). While the South African literature on UIG collaborations' supportive institutions is limited, government policy documents provide some abstract view of these supportive organizations. According to the government trade policy strategy documents (DTI, 2007; 2010; 2011; 2014; 2017a; 2017b; 2018), there are various collaborative partners for CTLF industry collaborations.

The Council for Scientific and Industrial Research (CSIR) is a government science council tasked with conducting R&D activities that contribute to the improved quality of the life (Mbatha 2020). The UIG R&D collaborations that exist between the CTLF industry and the CSIR are the Textiles and Clothing Centre of Excellence in Port Elizabeth together with the Nelson Mandela Metropolitan University (NMMU), Stellenbosch University (SU), University of Pretoria (UP), Durban University of Technology (DUT), Tshwane University of Technology (TUT), University of South Africa (UNISA), Walter Sisulu University (WSU), Vaal University of Technology (VUT) and Cape Peninsula University of Technology (CPUT) (DTI 2010; 2011; 2014; 2017a; 2017b; 2018). Mbatha and Mastamet-Mason (n.d.) argue that within these collaborations there are UIG R&D collaboration gaps. While this may be the case, it is still unclear what forms these collaborations take, and which government levels (local, provincial or national) are involved. This highlights the gap that the current paper sought to explore to strengthen the role played by the CTLF industry in the attainment of the stated SGDs and AU Agenda 2063 aspirations.

There are four main clusters associated with the CTLF industry: the Cape Clothing and Textile Cluster (CCTC), KwaZulu-Natal Clothing and Textile Cluster (KZNCTC), National Footwear and Leather Cluster (NFLC), and Exotic Leather Cluster (ELC). Porter (1998) defines a cluster as interlinked institutions, and product and service firms within a geographic region. According to Chaddha, Dhanani, Murotani, Ndiaye, and Kamukama (2009), the main objectives of cluster initiatives are to foster joint action between CTLF industries, achieve economies of scale and facilitate knowledge engagement through the exchange of CTFL industry-level expertise. The clusters are made of members of full clothing manufacturers, CMTs, clothing textile industries and retail groups. The CCTC and the KZNCTC are non-profit organizations established by collaborations between government, member CTLF industries and consulting firms to boost the competitiveness for such cluster members (CCTC 2017). While two of the clusters (CCTC and ELC) have an academic from clothing-related HEIs, the literature is almost nonexistent regarding forms of collaborations used in these UIG collaborations through clusters. The DTI also established the NFLC through the Vaal University of Technology (VUT) and the Exotic Leather Cluster through the University of Pretoria (UP) (DTI 2015). These are subnational non-profit organization clusters responsible for developing best-practice industry standards to improve long-term sustainability and desirable growth for the leather and footwear subsector industry (DTI 2015). The contribution of these clusters to the SDGs and the AU Agenda 2063 aspirations are evident in the progress within their respective sectors. The NFLC played a role in the production of over two million pairs of shoes in South Africa and the Exotic Leather cluster has improved the quality of crocodile and ostrich leather produced in South Africa (Mbatha 2020). Despite these successes, there is a dearth of literature on how UIG

collaborations are established from academia's context. This underscores the importance of this paper.

Forms of UIG R&D collaborations

For this paper, forms of UIG R&D collaborations are defined as channels in which UIG engages in collaborations. There is ongoing discussion around what constitutes UIG collaborations. Hughes (2006) argues that UIG collaborations could be information-seeking while Guiliani and Arza (2008) maintain that UIG collaborations should be formalized. After surveying the literature, the paper settled on the following forms of UIG R&D collaborations: *Contract research, joint research, joint supervision, incubators, technology transfer and science parks*. These forms of UIG collaborations were employed by Mbatha (2020) which is a pioneering study on UIG collaborations in the CTLF context. These are discussed below.

Contract research is commissioned and funded, wholly or in part, by industry, government and international funding agencies (University of Pretoria 2015). The ability of an industry to enforce written contracts is an important determinant for R&D investment and plays an significant role in the innovation of a country (Seitz and Watzinger 2017). According to Pouris (2012), new technologies result from multidisciplinary R&D and require the formation of new collaborations and strategic alliances to allow industries to engage in the process of innovation. Grobbelaar, Tijssen, and Dijksterhuis (2017) suggest that contract research should be formalized and open to include participants along the value chain. They add that HEIs should consider the types of processes and mechanisms, level and nature of research collaborations, collaboration networks, interactive learning spaces, student education and teaching or training of community members to improve contract research. Poor contract research is associated with lower R&D investment. The R&D intensity within an industry increases with the quality of the governmental judicial system (Seitz and Watzinger 2017). Empirical evidence gathered from the CTLF industry shows 61.4% of firms in the CTLF industry have never had contract research (Mbatha, Mastamet-Mason, and Seda 2019) and this may account for the low rate of innovation. A literature gap still exists regarding the empirical evidence showing contract research involvement from academia's point of view.

Joint research allows the industry to develop technologies in collaborations with other industries, universities, or research institutions (Martin 2011). Martin (2011) state that joint research maximizes internal and external resources, lowers development costs and reduces potential risks in technology development. According to the OECD (1997), joint research activities are a highly accessible measure as this includes the funding of university staff to conduct research. Furthermore, joint research analyzes the number of technical activities between industries and universities or research institutes and can be counted using data published by government-funding agencies, universities and other sources (OECD, 1997). In the context of the CTLF industry, Mbatha, Mastamet-Mason, and Seda (2019) found that 66.9% of CTLF industry firms had never engaged in joint research collaborations. No empirical findings are available in the academia context regarding joint research collaborations.

Kunttu and Takala (2017) state that joint supervision could include project groups of undergraduate students and thesis projects for Master's and PhDs where relevant thesis topics are co-supervised by university lecturers or professors and/or industrial managers. The

authors state that project success is obtained when students writing a thesis have access to relevant and good-quality supervision from both sides of the relationship to generate new ideas and valuable knowledge transfer outside of the thesis project. In the CTLF industry context, Mbatha, Mastamet-Mason, and Seda (2019) found no empirical findings to suggest that joint supervision does take place from the CTLF firms' point of view. No empirical findings suggesting that joint supervision takes place or not from the context of academia could be traced.

Incubation is the nurturing process during business support that accelerates the development of a start-up company by providing entrepreneurs with the necessary resources and services for a period until the business is self-sufficient (Sá 2011; Chisenga 2013). Harvey (2013) found that the number of fashion designers positioned within incubators in the Johannesburg fashion district had declined since 2006. The author further found that there was a lack of capital support for fashion-specific incubators and a non-existent partnership with HEIs in South Africa. This has, in part, acted as contributory factors to the decline of Johannesburg fashion incubators (Harvey 2013). Sithole (2013) argues there are other factors affecting incubators, such as the absence of an entrepreneurial culture, a lack of independence of university officials and government bureaucrats, a lack of companies permitting synergies within science parks and stakeholders not having a shared vision in a science park. Mbatha, Mastamet-Mason, and Seda (2019) state that a clothing-related incubator in the KZN failed due to the lack of implementation from the government side. Studies like the one undertaken could contribute to the body of literature by providing empirical findings from academia context.

Research parks are science parks and organizations managed by specialized professionals. The parks aim to increase community wealth by promoting an innovation culture and the competitiveness of its associated industries and knowledge-based institutions (International Association of Science Parks (IASP) 2002). Such parks are created through the joint effort of local government and university administration and are located on or adjacent to a university campus (Martin 2011). Research parks success is found internationally. This has in the past resulted in the transformation of an ordinary industrial park into a new model for a science park linked to university research (Etzkowitz and Ranga 2010). The lack of success of research parks in mainly the global south is attributable to five factors, namely function following form, the absence of planning, lack of expertise, lack of diligence, and an unsupportive market (Sithole 2013). Studies like this paper could contribute to the existing body of literature by providing empirical findings from academia in HEIs within clothing-related programmes' context.

Technology transfer centres or offices are institutions where the process of transferring scientific findings from one organization to another for development and commercialization takes place, either as patent licensing or non-patent technology transfer (Cannady 2006; Martin 2011; Sithole 2013; Chau, Gilman, and Serbanica 2017). Patent-protected technology is commercialized through three main licencing strategies, namely, licencing in exchange for sponsored research, equity in a company, and cash (Sithole 2013). These types of facilities exist in universities, firms and government research laboratories and emanate from TH collaborations. According to Villani, Rasmussen, and Grimaldi (2017), the success of such centres depends on geographical, cognitive, organizational and social proximity. The authors

state that organizations with similar routines and rules may collaborate more easily due to organizational proximity. Researchers that have developed trust and common experiences are more socially proximate. This is all done for effective and efficient communication and transfer of knowledge. Mbatha (2020) provides empirical findings on a technology station within the HEIs with clothing-related programmes that are leading in science, technology and innovation produced through UIG collaborations. However, the literature on technology transfer centres in the CTLF industry UIG collaborations and the participation of academia is lacking.

Student placement in industries for research-related activities is organized as recess employment and provision is made to do research projects on an industrial basis (Ishengoma and Vaaland 2016). Developing countries are facing challenges concerning unemployment of graduates due to the lack of competitive skills demanded by industry (Ishengoma and Vaaland 2016). Graduate employability is relevant to HEIs and industry, as the latter demands graduates who can readily transfer into the workforce and effectively demonstrate their employability skills (McIlveen and Pensiero 2008). Ishengoma and Vaaland (2016) state there are three student employability activities and perceived effects, namely, collaborative training and educational, collaborative consulting, and collaborative research activities. In Masters-level and PhD-level theses, the emphasis is therefore placed on industrial projects with practical themes that are beneficial to industrial partners and for students to become integrated into the industrial way of working and to continue to work as employees of the industrial partners on graduation (Kunttu and Takala 2017).

Methods

Exploratory research explores research areas where little information is available regarding a specific topic. It aims to gain insight into a situation when examining a new and unstudied interest (De Vos, Strydom, Fouché, and Delport 2005; Kumar 2011). Quantitative research usually prompts respondents to give closed-ended responses by identifying a few variables to study. Data related to those variables were collected in 2018 and the methods of measuring each variable were identified, developed and standardized (Creswell 2014; Leedy and Ormrod 2015). The population of the study included TradUs, CompUs, and UoTs with clothing-related programmes selected in line with the definition of a population. A population is a well-defined set of people or organization(s) with a set of characteristics (Banerjee and Chaudhury, 2010). Participants of the study were purposively sampled using the total sampling methods due to the small size of the population (approximately 150) found in the above-mentioned academia. The total sampling technique was non-probability, judgemental (purposive) sampling that focused on the analysis of the entire population with a particular set of characteristics (Kumar 2011; Quinlan, Babin, Carr, Griffin, and Zikmund 2015). Total sampling was targeted at academic staff working in the following programmes targeted by the study: Fashion Design, Consumer Science, and Textiles and Clothing Management. Ethical approval was obtained from the research ethics committee of the hosting HEI. Further ethical clearance was obtained from the participating HEI research ethics-related committees as per the recommendation of the research ethics committee of the hosting HEI. The deputy vice-chancellors of research and, in some cases, the directors of research granted ethical approval for the study.

Data collection were conducted through an online questionnaire developed using Qualtrics. Qualtrics is a cloud-based management platform or software that is designed to gather, analyze and share data with no hardware or maintenance required (Qualtrics 2018). The questionnaire development was adapted from the Kruss and Visser (2017) scale in line with the TH framework. To explore and describe forms of UIG R&D collaborations, the paper looked into whether the following collaborations existed:

- Contract research
- Joint research and publication
- Joint supervision
- Incubation
- Research park / Technology transfer centres
- Studying Masters / M-Tech within a research collaboration project
- Studying PhD / D-Tech within a research collaboration project.

To answer the question of whether academia had UIG R&D collaborations with government, the paper looked at the existence of such, focusing on local, provincial and national levels. The paper further explored UIG R&D collaborations between academia and the following clothing-related organizations;

- Council for Scientific and Industrial Research (CSIR)
- Department of Trade and Industry (DTI)
- Cape Clothing and Textiles Cluster (CCTC),
- KwaZulu-Natal Textiles and Clothing Cluster (KZNCTC),
- Exotic Leather Cluster
- Other.

Lastly, the paper looked at UIG R&D collaborations between academia and CTLF industry firms grouped as follows:

- Full clothing manufacturing firm
- Cut-Make-Trim (CMT) manufacturing firm
- Small, micro, medium enterprises (SMMEs) clothing manufacturing firm
- Retail groups
- Textiles industry
- Exotic leather industry.

Respondents were given the following options:

- Never – meaning a respondent had never engaged in UIG R&D collaborations
- In the last three years – meaning the respondent had engaged in UIG R&D collaborations within the last three years
- More than three years ago – meaning the respondent had been engaged in UIG R&D collaborations more than three years ago.

Email addresses of academia were sourced from their websites and heads of department. The online questionnaire link was emailed to academia following the granting of ethical approval

by the stated authorities. Data collection resulted in 24 completed questionnaires. The 24 respondents (academic staff) came from the following institutions: four from Universities of Technology; six Comprehensive Universities; and eight from Traditional Universities. Six respondents choose not to respond to the questionnaires. The gathered data were descriptively analyzed. Descriptive statistics is a method that summarizes data through an average or characteristics associated with a data set (Hofstee 2006; Leedy and Ormrod 2015). Through descriptive statistics, data were analyzed and results presented in graphs. The reliability of this study was strengthened with the use of an adapted scale.

Research limitations

While the research sampled the entire population due to its size, the response rate was at 16% of the population. Due to the questionnaire being designed in a closed-ended manner, respondents could not explain why they were less involved in all the explored UIG R&D collaborations. The paper relied on the experiences of academia in South African HEIs with clothing-related programmes. As a result, the research directorates of the concerned HEIs, CTLF industry and clothing-related government departments were not sampled. Other clothing-related organizations were also not sampled. These limitations should motivate future research in this discipline and contribute to the limited knowledge of UIG R&D collaboration in the CTLF industry. In light of the above limitations, the researchers argue that the paper yielded valid empirical findings for the paper to conclude UIG R&D collaborations from the perspective of academia.

Findings

Results on forms of collaborations

One of the questions gauged the understanding of the forms of UIG R&D collaborations that academia was involved in. Figure 1 outlines the results of the stated objective. Six questions were tested and the options available to respondents are indicated at the top Figure 1 as *Never, In the last 3 years* and *More than 3 years ago*.

Looking at Figure 1, the majority (79%) of academia indicated that they had never engaged in these forms of UIG R&D collaborations while 29% indicated that they had. These results corroborate the findings by Mbatha et al. (2019) that CTLF firms generally are not engaging in UIG R&D collaborations. The fewer UIG R&D collaborations in Figure 1 are corroborated by Mbatha et al. (2019) who also found that CTLF firms had fewer UIG R&D collaborations. Incubation had the least involvement with 92% of the respondents not having participated in this form of UIG R&D collaboration. These results corroborate the findings by Harvey (2013) and Sithole (2013) who state possible reasons for lack of incubations being due to the lack of entrepreneurial culture, lack of capital support for incubators and a non-existent partnership with HEIs.

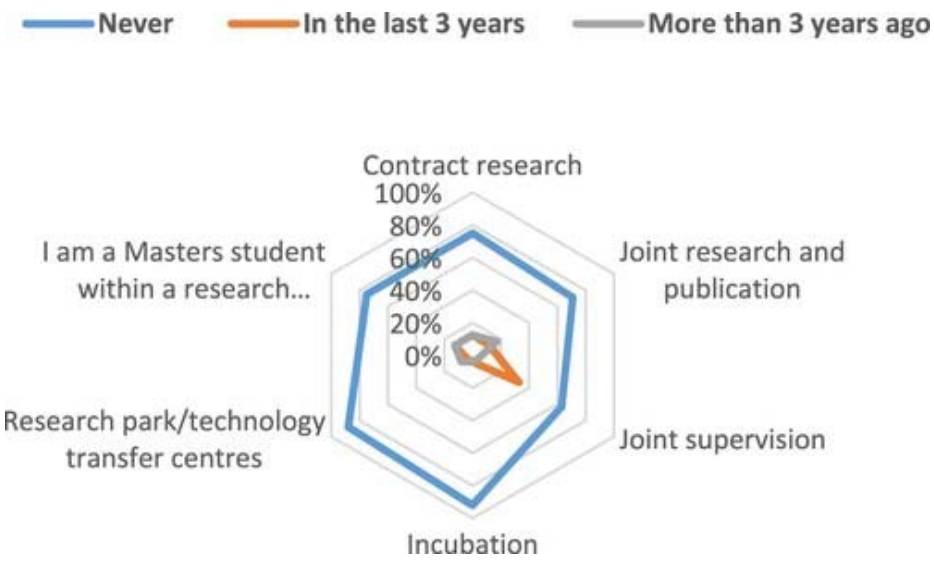

Figure 1: Forms of research collaborations (n = 24).

The findings in Figure 1 corroborate the findings by Mbatha (2020) on the CTLF industry's NSI structural gaps. These findings supports existing literature that UIG collaborations in Africa are largely absent or weak and should be implemented or strengthened (Bartel and Koria 2014; Patra and Muchie 2018). The low percentages in UIG R&D collaborations by academia suggest that their role in achieving the listed SDGs and AU Agenda 2063 aspirations may be very limited. The science, technology and innovation required to achieve the SDGs and AU Agenda 2063 aspirations may be produced at a snail's pace due to the low percentages of UIG R&D collaborations.

Findings on levels of government

The paper explored UIG R&D collaborations that academia had with a local, provincial and national government. The data analysis found the results presented in Figure 2.

Figure 2 indicate that academia hardly (76%) had UIG R&D collaborations with various levels of government. In their paper, Mbatha et al. (2019) found that CTLF firms also had few UIG R&D collaborations with the government. The paper highlighted that the low percentage of UIG R&D collaborations was due to CTLF firms and fashion design programmes not applying for UIG R&D collaboration funding from the government. While the government IPAP policy documents showed that the CTLF industry had collaborations with nine HEIs with clothing-related programmes (DTI 2010; 2011; 2014; 2017a; 2017b, 2018), the results indicated that fewer members of academia were involved in such collaborations. It can be argued that the low percentage of government involvement in UIG R&D collaboration was due to few UIG R&D collaboration applications from academia. While the government may have the necessary UIG R&D collaboration policies and funding (Mbatha 2020), without applications from academia and the CTLF industry, its role in achieving the SDGs and AU Agenda 2063 aspirations is negatively affected.

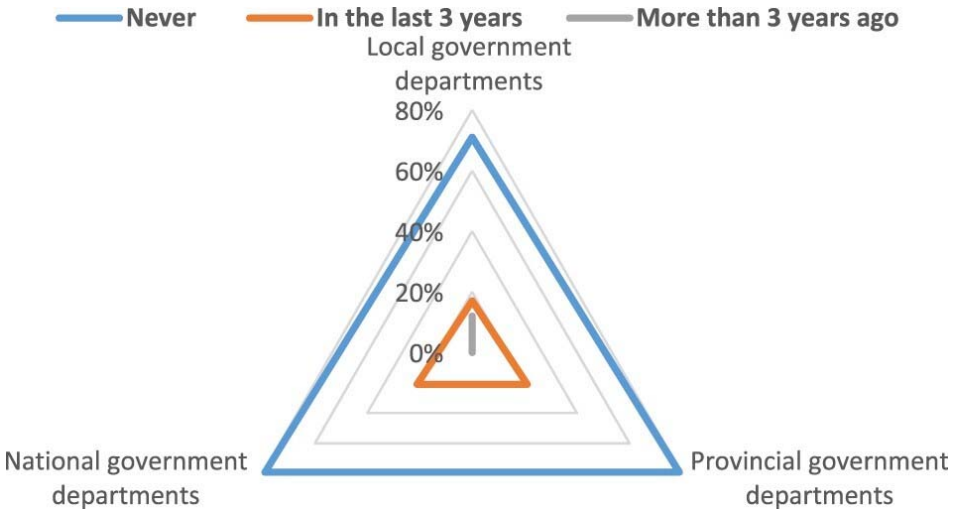

Figure 2: Levels of government (n = 24).

Figure 2 indicates that local government (17% + 12% = 29%) has more UIG R&D collaborations overall when compared to the provincial and national government. The explanation for this by Mbatha (2020) is that local government gets involved in unlawful collaborations. Mbatha (2020) state that, according to the Public Financial Management Act (PFMA) and the Municipal Financial Management Act (MFMA), the government is not allowed to use its funds for activities that involve firms or organizations not complying with South African labour law. Mbatha (2020) show that local government does have UIG R&D collaborations with CTLF firms that are non-compliant with the labour law. This explains why the local government's percentage of UIG R&D collaborations are higher than the provincial and national percentages.

The low percentage of academia and UIG R&D collaborations limits science, technology and innovation activities in pursuit of the SDGs and AU Agenda 2063 aspirations. As a result, the execution of the third mission (economic development) is hampered. Significant improvement in UIG R&D collaborations by HEIs with clothing-related programmes is necessary at all levels of government to realize the SDGs and AU Agenda 2063 aspirations.

Findings on clothing-related organizations

Figure 3 shows the clothing-related organizations' UIG R&D collaborations with academia. This is in response to the paper's question about UIG R&D collaborations between clothing-related organizations and academia. Six questions were tested and options available to respondents are presented.

Figure 3 show that 84% of academia never had UIG R&D collaborations with clothing-related organizations. These results corroborate those by Mbatha et al. (2019) that indicate that fewer UIG R&D collaborations take place. These results further support the view by Mbatha (2020) that the UIG R&D collaboration of the CTLF industry has gaps.

The KZNTCC had the least involvement as 92% of academia in HEIs with clothing-related programmes indicated that they had never participated in UIG R&D collaborations with the

clothing-related organization. This could be due to these organizations (KZNTCC and CCTC) being industry- and government-focused (CCTC 2017). The CSIR had UIG R&D collaborations (12.5% + 25% = 37.5%) with academia. These results are consistent with the CSIR's R&D mandate (Mbatha 2020). The low UIG R&D collaboration between academia in HEIs with clothing-related programmes and clothing-related organizations validates the view by Mbatha (2020) that there are gaps in the CTLF industry's NSI. The low percentage of UIG R&D collaboration between academia and clothing-related organizations will negatively affect the achievement of SDGs and AU Agenda 2063 aspirations.

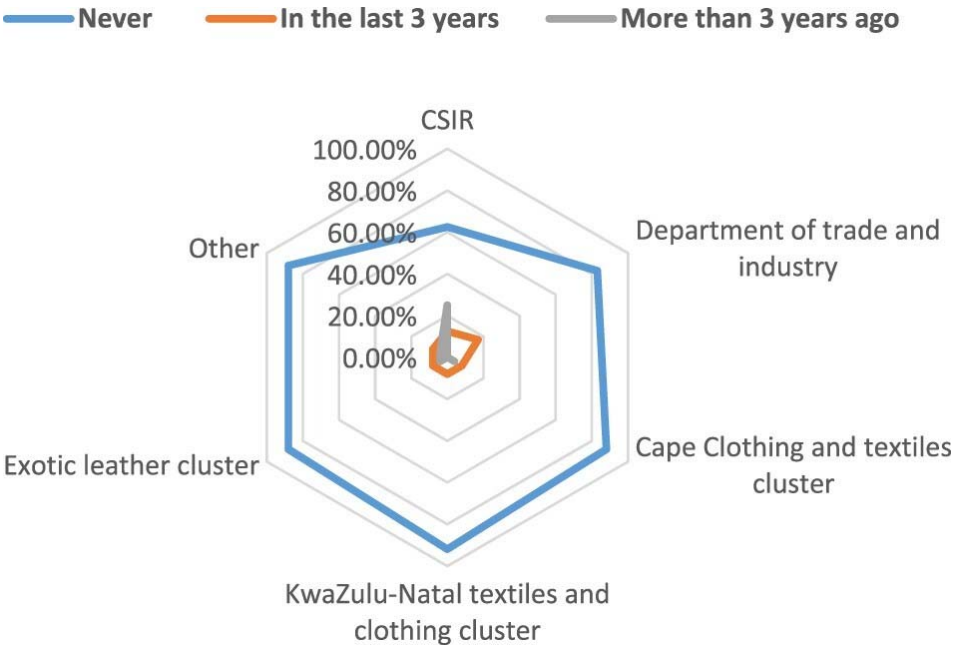

Figure 3: Clothing-related organizations (n = 24).

Findings on UIG R&D collaborations with clothing-related firms

The paper explored UIG R&D collaborations between academia and the CTLF industry. There are six industries, as is shown in Figure 4.

Figure 4 shows that 77% of academia had never engaged in UIG R&D collaborations with the CTLF industry. Only 23% did engage. This is corroborated by the findings by Mbatha et al. (2019) in which the CTLF industry highlighted that it had few UIG R&D collaborations with one of the clothing-related programme's academia. These findings contradict government IPAP documents which show that there are UIG R&D collaborations with academia.

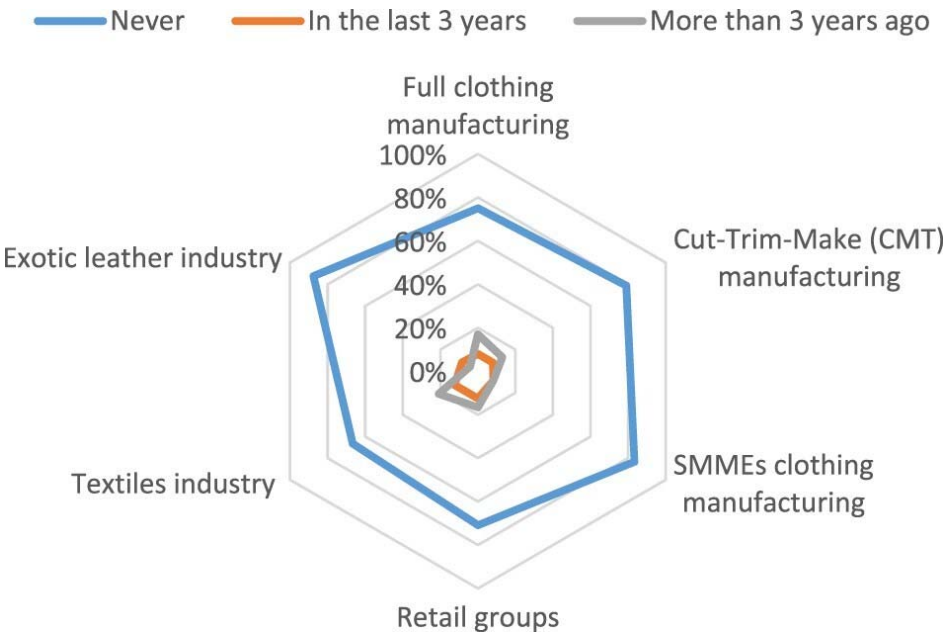

Figure 4: Clothing-related firms (n = 24).

The textiles industry had the most involvement (12% + 21% = 33%) and this could be due to the industry not just focusing on clothing textiles and being inclusive of other forms of textiles. Mbatha et al. (2019) corroborate this as they found more UIG R&D collaborations that link with the textiles industry. While this is the case, the textiles industry has been unable to overturn fabric challenges that negatively affect the competitive advantage of the CTLF industry (Morris and Barnes 2014; Mbatha and Mastamet-Mason 2015; Mbatha 2018). While the textiles industry many have more UIG R&D collaborations, its positive impact on competitive advantage has not been registered. As a result, it could be argued that despite better collaborations, the textiles industry may limit the achievement of the SDGs and AU Agenda 2063 aspirations.

Concluding remarks and policy implications

The clothing industry is important to South Africa and by extension to Africa because it can employ mainly unskilled citizens comprising of mainly women. It also contributes to the manufacturing sector. While it pays low wages, its contribution to poverty alleviation cannot be overemphasized. The clothing industry further contributes to the socio-economic development of Africa. Lastly, the clothing industry contributes to the informal sector through fashion design professionals involved in the Small, Micro, Medium, and Enterprises (SMMEs) sector of Africa. While this is the case, the findings of the paper show that opportunities to improve science, technology and innovation activities through UIG R&D collaborations in the clothing industry of Africa exist.

Manzini (2012) advises that sectoral systems of innovation should be studied to address innovation policy challenges. The findings of the paper presented in Figure 4 suggest that South Africa has innovation policy gaps due to the abstract nature of the South African innovation policies, a view shared by Patra and Muchie (2018). Existing literature shows that this is the case in other African countries (Aregawi 2013; Mpehongwa 2013; Bartel Koria 2014;

Borogo 2015; Ishengoma and Vaaland 2016). Africa lacks effective innovation policy that further focuses on respective sectors earmarked for industrialization, like the clothing industry in the case of South Africa (DTI 2016; 2017a). As is, the innovation policy of South Africa and by extension Africa, has not worked for the clothing industry. This is supported by Mbatha et al.'s (2019) findings that the UIG R&D collaborations in the clothing industry are at the statist model stage. Several studies from other African countries suggest that African UIG R&D collaboration are generally at statist model stage (Borogo 2015; Aregawi 2013; Derbew, Mungamuru, and Asnake 2015; Ishengoma and Vaaland 2016; Mpehongwa 2013). The ineffective nature of these UIG R&D collaborations at sectoral level supports the argument that Africa's innovation policy has not worked.

In addition to its overarching innovation policies, Africa and its respective countries can benefit from developing sectoral innovation policies to aid science, technology and innovation activities in sectors like the clothing industry. There should be national, regional (like Southern African Development Communities (SADC)) as well as African Union oversight committees trusted with ensuring African sectoral innovation policy implementation is effective. Such committees should be mandated to stimulate science, technology and innovation activities through UIG R&D collaborations at national, regional and Africa level. The development of national, regional and African collaborative organizations may be formed and strengthened through these sectoral innovation policy committees. The researcher argues that it is through such targeted sectoral innovation policy that Africa can begin to improve its innovation output and its contribution to the SDGs and Africa Agenda 2063.

Exploring science, technology and innovation activities through UIG R&D collaborations from the context of the African clothing industry has the following benefits. From the university with clothing-related programme's perspective, it offers these universities opportunities to explore African indigenous clothing and textiles manufacturing process, which may hold competitive advantage opportunities for the African clothing industry. The development of sizing charts for pattern design and construction in line with the body shapes that are predominately found in Africa can be accelerated (Mastamet-Mason 2008). The development of pattern construction, garment manufacturing, and textiles textbooks based on the African indigenous systems and body shapes can be accelerated. Engaging in the above science, technology, and innovation activities may also contribute to the increase in patenting activities from African universities with clothing-related programmes. The socio-economic development possibilities that can be realized by improving UIG R&D collaborations in African universities with clothing industry-related programmes cannot be overemphasized.

African universities with clothing-related programmes should learn from their international counterparts. The Institute of Textiles and Clothing (ITC) of Hong Kong Polytechnic University (Yu 2013), as well as the Swedish School of Textiles of the University of Borås (Textiles Fashion Centre 2020), are some examples of how universities with clothing-related programmes can contribute to science, technology and innovation activities through UIG R&D collaborations. These universities with clothing-related programmes are some of the leaders in the adoption and invention of high-tech clothing and textiles related products and manufacturing systems. The danger of failing to learn from these universities will result in African having universities with clothing-related programmes that have outdated technology, produce graduates that are not competitive globally, have smaller internationally recognized pools of academics, and

contribute less to their third and fourth missions. Should this happen, African universities with clothing-related programmes would contribute less to the SDGs and African Agenda 2063. The paper recommends that African HEIs with clothing-related programmes educate academia in these programmes about the benefits of UIG R&D collaborations and their roles in this regard to realize the SDGs and AU Agenda aspirations.

Exploring science, technology and innovation activities from the context of the African clothing industry has the following benefits for industry. The African clothing industry could though UIG R&D collaborations establish a comprehensive clothing value chain since the current value chains are dependent on imports (Mbatha 2018). Africa has the right climate conditions to farm textiles crops that are used in the clothing production value chain. Through UIG R&D collaborations, the African clothing industry could develop the capacity to develop value-adding industries to the aforementioned textiles crops, thus increasing the beneficiation of the clothing industry to Africa. The African clothing industry could be better positioned to take advantage of the African Growth and Opportunity Act by developing capabilities to produce clothing products that have their manufacturing inputs originating from Africa (Morris and Barnes 2014). Developing upwards beneficiation industries would see the African clothing industry contributing to the industrialization of Africa, develop competitive advantage and improve the achievement of SDGs and AU Agenda 2063.

Africa's clothing industry should aspire to adopt technology like Asia did while maintaining or increasing employment in the clothing industry. The African clothing industry should learn from the Asian clothing industry on how they have used UIG R&D collaborations to build a leading global clothing industry (Yu 2013). The findings of the paper should sound a warning call for HEIs with clothing-related academia. Should Africa not learn to transform its clothing industry as Asia did, Africa will continue to be the preferred dumping continent for clothing products, it will remain less industrialized, it will benefit less from the African Growth and Opportunity Act, and contribute less to the SGDs and Africa Agenda 2063.

From the perspective of government, exploring science, technology and innovation activities through UIG R&D collaborations from the context of the African clothing industry has the following benefits. Due to their active involvement, African governments would learn from the first-hand experience about their innovation policy cohesiveness, identify policy challenges and be able to improve them. By being involved in science, technology and innovation activities through UIG R&D collaborations in the clothing industry, African governments would be in a position to encourage the development of sectoral innovation policy. Improvements in sciences, technology and innovation through UIG R&D collaborations will increase Africa's adoption of innovation within its clothing industries. This may see the African clothing industry improve its competitiveness, thus increasing taxes and employment. Through these UIG R&D collaborations, African government can collectively improve their contribution to the SDGs and Africa Agenda 2063.

Singer and Peterka (2012) suggest that comparing innovation policies of various countries should be encouraged. African governments should learn from Asian and European governments (Patel, Jagger, and Nemoto 2015; Yee, Chong, and Kendall 2015) on how they used innovation policy to stimulate industrialization, as well as improving economic and socio-economic development. These lessons will assist African comments to develop an innovation

policy that is based on the African context and that is effective. Failure for African government governments to learn from such continents, the pursuit for SDGs and Agenda 2063 will be a challenging one.

From a practical point of view, a UIG R&D collaboration directorate suggested by Mbatha (2020) should be established within African governments. These directorates should have specialized staff overseeing the development and enhancement of UIG R&D collaboration at the sectoral level. In the case of South Africa, the respective government-funded agencies make funding available to fund postgraduate research through the National Research Foundation and the Department of Trade and Industry funds innovation technology projects that have a research component while the Technology for Human and Industry Programme (THRIP) funds UIG collaboration projects. While this is the case, innovation policy has not worked. This shows that a UIG R&D collaboration directorate may ensure that there are effective sectoral UIG collaborations that stimulate socio-economic development in South Africa and Africa at large. Technology transfer institutions should be developed in line with the strengths of universities with clothing-related programmes and regions for the clothing industry to take advantage of proximity and existing academic expertise. In the case of Africa, the African technology transfer committee should be situated in the AU to effectively exploit opportunities that come through African technology stations. This UIG R&D collaboration directorate should lead the development of science, technology and innovation capability in the clothing industry value chains due to its privileged position of having all stakeholders within its reach. For Africa to catch-up with the rest of the world in terms of innovation policy effectiveness, a UIG R&D collaboration directorate is recommended.

This paper adds new knowledge, from the perspective of academia in HEI clothing-related programmes, to the limited global south literature on UIG R&D collaborations.

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