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INCLUSIVE INNOVATION IN SOUTH AFRICA

by

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degree

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in

Comparative Local Development

in the

College of Economics and Finance

at

TSHWANE UNIVERSITY OF TECHNOLOGY

Supervisor: Prof. Mario Scerri

April 2024

DECLARATION

I hereby declare that this dissertation submitted for a Master's degree in Comparative Local Development at Tshwane University of Technology is my own original work and has not previously been submitted to any other institution of higher education. I further declare that all sources cited or quoted are indicated and acknowledged by means of a comprehensive list of references as presented in the reference/bibliography list.

M. Seshoka



DEDICATION

This study is firstly dedicated to God Almighty and my great Ancestors from both families (Seshoka and Ramaite) as the main sources and pillars of my life, ideologies, strength, resilience, peace, internal healing, self-esteem and acceptance.

Secondly, to my beloved parents (Mr N.D. Seshoka nicknamed Juluka and Ms I.M. Ramaite) for their unconditional love and unwavering and limitless support since my birth that encompassed but were not limited to the psychological, social, spiritual and economic aspects of my life. To you, my parents, this moment represents the harvest of your continuous trust, belief and investment in my life and endeavours.

Last but not least, I dedicate this research study to my life partner Ms N.C. Mhlongo and our beloved daughters Ms A.J.M. Seshoka (nicknamed Mopolokwanyana) and Ms T.V. Seshoka (nicknamed Mlungwane) for their sincere and unconditional love, patience, sympathy and resilient support for the duration of this academic endeavour. You best know the particulars of my struggle to accomplish this research study. All the family times, outings and gatherings that I missed are now justified by the achievement of this academic and life-changing milestone.

ACKNOWLEDGEMENTS

Firstly let me express my gratitude and honour to God Almighty and all my Great Ancestors for guiding, empowering and emancipating me to develop an interest in this academic path and field. It is indeed an enriching field of study that has immensely assisted me to rediscover my self-worth, potential and rationale for my existence in this motherland. I trust and believe in both the Holy Spirit and my Great Ancestors and I will forever be immensely grateful for their spiritual support, guidance, healing and protection.

This study would not have materialised without the incredible and valuable insights, inputs, impartial guidance, suggestions and support of the persons mentioned below.

Firstly, I humbly share my boundless appreciation of my amiable supervisor, Prof. M. Scerri, for his continuous support, profound advice, constructive and impartial reviews, suggestions and guidance that led to the accomplishment of this research study. Through steering me with both amiable and bold comments and reviews that led to the accomplishment of the research study, you planted an academic seed in this African soil whose growth will undoubtedly contribute massively to the development of Africa. This will include policy making, constructive reviews of developmental policies and nurturing Africa with vibrant innovative ideas to help solve development challenges. Under your supervision I gained in-depth knowledge, skills and competencies that are relevant to the development of our countries. I will always practise in a manner that honours your credibility, impartiality and the privilege of having been one of your academic mentees.

Secondly, to my best friend and sole pillar of strength, my father Mr David Ngoako Seshoka, I say a big thank you for your undiminishing understanding and support for my academic journey from inception to completion. Without your monetary and emotional support, this study would not have been accomplished.

To my family (N.C. Mhlongo, life partner, and two daughters Thato and Jennifer Seshoka), I sincerely thank you for your moral support since I started with this research project. It was never easy to miss my children's sports days, gaming times and other family activities due to this research project. Your endurance has now borne fruit and my wish for my daughters is that they emulate me with perseverance and resilience in their studies.

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Agricultural Research Council (ARC)	53
Armaments Corporation of South Africa (ARMSCOR)	30
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CHAPTER 1: INTRODUCTION

Innovation is now globally considered a key factor in driving economic growth and development (Eggink, 2012). This is strongly supported by Scerri (2020c), who states that innovation is one of the important elements for development and economic growth. However, the critical issue in this regard is whether the innovation approaches and models that the countries adopts serve to promote inclusive innovation and development. In South Africa, more specifically with consideration of the historical background of the apartheid regime, the country's adopted innovation approach and model has always narrowly focused on quantitative measures such as science, technology, research and development (Kahn, 2013). This also covers the years of segregation after colonialism and apartheid, which tended to ignore the consideration that the innovation system (IS) could be national, regional, local or sectoral. In other words, the persistent and uneven distribution of the innovation actors' capabilities could also be identified across sectors, countries and regions.

As a result, the skewed effect of innovation performance is a function of the specificity of national or sectoral factors. The competitive advantage of sectors and nations depends largely on how advanced the system of innovation in such areas is and how well it generates coherence and interaction amongst innovation agents. In this context knowledge flows, interactions in learning and the role of institutions are key elements (Oyelaran-Oyeyinka & McCormick, 2007).

As to the South African historical background, the country's majority population of black communities (here referring to black people grouped under apartheid as Africans, Indians, coloureds and Asians) was marginalised during apartheid and legally excluded from having equal access to formal educational opportunities and from participating in innovation activities. This greatly contributed to building and adopting an uneven functionality and a limited system of innovation in the country, which resulted in blockages of knowledge flows, networking and the exchange of knowledge amongst the country's innovation agents.

Research studies indicate that without knowledge transfer from routes such as education systems, training and research institutions amongst innovation institutions and actors, the country's innovation capacity and capabilities will be seriously hampered. A country must take deliberate steps and apply effort to ensure that knowledge flows among innovation agents is

facilitated. This will positively result in the expansion of the country's innovation capabilities and capacity building, which will later lead to improved innovative capabilities and activities of the country. This will on a long run further expand the country's economic development activities which will grow the competitive edge of the nation (Eggink, 2012). It is critical to note that the advent of the South African constitutional democracy in 1994 played a pivotal role in supporting the evolution of the country's system of innovation (Kahn, 2013). However, it is equally important to note that the major structural reforms that came with constitutional democracy did not include the transformation of the narrowly designed innovation model adopted and applied by both the apartheid and democratic regimes. The country failed to overhaul in totality the adopted model of innovation which was perceived to be of narrow perspective, focusing entirely on formal science, technology and associated innovation. This adopted innovation model sought to advance only the mainstream innovation and science and technology elements of an innovation system.

Mainstream innovation is the traditional approach to innovation which exclusively is associated with the research and development process and is highly capital and technology intensive. This innovation model mainly seeks to meet the needs of the elites, bourgeoisie and owners of capital, while excluding/minimally considering those of the majority representing the marginalised and disadvantaged lower-income population. Clearly this narrow innovation approach in South Africa contributed to the exclusion of the majority of the marginalised black communities and lower-income populations (Scerri, 2020c).

It is important to note that even with all the country's structural reforms adopted in post-apartheid South Africa, the country's economic structure remains highly centralised and beneficial to capital. Mondliwa and Roberts (2021) maintain that the country's economy in terms of ownership and control remains centralised and in the hands of the minority white capitalist population. This population controls and owns most large corporations that operate in the formal economy, while the larger marginalised lower-income population remains excluded from the formal economy and its benefits. Available empirical data show that the country's centralised economic status further restricts the country's innovation agents and the entire economy from being competitive and interlinked with the global market. This implies that the country and its innovation agents miss out on innovation opportunities and benefits.

There is no doubt that the exclusion of the previously marginalised and current lower-income majority from innovation activities and other economic domains severely harms the achievement of local synergy and further creates rivalries in the drive for development and evolution of the country's national system of innovation (Oyelaran-Oyeyinka & McCormick, 2007). The historical exclusion of the black majority through apartheid racial institutions and legislation required the democratic government to initiate relevant and robust policy reforms of both the economy and innovation to create an enabling environment for open collaboration and interactions among all innovation agents beyond race, culture, gender and region. It still remains to be seen, even three decades since the country's first democratic election, if the government in South Africa has achieved success in creating an enabling environment for innovative activities oriented towards inclusivity. This is doubtful, since the majority of South Africans are still largely excluded from full engagement in mainstream innovation activities. This points out to the failures by the democratic government to initiate structural reforms to foster an open and inclusive innovative environment.

Innovation and innovation systems in developing economies have been traditionally associated with large organisations that are mainly focused on formal research and development (Eggink, 2013). Although there is a positive link between large organisations and innovation, this does not mean innovation and its activities take place exclusively in these large organisations. Most of these organisations' innovative products and services target the export markets, with goods and services that are mainly consumed by the higher income populations. As such most of these innovative products and services bear witness to the inequalities suffered by marginalised South Africans through a delinked connection with and relevancy to addressing their needs. It is in above context that the search for an alternative innovation system that is inclusive of the marginalised lower-income population as potential innovation actors in innovation processes has seen a rise in popularity. Inclusive innovation has gained traction in the 21st century and is the innovation model with the potential to build an inclusive innovation system in a country. An inclusive innovation system explicitly perceives development in terms of the active inclusion of those who are marginalised or excluded from the mainstream development.

Inclusive innovation has the potential to contribute to the evolution of the country's NSI. From the perspective of evolutionary economics, the NSI is viewed as an evolving organism, a product of history where the concept of optimisation has minimal relevance when compared to search and interactive learning and ongoing processes of creative destruction (Scerri, 2020c).

The broad innovation framework is rooted in the evolutionary school of economics. This school of economics provides an alternative approach to economic dynamics and is better equipped to explain economic change than mainstream economics (Scerri, 2020b). Against the background of South Africa's apartheid-inherited economic and social inequalities that persist even in the post-apartheid constitutional democratic era, inclusive innovation is considered a relevant alternative innovation model. This is largely due to the choice of a macroeconomic model which failed to initiate the changes required for a meaningful and sustained shift to an inclusive economy. This is particularly relevant to the locality of the system of innovation and its potential innovation actors. Every locality has incidents of its own that affect in various ways the methods of arrangement of every class of business conducted in South Africa.

South Africa's economic development until the end of apartheid was a one-of-a-kind process. During the colonial, segregation and apartheid periods, the country's system of innovation (inclusive for example of its institutions, innovation actors and their networking) was negatively affected by the application of apartheid policies and laws that advocated its segregation and assured its structural fragmentation. The exclusion of the majority of the population from equal access to participating and networking in the country's system of innovation has resulted in the limited economic growth and development of the country even in the post-apartheid period (Oyelaran-Oyeyinka & McCormick, 2007). The strength of the linkages amongst innovation participants normally has a positive effect on the innovative performance of an innovation system reflected in the transfer of finances, knowledge and technology. It is based on this that the proximity of the innovation agents is often critical to the functionality of the broader system of innovation. This has a huge impact on knowledge creation, its diffusion or distribution and usage within a country and on yielding the required innovation performance.

However, in post-democratic South Africa, the distance/fragmentation of innovation agents within the system of innovation that prevails is caused by many such structural inequalities, like the unequal distribution of wealth and resources (Eggink, 2012). This study aimed to apply evolutionary economic theories to broadly review and explore the historical background of South Africa's NSI, its impact on the economic structuring and why inclusive innovation should be promoted.

The locality of the system of innovation in this research study pertains to South Africa as the main area of the investigation. Every locality has specificities of its own that affect in various ways the methods of arrangement of every class of business carried on in it. During the pre-democratic era, the country's NSI agents' composition and networking were heavily constrained by racial institutions and institutions deliberately designed to be segregational. This segregation and fragmentation of innovation agents and institutions severely damaged the country's NSI and restricted its evolution. This further affected the innovation activities and the development and growth processes (Oyelaran-Oyeyinka & McCormick, 2007).

It is argued that the legal structure in post-apartheid South Africa is aligned with an inclusive democracy, but the enduring economic institutions remain only partially reformed. As a result these institutions have preserved structural inequalities in the post-apartheid state which continue to exclude the marginalised lower-income population groups from the innovation system. The country's economic structure is still mainly based on extractive activities, agriculture and manufacturing which remain shaped by the structural inequalities and lack transformation (Kahn, 2013). This explains why the marginalised lower-income groups in South Africa remain excluded from the innovation system and innovation processes. These structural inequalities are preserved in democratic South Africa as a result of adoption by the government of Western or Washington macroeconomic policies that emphasise comparative advantage as the basis for economic planning. These policies in South Africa have contributed to the persistence of problems such as wealth distribution disparities, sluggish economic performance, severe health problems and service failures in most parts of the country caused by corruption and lack of good governance skills (Oyelaran-Oyeyinka & McCormick, 2007).

The country's continual confrontation with these development problems undoubtedly symbolise or constitute a failure by the government to fulfil the promises made during the fight for democracy. Based on this context, the primary aim of this research study is to explore and investigate how inclusive innovation as an alternative approach can help develop an inclusive innovation system. The systems of innovation is inclusive when it also brings the majority marginalised population groups to the centre of the NSI. Inclusive innovation is all about having an innovation system where all South Africans form part of the innovation process. Inclusivity may be both passive and active. The narrow passive inclusion category is concerned with reducing income inequality and bringing the poor out of poverty by raising their income and earnings. This may also mean their inclusion in learning programmes.

There is a misperception that actors in innovation systems are homogeneous and that learning that happens within the innovation system will automatically benefit all actors. The fact is that most marginalised communities even when included in innovation processes and systems are still not properly considered when it comes to developing, benefiting and designing innovative products (Oyelaran-Oyeyinka & McCormick, 2007). The broad active inclusion element is about giving rights, voice, capabilities and incentives for the excluded marginalised lower-income groups to also become central active participants in the processes of development and innovation. This emphasises the importance of inclusive innovation systems and was the area of concern for this study.

Innovation for inclusive development

The deployment of policies flowing from a neoliberal approach has failed to achieve the type of economic growth that reduces unemployment and inequality in South Africa. All too often the promotion of science, technology and innovation has co-evolved with inequality, especially pronounced in a country like South Africa under apartheid. This research argues that inclusive innovation policies can positively help redress the legacies of apartheid manifested in poverty and inequality through incorporating marginalised poor people into innovative activities. The study used an evolutionary system of innovation approach as the frame of reference in exploring, reviewing and analysing inclusive innovation policies from developing countries with reference to Brazil, Russia, India, China and South Africa (BRICS), the national development plan (NDP) and science, technology and innovation (STI).

Within mainstream economics, innovation is implicitly considered as primarily relevant to high and middle-income consumers in its production of new products and services that seek to improve the wellbeing of such consumers and boost the productivity of the formal economy. By focusing on the formal economy and economic growth, this notion of mainstream innovation has generally neglected the social and economic development needs of marginalised communities and is now partly associated with the reproduction and reinforcement of systemic inequality (Heeks & Foster, 2014). Problems of this kind prompted a push for new forms of innovation that focus on the excluded informal sector of the economy, while also supporting the formal economy sector.

The historical development and use of the concept of inclusive innovation date from the 1970s with the debates on appropriate technologies. Inclusive innovation as a term was coined in 2007 by Mark Dutz, who used it in a World Bank report on sustainable innovation in India. Dutz defined inclusive innovation as efforts for creating and adsorbing knowledge that is generated for and directed at meeting the needs of the poor (Kaplinsky, 2009; UNDP, 2020). Skills-based technological changes tend to favour those who are well skilled and possess the required knowledge, with some benefiting from patent or innovation rent, while to marginalised people this often means a loss of subsistence jobs and the growth of inequality. In the absence of intervention, technological change can contribute to increasing inequality in job opportunities, as well as economic and innovation activities (OECD, 2017). Greater capital intensity with automation in process innovation tends to replace lower-skilled workers with machines which, if not counter-balanced in new industries, would exacerbate unemployment and poverty (Cozzens & Kaplinsky, 2009). The rapid deployment of artificial intelligence across a wide range of sectors of the economy is also affecting job opportunities at the higher skills end, lending a new dimension to the category of displaced workers.

Innovation

Innovation is conventionally considered to be a key driver for economic development, but the theoretical foundation of this notion is still highly contested given its manifold lines which in turn result in several pitfalls in policy formulation and implementation processes (IERI, 2014). According to Scerri (2009a) and Maharajh (2011), innovation in South Africa has been narrowly interpreted within a version of the national system of innovation which is solely embedded in science and technology (S&T). It is within this perspective that the knowledge generated and produced in formal organisations is given priority and captured (IERI, 2014). The narrow perception of S&T as the exclusive key element driving growth and innovation is fundamentally emanating from mainstream economics. S&T is conventionally considered an essential exogenous factor that drives innovation of value-added products or processes of production which builds the competitive advantage of firms and economies (IERI, 2014).

Innovation strategies in developing countries are now moving beyond supply-side strategies to more demand-led options. These strategies are deployed to understand what low-income communities and excluded groups need and want. Countries differ regarding challenges, resources and needs and as such their policies and development structures will vary

considerably (Foster & Heeks, 2013). When the informal economy is ignored, especially in a developing economy context, e.g South Africa, the innovation capabilities of a country are often grossly underestimated. This is supported by arguments that innovation is implanted in specific social, political and economic relationships and is mostly influenced by the institutional context within which such relationship take place (Cozzens & Kaplinsky, 2009).

National system of innovation (NSI)

According to Scerri (2009b), the concept of a national system of innovation emanates from the work of the evolutionary school of economics. The failure of mainstream neoclassical analysis related to the nature, sources and effects of economic change has resulted in a growing dissatisfaction that has led to the re-emergence of evolutionary economics seeking alternatives as part of a growing body of heterodox ideas about economic dynamics (IERI, 2014:2).

The South African national system of innovation made tremendous progress from 1996–2016 in transforming the STI institutional landscape and in the expansion of scientific publications. Those who were marginalised by apartheid, more specifically black people in general and women in particular, are now meaningfully participating in the research and development workforce and there has been a marked increase in doctoral graduation rates (DST, 2018). However, the South African NSI is not yet fully inclusive and urgently requires a policy reorientation with reference to the role of STI in re-industrialisation, service delivery, modernising the agricultural sector and mitigating environmental challenges. The core themes of a revised STI policy direction are inclusivity, transformation and partnerships to achieve policy coherence on human capital development, knowledge expansion, innovation performance and increased investment (Walwyn and Cloete, 2018).

The vitality of a national system of innovation can only be credited and judged if the knowledge, technologies, products and processes developed and produced by the national system of innovation, science, engineering and technology are dedicated to the improvement of the quality of life for all of society, while contributing to the growth of the national economy (IERI, 2014). The framework used to analyse the inclusive innovation proposed for this research project was the broad version of the national system of innovation approach that was deemed adequate to conceptualise inclusive innovation.

Both narrow and broad perspectives of a national system of innovation are shown in Figure 1.

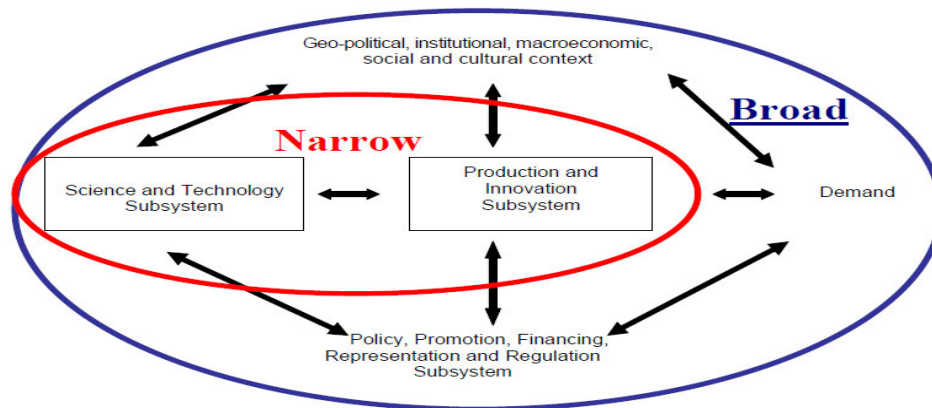


Figure 1: Narrow and broad perspectives of a national system of innovation

Source: IERI (2014)

Tacit and codified knowledge

One of the main characteristics of the knowledge base in marginalised communities, especially those in the informal sector, is that it is primarily tacit. The accumulation of technological capabilities that drives innovation is the outcome of diverse learning processes which lead to the accumulation of tacit and codified knowledge. This accumulated knowledge—tacit and codified—constitutes capabilities which are formed through path-dependent processes that are subject to obsolescence and depreciation. The concept of learning and capabilities in developing countries is vital. Innovation is an outcome of the interaction of complex actors through different institutions and these actors are called individuals, firms and organisations. Learning leads to the accumulation of knowledge which in turn gives rise to the accumulation of capabilities, resulting in innovation that solves local problems (OECD, 2010).

Inclusive innovation

There is no single consensual and universal definition of inclusive innovation, although similar terms have been coined and deployed in diverse contexts, such as pro-poor, grassroots and frugal innovation. These terms are used differently but they all seek to produce or deliver innovation solutions to the societal problems of the poorest, with or without their active participation in such innovation processes and development (Heeks *et al.*, 2013). Empirical evidence suggests that there are innovations that emanate from the informal sector such as

radical, frugal, social and grassroots innovations, some of which are incorporated into the formal STI domain. These types of innovation help to bridge the gap between formal and informal innovation systems. Inclusive innovation can serve as an important mechanism in addressing some of the socio-economic challenges (Daniels, Ustyuzhantseva & Yao, 2017).

According to Foster and Heeks (2013), inclusive innovation is broadly defined as the means through which new goods and services are designed and developed for or by the poor (NACI, 2015). For the purpose of this study, inclusive innovation is broadly defined as the means through which new goods, products and services are developed for and by those who are excluded from participation in the mainstream development and innovation (Mlosy, 2019). Inclusive innovation policies are designed to remove barriers to participating in innovation activities experienced by marginalised individuals, social groups, informal firms, sectors and regions. This is done by ensuring the optimal distribution of opportunities to excluded groups or those operating in the informal economy so that they proactively participate in innovation activities and benefit from them (OECD, 2017). Inclusive innovation is based on the levels that are depicted in Figure 2 and play an integral role in the systematic review of policies whose goal is the inclusion of marginalised groups in the formal economy. The following ladders and levels are discussed briefly.

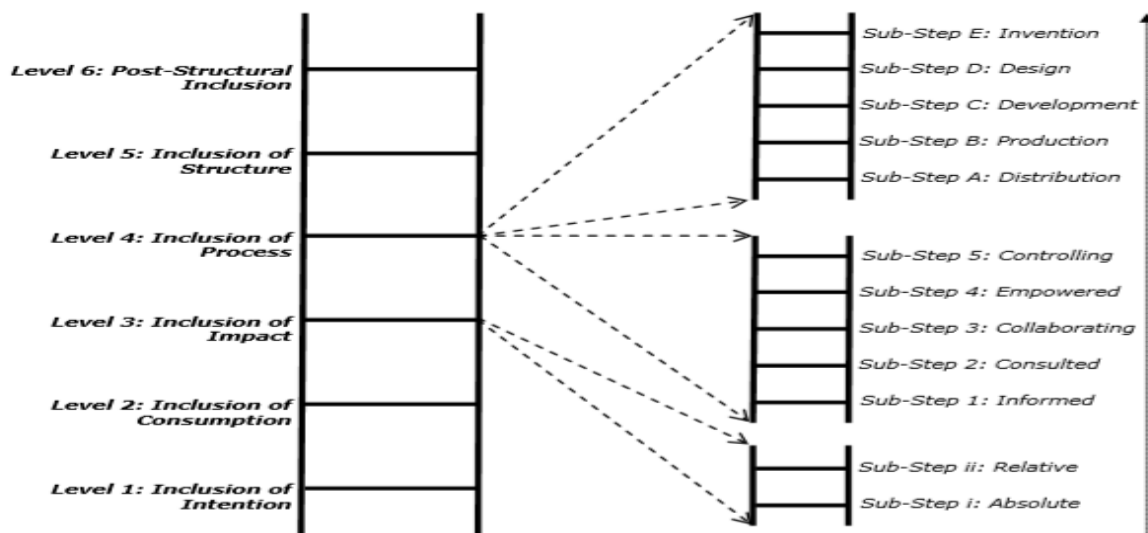


Figure 2: Understanding the levels and ladders of inclusive innovation

Source: Heeks, Amalia, Kintu and Shah (2013)

Level 1/Intention - The intention of innovation is inclusive if it is primarily formulated and deployed to address the needs, wants and problems of the marginalised group.

Level 2/Consumption - An innovation is considered to be inclusive if it has the primary purpose of being adopted and utilised by the marginalised group.

Level 3/Impact - An innovation is inclusive once it has a positive impact on the wellbeing of the marginalised or excluded group.

Level 4/Process - An innovation is inclusive if the marginalised group has the opportunity to participate in the development of such innovation.

Level 5/Structure - An innovation is inclusive if it is formed or developed from an inclusive structure that comprises a marginalised group.

Level 6/Post structure - An innovation is credited to be inclusive if it is developed within the knowledge frame and discourse that purposefully include marginalised sections of the population.

The general application of inclusive innovation is often confusing and may result in a sub-optimal contribution to policy reforms if not dissected to expose its characteristics in the form of the ladder. Innovation needs to be inclusive in at least two ways, which are the process and product sides of innovation. Here the process side refers to the way such innovation is developed while the product side refers to the impact of such an innovation product in relation to solutions it brings to the marginalised (Cozzens & Sutz, 2012).

Research problem

The premise of this research project is that policies founded on the principles of neoliberalism have failed to correctly address socio-economic challenges across the world but especially in developing economies. It is further argued that there is no guarantee that economic growth will result in the reduction of inequality; on the contrary, it often increases inequality (Cozzens & Kaplinsky, 2009).

The interest in innovation systems and innovation in developing countries has typically been focused on large formal enterprises, often shifting the balance of power relations between management and labour. The waves of innovation which are broadly categorised under the Fourth Industrial Revolution have further deepened the class rift and extended exclusion of the marginalised population from innovation processes. In some countries this exclusion is also evident in territorial or spatial planning inequalities (Cozzens & Kaplinsky, 2009). The push

for mainstream innovation has to some extent contributed to the reproduction and deepening of the structural inequalities in developing countries (Heeks, Amalia, Kintu & Shah, 2013).

Even after the wakeup call of the 2008 global economic crisis, innovation and R&D investments are still considered key drivers of economic growth. It is also noted by Kim (2002) that there is a prevailing misconception that economic growth will automatically better the life of everybody, while it has failed to alter the life conditions of the majority of marginalised groups in the informal sector by way of the expected trickle-down effect. The growth rate of the South African economy has been miserable (World Bank, 2012) and, given its persistent duality, a link between the two prevailing economies is needed as innovation in the formal sector rarely addresses the issues of marginalised people in the informal sector (Fioramonti, 2013, 2014).

Gault and Zhang (2010) argue that enabling the informal sector to capitalise on inclusive innovation will offer marginalised people the opportunity to address their socio-economic challenges. This will in turn have a spillover effect on economic growth. Foster and Heeks (2013) further argue that innovation in less developed economies should combine research and development and informal learning activities to allow for locally oriented innovations. Delinking the formal and informal sectors of the South African economy contributed to the disintegration of the country's innovation system. With the strong focus on and heavy investment in the formal economy, the majority of black people that mostly occupy the informal sector continue to experience major inequalities that bars them from becoming key innovation agents within the system of innovation. The partial inclusion of the marginalised lower-income populations to participate or form part of the country's innovation system is the main research problem of this research study. These poor marginalised lower-income people remain excluded from equally participating and benefiting from mainstream innovation model adopted by the developing country such as South Africa.

The main general question addressed in this study concerns the role of inclusive innovation in the development of the South Africa national system of innovation. The other issues which are implied in this general question concern the implications of poverty and inequality for the evolution of national systems of innovation. The various interpretations of inclusive innovation and innovation for inclusive development are also explored. The second main thrust of this

study is an examination of policy in this area in South Africa, and its effectiveness in addressing poverty and inequality in the post-apartheid era.

Significance of the study

The significance of this study is that it calls for the inclusion of the informal sector of the economy in the planning and implementation of innovation policy as innovation actor. It also contributes to the limited research on inclusive innovation and how it enriches, or adds insights drawn from the South African perspective. This paper highlights that inclusive innovation and innovation for inclusive development can play a significant role in curbing socio-economic ills like inequality, poverty and unemployment that serve as barriers to development. Within the context of South Africa, this study helps to highlight key elements that are considered to have an impact towards the preservation of the exclusionary elements of the country's system of innovation. It also recommends better approach to developing an inclusive innovation system that aims to accommodate marginalised lower income earners at the centre of innovation planning and processes.

Research methodology

This research made use of qualitative research methodology, with methods such as systematic review, exploration and analysis of secondary data, literature, statistics, case studies and other official documentation to gather data.

Chapters outline

This research study is structured into five(5) chapters which are briefly detailed below.

Chapter 1 is the introductory chapter of this research study. It provides the historical background of the South African NSI. This chapter details the South African state of economic transformation and main research problems that initiated this study. It discusses inclusive innovation as an alternative relevant framework to include marginalised lower-income people in innovation processes. It also explores in detail how inclusive innovation can contribute to the evolution of the country's innovation system to become more inclusive. It is mainly focused on providing a succinct overview of the research problem and questions that led to this research study. It details all the steps and processes followed and sources consulted during the research study and how they helped shape the conclusions drawn from this research study.

Chapter 2 offers a broader coverage of the literature review and entails the historical background of key terms such as innovation and innovation systems and how the concept of the national system of innovation is mostly used as a policy framework in national development planning. The narrow and broad conceptual perspectives of the NSI are further explored and the rationale behind the adoption of broader perspectives of the NSI as a relevant model suitable for this study is set out. It covers the terminology and definitions which include inclusive innovation and other related concepts. Several inclusive innovation ladders and steps are explored and how these steps fit the main research goal and aims of the research study. The chapter also addresses the pitfalls and constraints of inclusive innovation systems, including the different processes and stakeholders present in an innovation system.

Chapter 3 is an overview of the South African national system of innovation. It provides a historical perspective of the South African national system of innovation, its co-evolution with inequality and its role in promoting inclusive innovation. It tracks the historical transitional movements of the country's political economy and their impact on the national system of innovation. The period covered by this chapter ranges from the early 20th century with the formation of the Union of South Africa in 1910 to the collapse of apartheid in 1994. This chapter offers a brief conceptual elaboration of the national system of innovation, followed by the formation of the Union of South Africa.

This chapter also focuses on the macro-economic effects on the country's system of innovation and the impact of apartheid on innovation systems and innovation dynamics. The isolation consequences of apartheid are discussed. Later the chapter covers the apartheid education system and its implications for the evolution of the country's system of innovation. This chapter also provides a brief description of the country's system of innovation, inclusiveness and the spatial planning of apartheid which involve the modes and model of innovation and the viability of the system of innovation. The last part of the chapter discusses the post-colonial and apartheid human capital development impact, social capital and innovation.

Chapter 4 is an overview of the South African national system of innovation in the post-apartheid era commencing in the year 1994. The formulation, publication and adoption of the 1996 White Paper on Science and Technology in South Africa was a remarkable step undertaken by the South African government in transforming the country's national system of innovation (NSI). This research chapter focuses on key policies adopted by South Africa,

beginning with the 1996 White Paper on Science and Technology, together with subsequent white papers on science, technology and innovation, other strategic policies and theoretical frameworks. These reviews and discussions cover some strategic policies that are premised on neoliberal macroeconomic policies and some form of evolutionary school of economics.

Chapter 5 as the last chapter of this study provides a historical overview of the South African economy. This covers in detail the research analysis, findings, concluding remarks and recommendations related to the South African economy, its competitive nature and its national system of innovation. These findings answer the main research question of the viability of the country's national system of innovation and how inclusive it is.

CHAPTER 2: LITERATURE REVIEW

Introduction

The world we live in is characterised by many challenges such as unbalanced, inadequate, uneven development and demands for a better life. The majority of the people feel left behind in terms of development and innovation while some feel less important than others with regard to the accessibility of opportunities to reach their full potential (Cele, Luescher & Fadiji, 2020). The benefits and gains accrued from the economic growth have over the past been unevenly distributed. Many countries and more specifically developing countries such as South Africa, are even today still confronted with a substantial level of social, economic and environmental inequality (Kaplinsky, 2018). The adoption of existing innovations has enabled many developing countries or economies to leapfrog into more effective techno-productive standards, leading to substantial improvements in productivity.

However, it must be acknowledged that science, technology and innovation (STI) have worsened inequalities and also created new types of social divides and environmental hazards and expanded the gaps between those excluded and those that benefit (ESCAP, 2021). South Africa is not an isolated country; it has persistent socio-economic challenges and inequalities that the majority of the excluded groups continue to experience due to the adopted mainstream political-economic system model. This has led to the production and reproduction of inequalities and the continued rise of unemployment for the excluded groups in South Africa (Phiri, Molotja, Makelane, Kupamupindi & Ndinda, 2015).

It is widely recognised that innovation is an important driver of economic growth, although it has in some instances been labelled as a contributor to economic and social inequalities. This is however subject to the innovation model and approach that the country adopts. These negative effects are mostly visible in developing countries where the outcomes and benefits of innovation approaches adopted are unevenly shared among the rich and poor (Schillo & Robinson, 2017). South African socioeconomic challenges and inequalities are also (though not entirely) caused by the adopted innovation model that is solely based on research and development (R&D), science, technology and innovation (STI). This narrow model of innovation mostly addresses problems of the formal economy, while the informal sector is left out. In the absence of public and social policies to alter the co-evolution between innovation

and inequality, this capitalist innovation model will almost inevitably negatively impact the country's innovation, capabilities and distribution (Phiri *et al.*, 2015).

Innovation is generally a socially constructed concept with contradictory outcomes, particularly when it comes to the poor communities. Joseph Schumpeter characterised the surges of rapid innovation and technological change as ushering in a period of creative destruction that has the potential of sweeping out all the inefficient and old methods of production and replacing them with superior new methods of production. The argument that technological gain outweighs the losses is based on these perspectives. It should be noted that the negative side effects associated with the theory of creative destruction of innovation on those in the lower-income environment are immense (Kaplinsky, 2018). This extends to the people that will be forced out of their work by new effective technologies that may replace labour in the production processes, thus hampering people's socio-economic status (Schillo & Robinson, 2017).

There has been some interest globally in seeking for innovation models that will promote inclusiveness and equality through providing excluded groups the opportunity to benefit from innovation (Schillo & Robinson, 2017). The move is supported by the need to align prominent new technologies emanating from R&D, from learning and from the adaptation of existing technologies to societal needs and those of the market (Phiri *et al.*, 2015). In the context of increasing inequality and major pandemics (like Covid-19), it becomes all the more important to align STI with sustainable development goals and to ensure that no one is left behind. This requires a radical shift from pursuing new technologies and innovations to expanding the existing ones (ESCAP, 2021).

In response to the above-mentioned problems, inclusive innovation has been conceptualised to provide framework guidelines to measure and reduce innovation inequalities (Schillo & Robinson, 2017). By applying the inclusive lens to the formulation of STI policies, policymakers will be able to identify instruments that can maximise the societal impact of the policy (ESCAP, 2021). Inclusive innovation is proposed in this research study to be a relevant alternative innovation model that is suitable to address developmental challenges. Research data support the argument that inclusive innovation is key mechanism in addressing socio-economic and environmental challenges and innovation inequalities (Daniels, Ustyuzhantseva & Yao, 2017).

The primary purpose of this study is to explain inclusive innovation approaches and how they could contribute to the development of inclusive innovation systems in South Africa. This exploration is done first by broadly defining the concepts of innovation, inclusive innovation and system of innovation, which include the narrow and broad perspectives. Secondly, there is a brief history of the South African pre-post 1994 national system of innovation. Thirdly inclusive innovation is defined, its theoretical framework is explained and the reasons behind the push for inclusive innovation, its inclusivity terms and the dimensions of inclusive innovation are given. Fourthly its analytical framework is explored by looking into institutions and regulations, network and interactions, innovation actors, knowledge and learning and human capabilities building. Fifthly the constraints, pitfalls and challenges of implementing inclusive innovation are identified before the paper is concluded.

Innovation

It is important to first distinguish between invention and innovation. The invention is defined as the generation of an idea for a new product or process. Innovation is broadly considered the commercialisation of the idea that has been invented (Fagerberg, 2004). Innovation can be either incremental or radical. Incremental innovation refers to a cumulative process that gradually makes use of pre-existing possibilities and components in terms of the principles of path dependence. This innovation in simple terms entails imitations or modifications of pre-existing innovations. Radical process refers to revolutionary breaks from past innovations that discard the obsolete ones (Manzini, 2012). It seems to be inherent in humans to think about new and better ways of doing things and put them into practice. This innate human trait of curiosity to innovate may manifest in informal firms or formal firms. Without innovation, the world would look very different; e.g., it would be without computers, aeroplanes or automobiles, to mention just a few important innovations (Fagerberg, 2004).

Innovation is not only of great importance in industrialised countries but also matters to developing countries (Altenburg, 2008). As countries vary in their needs, challenges and resources, their policies and development frameworks will necessarily differ considerably (Maharajh & Kraemer-Mbula, 2010). Developing countries are characterised by low incomes which result from their low average productivity. They have limited capacity to develop new technologies or adapt, improve and diffuse existing technologies (Altenburg, 2008). The

dominant models of innovation globally tend to address the needs of the minority rich groups while leaving the excluded groups with nothing or with unfair benefits (Cele, Luescher & Fadji, 2020). The excluded groups are people who are trapped in conditions of inequality and poverty and are deprived of a dignified life, among other unfavourable conditions; they are the disfranchised members of the society, the low-income groups of developing countries, the marginalised groups, women, young people, disabled people, ethnic minorities, inequality affected people, below of pyramid (BOP) and needy (Castañeda, 2019; Manzini, 2012). These groups are the main target of innovation proposed by this paper.

There is no universal concise and clear definition of innovation. The following definitions are considered suitable and relevant to the purpose of this study:

Innovation is a process of change, where new or modified knowledge, expertise, social configurations or technologies are used and applied to address various societal challenges (Opola, Klerkx, Leeuwis & Kilelu, 2021).

Innovation comprises the activities and processes associated with the generation, distribution and use of new knowledge, which can be technological, organisational and institutional. It is stimulated by learning that emerges from relevant networks of actors working together based on a mutually agreed institutional arrangement (Swaans, Boogaard, Bendapudi, Taye, Hendrickx & Klerkx, 2014).

System of innovation

The system of innovation since its inception in 1980 has been utilised globally in analysing innovation processes such as development, acquisition, use and diffusion while also serving as a guiding tool for drafting innovation policies (Cassiolato, Zucoloto, Abrol & Xielin, 2014). Several authors argue that the innovation system is an analytical framework suitable for studying the impact of innovation on socio-economic inequalities (Castañeda, 2019) and a relevant framework for conceptualising inclusive innovation (Foster & Heeks, 2013). It is through continuous adaptation that an innovation system can help reduce inequality and poverty while at the same time addressing issues of inclusion. This implies that there should be a shift from a traditional innovation system or trajectory to an inclusive innovation system (Castañeda, 2019).

There is no contestation regarding the origin of the term or concept NSI. However, there is a conundrum regarding the individual who first coined the term. Christopher Freeman and Bengt-Ake Lundvall credit each other as the originator of the concept. After careful analysis, it appeared that Freeman was the first to use the term in an unpublished paper that was prepared and intended for the OECD expert group on science and technology. The purpose was to emphasise the government's role in developing a country's technological infrastructure. It is said that at a later stage Bengt-Ake Lundvall published his book using the term NSI in referring to the interdependence between technical and institutional change (Manzini, 2012).

The conventional innovation system approach may be officially adopted by either developed or developing countries; the advantages of this approach have never been fully achieved and to some extent it has failed to benefit the lower-income regions or societies (Intarakumnerd & Chaminade, 2011). The collective accumulation of the world's scientific knowledge, technological capabilities and innovation competence has contributed to and advanced the wellbeing of billions of people. However, this progress has not been fairly distributed or achieved without negative impact in the form of inequality, insecurity, environmental degeneration and the unfair spread of infrastructure and technical know-how (Maharajh & Kraemer-Mbula, 2010). IS was primarily developed to serve the developed countries (Manzini, 2012).

In developing countries, its application may not yield the desired outcomes if applied in a similar fashion to the North. It is within this context that it is considered an ex-post concept in its application to the South compared to the ex-ante concept of the North (Johnson, Edquist & Lundvall, 2004). The standard contents and features of this conceptual framework need to be modified to provide for inclusive innovation in developing countries. Successfully addressing inclusive innovation requires modification of the product or service nature, the stakeholders or innovation actors, their interrelation and collaboration, the learning type that they undertake and the institutional framework environment within which these actors operate (Foster & Heeks, 2013).

The system of innovation is thus defined as the means through which a country seeks to develop, acquire, diffuse and put into practice new knowledge which will help its citizens to

achieve collective goals, the fulfilment of which will also extend to individuals (Manzini, 2012).

An innovation system is defined as a group or system of diverse institutions or organisations that together contribute to the development of the innovation and learning capacity of a country, region, locality and economic sector. This system entails a series of elements and relations that are associated with the production, assimilation, use and diffusion of knowledge generated by the system (Cassiolato *et al.*, 2014).

An innovation system is defined as the ensemble of innovation actors who are directly and indirectly engaged in the innovation process. The reason behind this is that it cannot be viewed as an individual actor of innovation (firm). In reality, innovation emerges from the interrelationship between different actors in the innovation system (Chataway, Hanlin & Kaplinsky, 2014).

The approach to a national system of innovation adopted by Freeman and Lundvall aims at comprehending the innovation system in a broader sense. It covers broad innovation activities that focus not only on science and R&D but also on its interactive learning, ongoing activities in procurement, production and sales (Manzini, 2012). It further moves away from individuals and the isolation of unities within the economy towards the collective support and structure of innovation. This approach addresses the entire system that creates and diffuses knowledge, rather than the neoclassical approach that considers its narrow components. It is within this approach that innovation is seen as the outcome of evolutionary processes that take place within the system of innovation (Intarakumnerd & Chaminade, 2011). This broader perspective of the innovation system is the one proposed for this study.

There is limited information on how developing countries adopt a system of innovation approach in designing, adopting and implementing science, technology and innovation policies (Intarakumnerd & Chaminade, 2011). The concept has traditionally focused on identifiable locations, large formal institutions and organisations on the supply side, working on formalised and other technical research and development which are also embedded in the supply side. In developing countries there is great interest in non-traditional, demand-side innovations and informal sector workers who are engaging in incremental innovation to adopt and imitate new technologies to fit their societal and economic needs (Foster & Heeks, 2013).

Broad and narrow approaches of the NSI

The narrow and linear model of innovation that is mostly based on research and development is a model of separation between the processes, production and diffusion of innovation. Regardless of the dominancy of this approach and its resilience, this model has been criticised because it has little bearing on the realities of innovation. It should be noted that processes of innovation such as production, distribution or diffusion and implementation are not isolated. They all entail continuous innovation and feedback (Foster & Heeks, 2013). This innovation model tends to focus on research and development and science, technology and innovation (Johnson, Edquist & Lundvall, 2004). It is further based on the tradition of having a few key experts mostly coming from research and development that are main innovation agents or actors (Andersen & Andersen, 2016). It may have assumptions that all novel (new) technologies and other sets of innovation are beneficial and progressive.

This is contrary to the broader focus of the system of innovation which includes a discussion of desirability, costs, benefits and direction of innovation. It is the latter model that provides the majority of the marginalised, remote and bottom-of-the-economic-pyramid people a chance to participate in addressing their societal needs (Andersen & Andersen, 2016). This focus on the systematic relationships between research and development efforts in firms, S&T firms or organisation like universities, non-governmental organisation (NGOs) and the government (Johnson, Edquist & Lundvall, 2004) includes financing organisations and other actors and their elements that influence innovation processes. It considers the historical process which accounts for a variety of socio-economic capabilities and development models and institutions' evolutions. This makes IS context-specific, with local dynamics and features (Cassiolato, Zucoloto, Abrol & Liu, 2020).

The broader perspective of the NSI is considered the relevant innovation approach, according to Freeman and Lundvall; it incorporates different, connecting subsystems that are impacted by diverse contexts – political, institutional, macroeconomic, social, cultural, etc. It entails, firstly, the production and innovation subsystem which examines the structure of the economic activities, their sector diffusion, level and quality of employment, type and quality innovative effort, spatial diffusion and size of diffusion. Secondly, it entails a subsystem of science and technology that covers education from basic to postgraduate, research, training and other

scientific and technological infrastructure such as consulting and information. Thirdly, it covers policies, promotions, financing and representation and their institutional subsystems that contain different forms of public and private policies that indirectly or directly promote innovation. Finally, the demand is often absent from the mainstream innovation model. These dimensions further include the traits of income distribution, consumption structures, social cohesion and organisations, social demand such as basic infrastructure, health and education (Cassiolato *et al.*, 2020).

Pre- and post-1994 NSI history

The South African national system of innovation has its foundations and genesis in the search to comprehend and exploit the natural environment. Knowledge was first generated by the first peoples and later added to by numbers of invaders, colonists and settlers (Kahn, 2006). It was after the end of the Napoleonic wars in 1815 that South Africa saw the establishment of the first scientific institute in the Cape to produce Jenner's smallpox vaccine. The Royal Observatory was established in 1820, the South African Museum in 1823 and the South African College in 1829.

The discovery of diamonds in Kimberley in 1870 birthed the Cape College of Mining which became the University of the Witwatersrand after the discovery of Gold in 1886. Several institutions of the system of innovation grew around industries, health and the social problems of mining. During the closing years of the Second World War science and technology gained popularity because of their contribution to industrial performance. This led to the establishment of the Council for Scientific and Industrial Research in 1945 and the SA Bureau of Standards the same year. It was after the National Party (NP) had come to power that the Council for Scientific and Industrial Research (CSIR) saw its mandate expanded to include defence research along with SASOL, the Armaments Corporation of South Africa (ARMSCOR) and the Nuclear Energy Council SA (Kahn, 2006).

In May 1994 for the first time in the history of South Africa a democratic government took over the reins of the middle-income economy. The economy limped with inequalities and some distortions of apartheid. It was at this time that the government had to both modernise the state and accelerate globalisation (Kahn, 2006). South Africa for the first time through the adoption of the 1996 White Paper on Science and Technology introduced the concept of the NSI into formal public policy discourse (Manzini, 2012). However, policies adopted since 1994

continue to produce and reproduce social and economic inequalities which harm inclusive innovation, development and innovation in the informal sector. Some of these policies have been geared towards strengthening mainstream innovation with its capital-intensive and top-down approach, contributing to the persistence of social and economic inequality (Phiri *et al.*, 2015).

South Africa is considered to be a research-intensive developing economy even though it still lags behind the developed countries concerning research and innovation. Conversely, South Africa is way ahead of other developing countries. It is further noted that the NSI of South Africa is well established (Cassiolato *et al.*, 2020) and that post-apartheid South Africa is a development puzzle. This is because South Africa is considered one of Africa's largest economies with its world-class infrastructure in finance, health, transport, telecommunication, information and communication technology (ICT), banking and other knowledge production institutions that compete globally. Yet its production capabilities and output are still considered extremely small even when compared to other BRICS countries (Phiri, Makelane, Molotja & Kupamupindi, 2013).

South Africa is operating in a racially separated environment where skills, educational opportunities and other social capital are unfairly distributed and this has undermined inclusive innovation activities and the creation of a competitive society. It is further argued that South Africa's NSI needs to be able to diffuse the knowledge of its interactions and linkages of production of new knowledge that are positioned to adequately address the pressing challenges of the day. It is said that the state has failed to incorporate the majority population into formal, skill-intensive sectors of the economy (Phiri *et al.*, 2015). The South African government should strive to lead both in innovation and R&D activities which should also include non-R&D activities that incorporate the informal sector innovation activities. The government should create a space where broadband accessibility is increased to foster grassroots or inclusive innovation (Phiri *et al.*, 2013).

Inclusive innovation

While there is no universal definition of inclusive innovation, it is argued that instead of adopting the global mainstream theory of innovation it is important to allow different ways of enacting inclusive innovation (Opola *et al.*, 2021). Inclusive innovation is founded on the

principles of evolutionary economics which entail the social group orientation approach. Various concepts proposed resemble inclusive innovation approaches, such as pro-poor innovation, below-the-radar innovation, bottom-of-pyramid innovation, grassroots innovation and the Jugaad or frugal innovation (Schroeder, Dalton-Brown, Schrempf & Kaplan, 2016). While all these terms may be defined differently, their common purpose is to advance the production and diffusion of inclusive products or services that are capable of solving the social problems of those excluded groups. There are several definitions of inclusive innovation which are considered relevant to this paper:

Inclusive innovation is defined as how new goods and services are designed and developed for and by the poor people or those with the lowest incomes (Schroeder *et al.*, 2016).

Inclusive innovation is also defined as the means through which new goods, products and services are crafted and developed for and/or by the marginalised populations. It explicitly conceives development through the active inclusion of groups outside mainstream development. This further refers to the inclusion of such populations in some aspects of innovation (Peerally, De Fuentes & Figueiredo, 2019).

Inclusive innovation in short is how new products, goods and services are built or developed for and/or by those that have been marginalised and excluded from mainstream development. This specifically refers to the billions of people living on the lowest incomes (Heeks, Amalia, Kintu & Shah, 2013).

Inclusive innovation regards development in the context of marginalised individuals (Alonso, Kok, O'Brien & O'Shea, 2020). It acknowledges that marginalised communities continue to experience additional burdens that hinder them from reaping the benefits of innovation (Alonso *et al.*, 2020). Inclusive innovation policies seek to develop goods and services for and with those who have been historically excluded from mainstream development and its innovation model. Inclusive innovation approaches are considered a response to traditional innovation systems approaches which do not adequately consider the inclusivity of the poor in the processes of innovation (Swaans *et al.*, 2014). This may be considered a good alternative model of innovation that South Africa should embrace and promote to curb the continuing socio-economic challenges and inequalities that the country experiences. However, inclusive innovation should be adopted to not only target the historically excluded but also those who

may be excluded or affected negatively by future models of innovation, e.g., the Fourth Industrial Revolution.

There are three proposed objectives of inclusive innovation policies (Cele, Luescher & Fadji, 2020), which are:

Industrial inclusiveness - This targets less innovative firms through strengthening their innovative capacities and building an adequate business environment for innovation.

Territorial inclusiveness - This targets those regions which lag behind and are less innovative through narrowing innovation performance gaps with leading regions.

Social inclusiveness - This seeks broader participation of excluded groups or communities. The uneven distribution of innovation capacities will have a severe impact on the social wellbeing of the disadvantaged sectors of a society and it is the primary target of this objective of social inclusiveness to reduce the impact. In this study, the social inclusiveness objective is considered a major focus.

Theoretical framework of inclusive innovation

Inclusive innovation stems from the ideas of E.F. Schumacher and the concept of appropriate technologies as an alternative to the traditional innovation model. It has the purpose of developing and delivering innovative technologies (goods and services) that are socially or locally aligned to the needs and interests of those excluded from the traditional innovation model. Inclusive innovation is a conceptual term originating from the work of Dutz and Dahlman (2007) which has been gaining interest for many years in academia (Heeks *et al.*, 2013). Inclusive innovation is a multi-dimensional concept that entails many variables whose causal relations are arguably too blurry and vague to serve theoretical purposes (Alonso *et al.*, 2020).

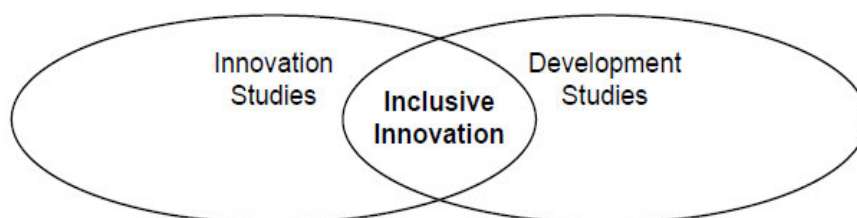


Figure 3: The disciplinary foundation of the concept inclusive innovation

Source: Heeks *et al.* (2013)

It is clearly stated that inclusive innovation has no specific demographic domain. It is now considered relevant to all parts of the world. Most academic literature on inclusive innovation is precisely focused on developing countries. This innovation model should be understood as a cross-border product of the disciplines of innovation studies and development studies as depicted above (Heeks *et al.*, 2013).

Why inclusive innovation?

There is evidence from the literature that a gap exists in terms of advancing our knowledge of innovation as the matrix for inclusive innovation and development. Inclusive innovation takes a different perspective of development than the traditional forms of innovation model. The traditional innovation approach views development as generalised economic growth, while inclusive innovation explicitly considers development in terms of the active inclusion of those outside the mainstream model of development and innovation (here referred as the previously marginalised lower income groups). It simply refers to the inclusion of marginalised groups within some aspect of innovation activities (Heeks *et al.*, 2013). Inclusive innovation has the potential of orchestrating socially responsible endeavours. This means it has the capability of addressing social and economic exclusion (Schillo & Robinson, 2017).

Today there is an increase in policy, practice and academic popularity and interest in inclusive innovation (Heeks *et al.*, 2013). It is argued that the marginalised people in South Africa hardly participate in the innovation processes and debates. There are indications that innovative activities in developing countries mostly occur in areas where R&D is not a major driver of innovative outcomes (Phiri *et al.*, 2015). The current dominant trajectory of innovation is in some instances a key contributor to economic growth that co-exists with inequality and poverty. Its capital-intensive nature, scale intensity, reliance on highly skilled labour and supply-side products and services and dependence on high-quality networked infrastructure are the reason for seeking alternative models of innovation (Chataway, Hanlin & Kaplinsky, 2014).

Inequality is more visible in developing countries than developed countries (Cele, Luescher & Fadji, 2020). As innovation is likely to suffer from market inequalities and failures as such the government should play a key role in overcoming these market failures and strengthening competitive advantage. It should promote the dissemination of information, support grassroots innovators, create specific incentives for researchers to provide knowledge inputs to excluded groups and set up funds to acquire rights to pro-poor technologies (Altenburg, 2008).

Inclusive innovation offers some prospect of facilitating sustainable and equitable economic growth. It has three major characteristics: firstly, the production of innovative products or services that are appropriate to addressing the needs and income disparities of the marginalised population; secondly, providing access and opportunities for the marginalised population to participate in the innovation process itself; and thirdly, offering platforms for the involvement of marginalised people and communities in the processes of production and innovation (Kaplinsky, 2018). The inclusive innovation approach is used by countries to eliminate the disparities that exist between the rich and the poor. It is an adequate response to the increasing realisation globally that the traditional innovation model has resulted in the social exclusion of lower-income communities (Levidow & Papaioannou, 2018).

This approach has so far improved the consumption of innovation products by lower-income earners while also opening up innovation opportunities for them to actively participate as innovation actors. Knowledge from innovation studies and development indicates that inclusive innovation policies can positively facilitate and expedite open access to resources by those historically marginalised people. This will further result into reduction of poverty and inequalities that are faced by these marginalised groups. This is because when innovation opportunities are openly shared among all actors in a society without any attachment to race, nationality, gender or economic status, the society at large will likely benefit. This is likely to improve the standard living of the society. Inclusive innovation policies are most impactful if the benefits and risks of innovation are shared equally and the outcome is sustainable societal health and wellbeing (Cele, Luescher & Fadiji, 2020). Inclusive innovation is a concept crafted to be people-centric; in most cases, these people are in a dire situation and experience inequality (Phiri *et al.*, 2013).

How inclusive should innovation be?

According to Schroeder, Dalton-Brown, Schrempp & Kaplan (2016), the inclusive part of inclusive innovation is perceived to encompass the following:

- The poor are provided with a platform to engage in the definition of their problems to ensure that innovation is relevant to addressing them.
- The poor are actively involved in the development and application of innovative solutions to their problems.

- The poor are fully engaged in the adoption, assimilation and diffusion of innovative solutions to their local problems.
- The poor are part of the innovation impact, to ensure that the output of such innovation maximises the consumption and incomes of the poor.

To answer the question of how innovation should be inclusive, the following ladders and levels of inclusive innovation are proposed as they are a holistic representation of an inclusive innovation approach.

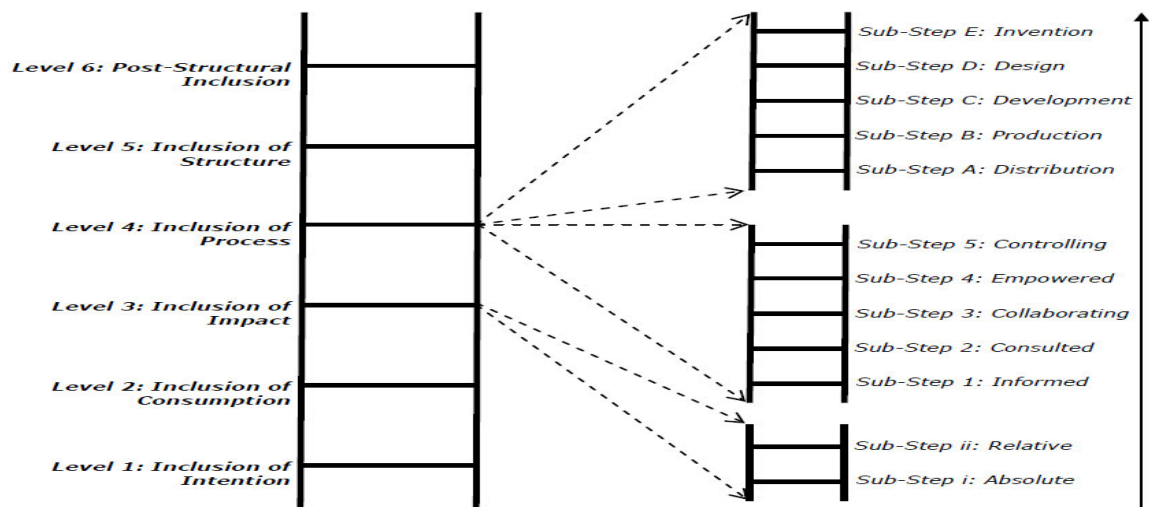


Figure 4: Understanding different levels of inclusive innovation

Source: Heeks *et al.* (2013)

Level 1/Intention - Here innovation is inclusive when it is capable of addressing the needs and wants or context problems of the marginalised or excluded group.

Level 2/Consumption - Innovation is inclusive if it is capable of being purchased, adopted and used by the excluded groups.

Level 3/Impact - Innovation is inclusive when it has an impact on the welfare of marginalised people or groups. The impact may differ from domain to domain, e.g., resulting in greater productivity or greater welfare. While some define impact in terms of wellbeing or access to livelihoods, others consider impact in terms of conditions that benefit excluded groups.

Level 4/Process - Innovation is inclusive if it integrates excluded groups into the development of innovation. It may be difficult to involve anyone but its focus should be to ensure that the excluded groups are offered opportunities to actively participate in innovation processes such as invention, design, development, production and distribution. Some researchers may include

subsets such as being informed, being consulted, being collaborated with, being empowered and being in control.

Level 5/Structure - Here innovation is considered to be inclusive if the structure established to push for such innovation is itself inclusive. At times the inclusive process may be temporary, while deep inclusion will cover the traditional institutions, organisations and relations that build innovation systems that are inclusive. This may require significant structural reforms of existing innovation systems or the creation of alternative innovation systems.

Level 6/Post structure - Innovation is inclusive if it is developed and created within a frame of knowledge and discourse or debate that itself is inclusive. It is only if the marginalised groups are included within the knowledge frame of innovation that such innovation can be called inclusive.

It is important to note that inclusive innovation would require one or more of the above levels and steps for its inclusiveness to be recognised. It would also require one or more of the below four aspects of inclusivity to pass the scrutiny of inclusive judgement that is mostly absent in the mainstream innovation model. This requires a micro-level lens and entails the wellbeing of the excluded groups. This may be different or contrary to the macro-level (national, regional, sectoral) analysis that is commonly found and used as mainstream approaches to innovation. According to Foster and Heeks (2013), four aspects of inclusivity are pivotal to successfully position and attain inclusive innovation. These entail the following:

1. **Inclusivity of innovation forerunner (predecessor)** - Here it refers to the problems of the people which should form the basis of innovation and which are relevant to the poor population.
2. **Inclusivity of innovation processes** - This refers to the inclusion of excluded groups in the development of innovation goods, products and services which they consume or later trade.
3. **Inclusivity in innovation adoption** - The excluded groups as consumers and innovators should possess or be equipped with relevant capabilities to also imitate or absorb innovations to fit their societal and economic needs.
4. **Inclusivity of innovation impacts** - Innovation products, goods and services that are output should be of benefit to the wellbeing of the poor.

Dimensions of inclusive innovation

Inclusive innovation is not simply about selling innovative products to socially excluded groups or perhaps integrating a small percentage of excluded individuals within innovation structures and processes. To see the impact of inclusive innovation it is important to develop the innovative capacity of the excluded groups. Complementing the existing innovation systems with additional BOP programmes will also not solve, or yield any measure that can curb, inequality and socio-economic challenges (Schillo & Robinson, 2017). Those who participate in processes of STI policy formulation play a key role in directing who will benefit from the outcomes of such innovation policy and who may not. Inclusive innovation policy provides a platform for inviting stakeholders from different sectors to participate in all stages of policy formulation either through facilitation, discussions, national consultations or training webinars (ESCAP, 2021). Inclusive innovation offers a plausible (mixed) scenario for increased social, economic and environmental sustainability on a global scale (Schillo & Robinson, 2017).

The dimension of inclusive innovation is examined by focusing on four questions. Firstly, who are the people or groups that need to be included in inclusive innovation activities? Secondly, what type(s) of innovation activities do the excluded groups need to be included in? Thirdly, what is the broad range of outcomes and benefits they should get? And lastly, what are the governance mechanisms of innovation? (Schillo & Robinson, 2017).

Who?

The question of who should be included in inclusive innovation activities or processes has to be addressed in two parts – which groups of people should be included and how should they be included. People who should be included are the excluded groups with a more specific focus on poor populations which in developing countries are commonly referred to as the bottom of the pyramid (BOP). BOP is defined by an income in United States dollar (USD) of \$1.235 per day (Schillo & Robinson, 2017). For those excluded groups and low-income communities, scientific progress and emerging technologies are meaningless unless they are affordable and applicable to their context. In most cases, mainstream businesses or markets do not develop in the interests of addressing societal problems. They generally offer products and services that do not meet the needs of the poor due to low purchasing power, inadequate basic infrastructure and other challenges (ESCAP, 2021).

Inclusive innovation should not focus on the social exclusion of the historically marginalised people only, because this may ignore other groups that will be affected by the arising societal, technological and broader innovation trends. Its policies should be both anticipatory and historically based to ensure that not only the historically excluded groups are considered but also those groups that may experience pressure due to the negative impact of innovation (Schillo & Robinson, 2017). For instance, artificial intelligence (AI) models are likely to affect some jobs, which may result in the exclusion of the people employed in those jobs. Inclusive innovation considers marginalised people as key stakeholders that should also be given the opportunity to participate in innovation activities. This could be in and outside fields of formal, academic or industrial scientific research. It provides platforms for the provision of tools, resources and other training that will benefit diverse excluded groups. With fair access to innovation activities, the excluded groups will be empowered to use and develop technologies to their benefit and address their societal problems (Schillo & Robinson, 2017).

How?

How these groups should be included is covered in the six inclusive innovation levels that are explicated above, the first of which entails the intention to address the needs, wants or problems of the excluded group. The second level is consumption which deals with excluded groups as users of innovation and this implies that the group can access and afford the innovation products or services and that it has the motivation to adopt them. The third level is about inclusive innovation having an impact on the focus group. This may entail economic perspectives, wellbeing, capability increase, etc. On level 4 is the process that sees the inclusion of the excluded groups in the development of innovative products or services; its sub-levels constitute being informed, being consulted, collaborating, being empowered and controlling the development of innovation. On level 5 is the structure that goes beyond individual innovations and focuses on the inclusiveness of institutions, organisations and relations that build up innovation systems. Lastly, on level 6, is the post structure which acknowledges that innovation occurs within the frame of knowledge and discourse that serves as the foundation of power distributions of societal outcomes (Schillo & Robinson, 2017).

What?

The past and current academic and policy conversations on inclusive innovation mainly concern science and technology-based innovations and their commercialisation. This may be exemplified by grants to researchers from disadvantaged groups, some popularisation of

science and technology and the provision of microcredit to entrepreneurs (Schillo & Robinson, 2017). Activities such as the combination of technological innovation, organisational innovation, social innovation, financial innovation and institutional innovation would be useful to better position the relevant frameworks within the current promotion of innovation (Schillo & Robinson, 2017). The concentration of innovation capabilities in specific geographical areas supports the economic growth and social development of such areas. The proximity of enterprises, communities, markets and research institutions with different forms of expertise and knowledge leads to considerable gains in scale and scope that come from the collective effort. It should be noted that those on the periphery will lose opportunities to access such important public services and employment opportunities in innovation. Inclusive innovation policies constitute a countermeasure, giving innovators access to knowledge, services and funding from outside the capital and major cities (ESCAP, 2021). Inclusive innovation activities cover not only formal but also informal innovation activities and some form of informal skills training which will help to create innovative spaces for those marginalised lower-income people. It is within these scenarios that a broader innovation model is superior to a narrow model of innovation systems.

Why?

If the markets are the sole drivers of innovation direction, these may neglect or even compromise the broader societal needs. At times when such inclusive technologies are created solely by the market, they may not flourish and diffuse properly to the entire society due to a lack of adequate support from the public sector or society at large (ESCAP, 2021). Innovation focusing only on economic growth is narrowly defined. An inclusive innovation model should have policies for health, economic, social and environmental outcomes and also contribute to solving cross-cutting societal challenges. It is now known that capturing such outcomes is difficult and to some extent only positive outcomes are captured while the negative outcomes are not integrated into analysis and decision making. The quality improvement of outcomes of inclusiveness is important and so are the broader abilities to achieve greater equality in the distribution of such innovation outcomes (Schillo & Robinson, 2017).

Which governance?

Inclusive innovation is likely to have an impact on the institutions, structures and mechanisms that govern how innovation is implemented and conceptualised. It may be the involvement of a range of stakeholders in innovation policy, major changes in the innovation process and the

need for institutional flexibility within innovation processes. The development of key mechanisms or measures that will allow for the inclusion of excluded groups as stakeholders in the innovation process is a key starting point. Achieving innovation outcomes that are aligned with societal challenges strongly depends on the capacity to innovate the way innovation happens rather than only accelerating technology development (Schillo & Robinson, 2017).

The analytical framework of an inclusive innovation system

Several analytical framework elements of inclusive innovation were applied in this study, entailing networks and interaction, innovation actors, knowledge and learning and human capability building. These elements are briefly detailed below.

Institutions and regulations

Institutions are key elements that shape economic and social behaviour. They are the rules of the game in society and are considered human-devised constraints that determine interaction (Altenburg, 2008). These institutions can be either private or public organisations that are triggered by different economic or social motives. They may also be the formal and informal habits, routines, rules, norms and laws of the interactions and relations amongst those innovation organisations that serve to regulate and control them (Manzini, 2012). These institutions play a key role in reducing transaction costs in economic life (Altenburg, 2008).

Institutions have three main objectives. The first is to channel/diffuse information about the environmental market conditions, goods and participants. Secondly, these institutions define and enforce property rights and contracts. Thirdly, they serve to regulate the competition. For instance, the transaction costs that are compiled to determine market opportunities typically come from insufficient information, partially defined and inconsistent enforcement of property rights and other poor regulatory methods that serve as barriers to market entry. Institutions are necessary for the expansion of inclusive innovation, trade and transformational development (Johnson, Edquist & Lundvall, 2004).

As innovation is uncertain and causes major disruptive technologies, it is important to ensure that regulatory frameworks balance pro-innovation interests with the interests of other stakeholders potentially affected by disruptive technologies and innovations. It is also important to broaden participation in the regulations of innovation (ESCAP, 2021).

Networking and interrelations

The relations among innovation actors within the innovation system play a key role in determining how different learning factors and dynamics should play out. This is based on the assumption that more formalised relations between innovation actors will give rise to a well-guided and coherent innovation system. However, if the prevailing relation is loose, this will yield more flexible but risky and higher cost relations within the innovation system (Foster & Heeks, 2013). It is important to promote the effective interaction of those institutions that are capable of yielding free-flowing communication and the interlinked functionality of innovation actors. This interaction will reflect the sense of connectivity in which an effect on one part of the network will induce changes to the other part. The connection between the institutions must be well established and should holistically benefit all participating innovation actors (Manzini, 2012).

It is important to ensure that the quality of the network amongst innovation actors within the system is well established. This will build a solid foundation for organising the country's collective effort in science and technology and non-technological learning and knowledge. The issue of synergy is more pronounced in developing countries where it could help build a robust innovation capability (Manzini, 2012). The expansion of networks with different local innovation agents may trigger new negotiations on what is problematic, what is not, which kinds of solutions will work for the society and which ones may not work (Fressoli, Dias & Thomas, 2014).

Innovation actors

Innovation literature proposes that innovation actors will over time vary between sectors and countries. However, they will generally be drawn from the private sector, state-owned institutions and universities (Chataway, Hanlin & Kaplinsky, 2014). The character of the innovation produced by the innovation system of a country will depict the tacit and codified routines and characteristics of that innovation system or its actors (Chataway, Hanlin & Kaplinsky, 2014).

It should be noted that some innovation agents such as the state, development agencies, universities and parts of the private sector do not subscribe to the current theoretical norms and narratives of inclusive innovation. Instead, they shape inclusive innovation to suit their context and mandate, while borrowing some of the existing theoretical narratives (Opola *et al.*, 2021).

Inclusive innovation requires developing valid innovation concepts, projects and programmes that will include a mixed group of innovation actors, both traditional and non-traditional. They will collectively engage in learning and knowledge generation, production, diffusion and adaptation which will require new approaches to science, technology and innovation (STI) policies. This will ensure that the traditional top-down innovation approaches are supported by bottom-up innovation approaches (Grobbelaar, Gwynne-Evans & Brent, 2016), in the case of South Africa mostly the rich informal sector of the economy that has adequate local knowledge of the societal problems and innovation needs of the excluded groups.

Knowledge and learning

Knowledge is considered a key factor in achieving continuous innovation and these two factors are closely related (Liao, Fei & Chen, 2007); the latter is the successful application of the former. The process through which such knowledge is generated, transformed into a useful form and implemented is non-linear and dynamic (Maharajh & Kraemer-Mbula, 2010). Knowledge in evolutionary theory and the innovation system approach extends to tacit knowledge. It can be either general or specific and costly. It is within the neoclassical theories that knowledge asymmetries are considered to be market failures, while the existence of such asymmetries is essential to provide a variety of innovations (Intarakumnerd & Chaminade, 2011).

It is argued that what matters most for economic development is its ability to learn rather than its existing stock of knowledge. Learning and change are the sources of economic dynamism (Maharajh & Kraemer-Mbula, 2010). It is important to establish a multilevel structure or multilevel structures capable of facilitating various forms of learning events through vertical and horizontal links. This will allow diverse stakeholders to interact, learn and exchange knowledge. This trajectory will contribute to the development of knowledge through adaptation so that it can address socio-economic, environmental and local innovation challenges (Lema, Lobry de Bruyn, Marshall, Roschinsky & Duncan, 2021).

Innovation policies in developing countries should be aligned to the existing processes of technological learning (Maharajh & Kraemer-Mbula, 2010). In South Africa this approach could dispose of the existing discrepancies in the formal and informal economy by merging innovation knowledge and capabilities. It may offer excluded groups the opportunity to benefit equally and also contribute to the development of innovation in the country. From the

perspective of evolutionary economics, learning and innovation are key factors for development. Involving excluded groups in learning and innovation activities is thus a central part of inclusive development (Andersen & Andersen, 2016).

The technological learning of NSI refers to a group of institutions whose interactions are aligned to bring about a technological change in the economy. Thus each institution plays a role in a process that ultimately leads to outcomes of knowledge or collective property that a non-individual firm could yield individually. This process is referred to as co-discovery and co-learning. Institutions collectively discover new knowledge and learn to position themselves to remain in business (Manzini, 2012). Knowledge and competence are becoming the most critical resources for people, firms and economies. The focus should also be placed on the once neglected domain of tacit knowledge in sustaining competitiveness and its role in innovation and organisational learning. Tacit knowledge simply refers to knowledge that is difficult to articulate or transfer because is not codified and context specific. This knowledge is a key source of sustainable competitive advantage in the dynamic and turbulent environment of business operations (Lam, 1998). It will ensure that there is a shared vision of inclusive innovation among the actors and will serve as a tool to bridge the disconnect between the users and producers of innovative products and services (Andersen & Andersen, 2016).

South Africa is rich in tacit knowledge, considering that the excluded groups have gained such knowledge through social cohesion and sharing. This is because most black people were not afforded the opportunity to acquire formal or codified knowledge through universities. Supporting, reorienting and creating adequate innovative networks and interactive learning within and across technological sectors, formal markets and the informal economy are important to address issues of inclusive innovation. This will increase the chances of mutual understanding and trust amongst all the innovation actors and provide platforms and opportunities for the identification and articulation of poor people's needs and its translation into demand knowledge. It will develop innovative products and services that meet the broader societal needs (Andersen & Andersen, 2016).

Human capacity building

The capability base approach devised by Amartya Sen in 1999 is considered an expansion of freedoms that people should enjoy. These substantive freedoms are defined as the capabilities that people should have to live the kinds of lives they desire and value (Johnson, Edquist &

Lundvall, 2004). It is said that developing countries have traditionally benchmarked their innovation against technologies generated abroad and that the ability to acquire, absorb and assimilate such innovation is considered pivotal. The acquisition by itself is not considered sufficient (Maharajh & Kraemer-Mbula, 2010). Absorptive capability is defined as the ability to note and recognise the value of emerging information, to imitate or modify it and apply it for commercial purposes (Liao, Fei & Chen, 2007). It is not only about rapid technological output but also about the capacity of the economy to position itself to adapt and absorb innovations and technologies. This can be achieved through platforms such as intra-organisational relations (Manzini, 2012).

Innovation in developing countries is likely to be incremental, based on adopting, adapting, imitating and improving foreign technologies. Innovators in developing countries regard incremental rather than radical innovation as their main source of innovative performance (Maharajh & Kraemer-Mbula, 2010). This ensures that the innovation actors within the innovation system focus on enhancing and promoting responsiveness to changes and developing language and practices that are aligned to the current and future needs of marginalised people (Andersen & Andersen, 2016).

While acquiring technology can be a matter of accessibility to foreign markets and finances, effective assimilation of technology traditionally required a broad range of skills and critical mass of technical expertise. Human resources constitute a key element of the assimilation of foreign innovations. Assimilation requires more than just the existence of sufficient technical skills. It demands explicit and deliberate investments and efforts by domestic firms or states such as on the job learning and knowledge sharing. Developing and improving the set of absorptive competencies in developing countries' firms is crucial but widely ignored in research studies (Maharajh & Kraemer-Mbula, 2010).

Constraints, pitfalls and challenges of inclusive innovation

There are several challenges to the implementation of inclusive innovation policies amongst the disadvantaged groups like a low level of awareness, limited capabilities, low skill levels and difficulty to reach established businesses and other financial networks. These challenges exacerbate the already dire situation of the marginalised groups, making it almost impossible to secure the means to lift themselves out of abject poverty and deprivation (Cele, Luescher & Fadji, 2020). Problems such as lack of electricity put huge constraints on the provision of

specific inclusive products and these require innovative approaches to meet the needs of the society (OECD, 2015). South Africa is confronted with both inequalities of opportunity and inequalities of outcome that hamper progress towards education and employment. These social factors inhibit inclusive innovation (Phiri *et al.*, 2015).

According to Heeks *et al.* (2013), there are several barriers to adopting and implementing inclusive innovation, some of which are:

- **Legal/policy** - The absence of legal or policy support for inclusive innovation
- **Institutional** - The prevailing lack of collaborative structures and organisations that support inclusive innovation
- **Human** - The scarcity of adequate and relevant skills and knowledge to drive inclusive innovation
- **Financial** - The limited access of marginalised people to funds and capital due to unemployment, low incomes, etc.
- **Technological** - The poor ICT connectivity of excluded groups
- **Drivers/demand** - The absence of the will to address marginalised groups and lack of information about the demand for innovation among those groups.

Other constraints are related to weak or non-existent infrastructure, which adds costs to the delivery and production of inclusive innovation products and services to certain areas like remote regions, e.g. bad roads. These problems continue to hamper the ability of the majority of rural and excluded groups to access and benefit from innovation processes and products (OECD, 2015). It is, however, difficult to find the right technical expertise for in-house focused innovation. There is also limited access to external knowledge, signifying a lack of absorptive capabilities. Traditional and grassroots innovators should collaborate, sharing expertise and skills. In South Africa a lack of access to banking services and proper infrastructure—more specifically in remote areas—and some rigid neoliberal institutions are major obstacles to inclusive innovators (Manzini, 2012).

Conclusion

The system of innovation in South Africa has shown resilience in the face of losses emanating from emigration, industry restructuring and the slowdown of state-funded research, as well as

a shortfall in skilled personnel. South Africa has the difficulty of defining and developing innovation policy in a way that adequately includes and promotes marginalised groups in innovation activities (Phiri *et al.*, 2015). The biggest threat to enhancing NSI performance and its ability to respond to new demands and challenges is the state's inadequate development of human resources (Kahn, 2006).

Inclusive innovation is particularly applicable to those countries subject to increasing inequality and the uneven sharing of economic growth and innovation opportunities. South Africa has to define innovation policy so as to include the marginalised groups and the poor (Phiri *et al.*, 2015), like the rural or majority black populations. Inclusive innovation seems to be a relevant alternative innovation model that may help achieve social, economic and innovation equality, though it should not be perceived as a silver bullet for all societal problems.

It is important to note that the inclusive innovation model should not be seen as a substitute for the mainstream innovation model. It is an alternative innovation model that may serve to incorporate sectors or parts of the economy that have been neglected or excluded from the traditional innovation model. The integration of traditional innovation and inclusive innovation can help address both local and global needs. Local needs may be related to health or the economy but should be balanced with global trending technologies; keeping up with these will help reduce the disparities with developed nations when it comes to technology.

Inclusive innovation cannot be adequately advanced if the excluded people of South Africa remain less capacitated or do not have the opportunity to participate fairly in innovation activities. It is the government that should be proactive in advancing the knowledge and competency of the people of South Africa, positioning them to participate in innovation activities. South Africa should promote inclusive innovation that gives it global competitive advantage while adequately addressing the local challenges of its people.

CHAPTER 3: OVERVIEW OF THE SOUTH AFRICAN NATIONAL SYSTEM OF INNOVATION

Introduction

This chapter provides a historical overview of the South African national system of innovation, its co-evolution with inequality and its role in promoting inclusive innovation. It tracks the historical transitional movements of the country's political economy with relevance to its impact on the national system of innovation. The chapter covers the early 20th century from the formation of the Union of South Africa in 1910 until the collapse of apartheid in 1994. The primary purpose of this chapter is not to give details of the chronological political-economic events that took place but to succinctly outline how such processes and events racially structured and developed the country's system of innovation and how they advanced inequality.

This chapter firstly provides a brief conceptual elaboration of the national system of innovation and secondly covers the formation of the Union of South Africa. Thirdly, the chapter focuses on the macro-economic effects on the country's system of innovation followed by the impact of apartheid on innovation systems and innovation dynamics. The isolation consequences of apartheid are set out. Then the apartheid educational systems are discussed together with their impact on the system of innovation. There is a brief description of the country's system of innovation and inclusiveness and the spatial planning of apartheid, which helped shape the modes and model of innovation and the viability of the system of innovation. The last part of the chapter discusses the post-colonial and apartheid human capital development impact, social capital and innovation before the conclusion of the chapter.

Concept of a national system of innovation (NSI)

According to research, the country's ability to effectively innovate is linked with the prosperity of industrialisation that leads to social and economic development (Manzini, 2015). It is important to note that the NSI approach is not without problems: its style of adoption (version) may be a distortion of its original concept, resulting in the adoption of a narrow innovation model that conceives innovation to emerge exclusively from research and development (Cassiolato, Pessoa de Matos & Lastres, 2014). The narrow version of the system of innovation is defined as an innovation process that leads to innovation output that is premised solely on

the codified knowledge of science and technology (Gerryts & Buys, 2008). This model of innovation approach is considered to be narrow and limited and it disregards other key elements of innovation that emanate from non-scientific and non-research and development elements. The country may boast modern science and technology systems but still have a poorly designed and developed system of innovation. This is supported by research findings that the single focus on science and technology systems limits the human capital factor of a national system of innovation to one based solely on higher education (Scerri, 2019). Thus one cannot be naive and conclude that a country with sophisticated modern science and technology systems has an evolved system of innovation.

The union of South Africa

The formation of the Union of South Africa as a result of the incorporation of the Cape colony, Transvaal, Orange Free State and Natal in 1910, marked the transformational beginning of the country's political economy (Scerri, 2016). This formation of the union initiated a political power shift to the indigenous white minority Afrikaners (Scerri, 2009a). According to Scerri (2009a), the socio-economic reforms flowing from the Union had a massive impact on the country's system of innovation, although the system of innovation retained some elements of and ties to the former colonial power. The political-economic reforms of the Union during the early part of the 20th century resulted in the establishment of a racial capitalist mode of production in the mining sector (Scerri, 2016).

The discovery of diamonds, ores and other valuable minerals in Kimberley and later gold in the Witwatersrand established, popularised and consolidated the country's use of a science and technology system (Fotoyi, Tetani, Tsedu & Wood, 2016). Before the establishment of the Union, the country's economy was mainly based on the agricultural sector which had narrowly contributed to the development of the country's science and technology systems since the arrival of the Dutch settlers in 1652 when the Cape served as the provisioning and hospitality station of the Dutch travellers and merchandisers to India (Scerri, 2016).

The mining activities following the discovery of diamonds in Kimberley and later gold in the Witwatersrand boosted the existing indigenous innovation systems with modern mining and industrial innovation systems in Southern Africa. One of the means to achieve this was the importation of international skilled personnel with the technical know-how, knowledge and

expertise that were required for the mining sector (Scerri, 2016). The mining sector boosted the country's science, technology and innovation systems but also negatively affected the country's indigenous innovation and capabilities through the adoption of racial forms of capitalist accumulations that divided the country's populations and workforce. This was done by enacting several racial acts such as the Mines and Workers Act of 1911 and the Labour Regulations Act which advanced the colour bar labour structuring in the mining sector. These further tightened employment exits or contract termination for black labourers in the mining sector; terminations of employment contracts were made illegal and persuading black African labourers to terminate their employment contracts for higher-paid jobs became an offence (Terreblanche and & Nattrass, 1990).

The native land act of 1913

The legislative measure triggered by the political reform during this period which probably had the greatest impact on the African population was the Native Land Act of 1913. This legislation effectively deprived the country's African peasantry of the agricultural land on which they had survived and thrived. Virtually overnight, the majority of the country's population was deprived of its accumulation base.

The rationale behind this Act was to restrict the black African peasantry's access to farming land. This was deliberately orchestrated because African farmers were generating enough surpluses on farming to provide them with the means to buy additional land from Afrikaner farmers who were less productive and generating fewer returns. An additional reason was to convert African farmers into a low wage mining proletariat class (Scerri & Lastres, 2020; Maharajh, 2011). According to research, another motive behind this Act was to unfairly expropriate land from black farmers (Scerri, 2016).

It should be brought to our attention that native land acts negatively affected the country's labour market, innovation processes and other social elements of the African peasantry. African black people were moved from their productive lands to undeveloped and less fertile lands which further deprived them of their means of innovation. Those surpluses that were generated by the African peasantry were lost and their access to innovative opportunities decreased. This in turn affected social wellbeing. People should use their financial resources to invest in education innovation, systems and scientific knowledge with the power to enhance national

wellbeing (Maharajh, 2011). According to Terreblanche and Nattrass (1990), these acts severely limited African people's access to land and also promoted squatting on white farmers' lands to ensure a sufficient supply of cheap black labour.

Racial capitalism

The polarisation of mining activities resulted in an influx of foreigners supported by the deliberately orchestrated racial policies that sought to advance the interests of white capitalists while excluding African black people (Phiri *et al.*, 2013). This importation of skilled workers and foreign technologies was due to the lack of skilled personnel and advanced technologies required by the mining sector (Scerri, 2016). It should be noted that the racial capitalism measures targeting black African people directly excluded them not only from participating in research and development (R&D) activities or other sophisticated innovation activities but also from financial systems playing a crucial role in promoting innovation and innovation activities. This was done by paying them less than their white counterparts. Research and development are considered important elements that give effect to innovation. According to research, the racial political economy that is linked with knowledge systems and the system of innovation mostly displays distortions and contradictions (Scerri, 2009a).

One should note that other non-research and development activities can give rise to innovation. These entail activities such as the purchase of new technology or machinery, new market activities and perhaps purchasing or licensing external knowledge through renting (Moses *et al.*, 2012). African black people were further excluded from these non-research and development innovative activities. Such exclusion was attributed to, or triggered by, racially motivated low-income wages for African black labour. Clearly these low-income wages kept black Africans from investing in new technologies or renting external knowledge that would enable them to innovate.

The macro-economic shift in or impact on the country's system of innovation

The macroeconomic shift that the country experienced had the power to reform the country's economy from one based on agriculture and mining to an industrialised and diversified modern economy. One of the main indicators of the shift in national economic policy was the founding of the Iron and Steel Corporation (ISCOR) in 1926. This organisation was established through

state intervention as a result of the adoption of policy programmes that sought to advance Afrikaner nationalism. The processes of state intervention which gave effect to the establishment of ISCOR and other industrialised institutions could promote the development and production of the manufacturing sector. Research indicates that ISCOR played an enormous role in shifting the country's economy from sole reliance on mining and agriculture (Scerri, 2016).

Another science and technology organisation that was established under the macro-economic policy shift in South Africa was the Council for Scientific and Industrial Research (CSIR). The CSIR was formed in 1945, three years before the advent of apartheid after the election victory of the National Party. The CSIR was tasked with ensuring that science and technology were diffused throughout the economy, although it should be noted that ultimately the CSIR failed to reach its targeted population. The organisation was then redefined, as it kept failing to facilitate the development of a sound economy premised on modern and sophisticated technologies (Maharajh, 2011).

Some science and technology organisations established to advance the country's system of innovation were the Council for Mineral Technology (MINTEK), Medical Research Council (MRC) and Agricultural Research Council (ARC). These institutions continued to consolidate the establishment of a system of innovation in the country through science and technology. Science and technology institutions include the National Physical Research Laboratory, National Institute for Personnel Research and National Institute for Aeronautics and System Technology (Maharajh, 2011).

The industrialisation of the economy during this time was structured within the frame of reference of segregation and apartheid to advance the interests of the white minority while excluding the black population. Apartheid was constitutionally and legally constricted as a racist political economy affecting virtually all aspects of economic and civic life, including ownership, employment, housing and other residential rights. The period between 1932 and 1948 saw the dominance of Afrikaner nationalists, set against the British empire, intensify. D.F. Malan in 1923 during the Bloemfontein church conference had already formulated the industrial segregation principles that were geared to advance territorial segregation between white and black labourers. These principles were a response to the large poor white, mostly

Afrikaner, population and also predictions that African black labours posed a threat to white Afrikaners regarding cheap labour and some unskilled jobs (Terreblanche & Nattrass, 1990).

During the 1940s the country's economy suffered from the strong demand for highly skilled personnel and some labour was lost during the war. As a responding strategy, the government resorted to lifting restrictions on African black people by offering them the opportunity to work in skilled positions. This was done by abolishing some pass or identity laws. It was further advocated by the Native Land Commission that regulations with regard to black urbanisation should be eased to ensure sufficient labour for the requirements of industrialisation (Terreblanche & Nattrass, 1990). In 1943 D.F. Malan in his election speech proclaimed the word apartheid and started using it in parliament. He advocated apartheid as the means through which Afrikaner people could reclaim what was just and fair to them and belonged to them. D.F. Malan is better known as the architect of the apartheid system. It was during these times that apartheid or “separate racial development” was promoted with the use of racially organised production modes with the deliberate intention to ensure a sufficient supply of cheap black African labour (Maharajh, 2011).

The CSIR was formed and given the responsibility of advancing defence research. Some other institutions that served to consolidate the establishment of a system of innovation in the country through science and technology were the National Physical Research Laboratory, National Institute for Personnel Research and National Institute for Aeronautics and System Technology. The CSIR was tasked with ensuring that there was diffusion of relevant technology throughout the economy, although it should be noted that the CSIR failed to adhere to its mandate of meeting the targets of the society it was supposed to serve. Subsequently its terms of reference were redefined, as it consistently failed to facilitate the development of a sound economy premised on and supported by sophisticated technologies (Maharajh, 2011).

Apartheid and its impact on the innovation system and inclusivity

The period of apartheid may be described as the coercive Afrikaner nationalist domination era marked by intensive state control of or intervention in restricting political and social science, technology and innovation. The state intervention mainly served the interests of the Afrikaner population. As the country's economy was modernised and urbanised, the government instituted welfare programmes to compensate around 80% of the poor Afrikaners who suffered

hardship and poverty as a result of the industrialisation process. Some measures were also taken to pay wages to whites following the rates linked with civilised standards of living as opposed to remuneration following the labour market rates (Terreblanche & Nattrass, 1990). This coercive regime adopted the narrow strategies of state control and using military forces to isolate national energy and food supplies (Flowerday, 2015). The state further adopted racial welfare policies and programmes that were deliberately geared to ease and improve the lives of the poor white Afrikaner population affected by the processes of industrialisation.

According to Phiri *et al.* (2015), social welfare policies have the power to initiate and advance the innovation activities of a country through building human capabilities, reducing poverty and boosting skills formation. These racially driven welfare policies contributed to the growing inequality in innovation activities as they sidelined or excluded the black majority. These programmes mainly stimulated the social contract of the white population. Research indicates that a social contract based on skilled labour and minimal income inequalities is likely to promote innovation activities. This is simply because the society will have skills that are relevant for innovation and the income surplus to invest in education and human capital advancement (Maharajh & Pogue, 2008).

There are, however, research studies that argue that the provision of social programmes such as relief funds and conditional cash transfers that are intended to reduce poverty and inequality somehow contribute to the exacerbation of inequality. The main proposition here is that innovation is centred on the people and that people innovate mostly in situations where they experience severe poverty and inequality (Phiri *et al.*, 2013). What this proposition does not take into account is that the failure of government to address the discrepancies associated with innovation activities through the provision of social relief and the adoption of some form of welfare system will exacerbate inequality. Research further argues that the unstable fiscal provision for these families by the state can be regarded as a hindrance to human capital formation. Hence human capital formation is costly if there is no state intervention to assist with and build human capital and it is left in the hands of a few rich people (Scerri, 2009b).

An absent state when it comes to the provision of some basic welfare grants will hinder the evolution of the country's system of innovation. The ideology of innovation centred on people may signify the potential elements of non-science and technology or R&D-based innovation that is mostly performed by the marginalised low-income populations. Without a doubt the

racial segregation laws and practices of the apartheid regime indirectly promoted inclusive innovation activities by isolating African black people from modern cities in peripheral agricultural areas with limited means for survival. It is within this dire situation that survivalist innovation by the marginalised people may be perceived to have been indirectly promoted by the apartheid regime.

The adoption of racial segregation policies and other legislative measures by the apartheid regime further strengthened inequalities in innovation activities between whites and people of colour by isolating black African territories. South Africa as a country still faces the development challenges of poverty, inequality, environmental crisis and increasing unemployment, mostly caused by the failure to address the spatial economy of apartheid. While the country as a whole is affected by these development challenges, the majority of black people who reside in informal and remote areas are severely impacted (Kraemer-Mbula *et al.*, 2015).

It is important to note that innovation is not only locally premised but also depends on, expands and evolves from external knowledge. The country's knowledge economy is based on the formal economy which is confined to specific regions (Booyens, Hart & Ramoroka, 2018). The fragmentation in the innovation system is globally experienced; however, in South Africa with its continuing racial measures the fragmentation is deepened by limiting the innovation capabilities of black African people (Kahn, 2013). These challenges are not solely experienced by South Africa. According to Raphasha (2016), the fragmentation and inefficiency of innovation systems are prevalent in developing countries.

The period from 1948 was marked by the victory of the National Party in the general elections which facilitated the establishment of apartheid and its legalisation. This was followed by the enactment of legislation that promoted the dominancy and interest of the Afrikaner nationalists. As the white unity became more coercive during this period, the majority of African black people were excluded from participation in key economic, social and political sectors and even parliament (Terreblanche & Nattrass, 1990). The apartheid regime recognised science and technology as capable of building a transformed and developed economy (Lall & Pietrobelli, 2005) and thus established sophisticated science and technology systems. According to Kahn (2013), the apartheid regime managed to produce globally acclaimed science and technology

systems in medicine and mining and the plant, animal and environmental sciences; some were associated with sectoral systems of innovation.

The 1948 election victory of the National Party provided a ticket for advancing the Afrikaner nationalist interests. This was done by establishing apartheid systems that reformed the country's political economy and power balance in the interests of Afrikaner white nationalists. Shortly after its election victory, the National Party adopted three programmes of action that sought to advance nationalism (Terreblanche & Nattrass, 1990):

- New discriminating laws were added to also include coloureds and Indians.
- The country's bureaucracy and some state entities were enlarged to create more employment opportunities for Afrikaners.
- Some socio-economic welfare programmes were established and promoted to further redistribute the wealth and also to uplift the poor white Afrikaner nationalists.

The apartheid regime had the power to overhaul the established science and technology systems with a narrow model that sought to advance the interests of the nationalist Afrikaner population. During the period of apartheid there was a decline in science and technology programmes (Maharajh, 2011). According to Maharajh *et al.* (2011), under the apartheid regime the evolution of the country's system of innovation was on a development trajectory that was perceived to be anti-modern. South Africa under apartheid adopted science, technology and innovation systems that are perceived to be far from modern (Scerri, 2020a). Science and technology systems of other countries during this time mainly relied upon human resources skills development as the core element of economic development. South African systems followed an opposing model, given its scarcity of and fragmented human resources caused by the apartheid nationalist policies (Maharajh *et al.*, 2011).

Under the apartheid regime with its spatial segregation laws, African people were isolated from the main industrialised cities and were left in Bantustans established in peripheral areas and later remote provinces. These remote areas are still marked by a lack of resources and infrastructure to support the use of modern innovation systems. Thus the majority of the black South African people and those previously excluded ethnic minorities yet experience exclusion from innovation activities. Regional networks in South Africa are considered to be limited or lacking and likely to be active in big cities (Booyens & Hart, 2019). Research indicates that the

cost of the continuation of this racially segregated mode of capital accumulation and production in the country was felt by the National party which had to initiate a form of settlement with the African National Congress (ANC) (Maharajh, 2011).

Isolation effect of the apartheid government

This period saw the intensification of mine workers' strikes which resulted in the deterioration of the business operations of the country's corporations. This, together with the global rejection of apartheid and its political economy and the growing isolation of the country and distancing from the commonwealth, applied pressure for an end to apartheid (Scerri, 2019). Due to severe challenges experienced by the country, such as the exclusion from the commonwealth and the depreciating value of the Rand currency, the government had to reconsider its policy stance. If the country did not introduce some political and constitutional reforms, it faced the risk of isolating itself further from the global economy. This would result in failure by the nation to interact with other global and foreign national systems. This is where local systems would be able to learn, adjust, adopt and diffuse globally trending innovation activities. The country would risk experiencing huge rents accrued from importing foreign technologies, which would result in an enormous cost burden to the nation (Terreblanche & Natrass, 1990).

At this time the country was also confronted with a petroleum shortage with no crude oil reserves, which led to the establishment of the Industrial Development Corporation (IDC) in 1940 (Maharajh, 2011). Its primary purpose was to enhance industrial development and create employment opportunities (IDC, 2021). This effort paved the way for the establishment of the South African Coal, Oil and Gas Corporation Ltd (SASOL) in 1949 as the producer of oil. Later ARMSCOR also entered the global market with research and development output activities and the provisioning of weapons. During the 1980s the organisation was very productive and met the needs of the South African Defence Force. However, due to the country having limited research and development capabilities that did not resemble the Western arms producers, the company only focused on upgrading and modernising existing armaments and other weapons systems. Later ARMSCOR was challenged by high production costs and a declining demand for its products (Maharajh, 2011).

Apartheid higher education, science, technology and innovation systems

A significant move to boost the country's higher education (HE) sector and also the NSI can be traced back to the establishment of the South African College in Cape Town (now known as

the University of Cape Town) in 1829. This was prompted by the exorbitant costs associated with sending students overseas to study in London in the United Kingdom. The establishment of this university was based on the London teaching mode and students were tested on a similar educational system (Maharajh *et al.*, 2011). The demand for highly skilled personnel to meet the requirements of the mining sector and its foreign capital led to the establishment of the University of the Witwatersrand, which played a key role in the development of expertise required by the mining sector at the time, although this university was later migrated to Gauteng (Scerri, 2016). The years after that saw several institutions of higher education established due to the emerging skills gap and requirements of the modern industrial economy. The purpose of these universities was to ensure a sufficient pool of skilled and competent labour ready to fill the worker deficit of the economy (Maharajh *et al.*, 2011).

It is globally accepted that the apartheid regime with its racial segregation measures affected not only the country's economy, politics and society, but also the higher education sector. Science and education systems during the period of racial segregation and apartheid were racially structured (Maharajh *et al.*, 2011). Bunting (2006) points out that the country's higher education system under the apartheid regime was fragmented and loosely coordinated. During this period the higher education system was deliberately designed to advance and consolidate the tenets of apartheid. Universities were founded along racial lines; there were separate black and white universities with English and Afrikaans as the dominating languages of teaching. The first university established with the primary purpose of accommodating black students was the University of Fort Hare. Furthermore, the development of science in South Africa under apartheid took a trajectory that differentiated it from that of other colonies. The apartheid ideologies in South Africa commanded the country's scientific system based on the ideology of racial segregation (Sooryamoorthy, 2010). These apartheid higher educational measures excluded black people from gaining the skills that would enable them to initiate innovation activities and also fill skilled employment openings. These measures may further be perceived as contributing to the exclusion of unskilled and semi-skilled Africans from innovation.

The racial divisions under apartheid were not left unchallenged. Apartheid was globally rejected and declared a crime against humanity by the United Nations (Maharajh *et al.*, 2011). During the hard times of discrimination, segregation and conflicts, the value of science and technology systems suffered severely (Lall & Pietrobelli, 2005). There was a decline in science and technology programmes, with some science and technology research institutions being

reformed during the apartheid era (Maharajh, 2011). Apartheid severely damaged the science and technology status of South Africa with its racial capitalist exclusion measures that were deliberately directed at excluding African black people while benefiting the minority white capitalists and mostly nationalist Afrikaners. Sooryamoorthy (2010) argues that some of the credible researchers also emigrated from South Africa as a result of apartheid. This brain drain was severe and was not only affected by apartheid but also by lower wages.

Research indicates that the country's HE sector from the post-colonial era up to the advent of democracy was shaped by two elements: the HE sector was instrumental in providing the skills supply that was demanded by the national system of innovation (NSI) and the NSI excluded the majority of black people due to racial laws. At this time the country's system of innovation was still developing, compared to those of other British colonial states such as India, which had sophisticated and complex systems. It should be noted that during the period when industrialisation was polarised with some state intervention in South Africa, the development of the HE sector was promoted, giving effect to the stimulation of the country's system of innovation agencies. At this time the development of the country's HE was linked to the mining and agricultural sectors (Maharajh *et al.*, 2011).

SA national system of innovation and inclusiveness

The NSI should be capable of empowering all South Africans through its ability to achieve social, economic, political and environmental goals (Kahn, 2013). It should be noted that South Africa's system of innovation has not fully transitioned to reflect all the elements of inclusivity. The dominant innovation policy planning model in South Africa is still the top-down triple helix model with the Department of Science, Technology and Innovation (DSI) in combination with universities and private enterprises as the custodians of innovation. The country's innovation drive is still mostly based on a linear mode that is narrowly embedded in science and technology supply (Raphasha, 2016). Research indicates that the country's innovation system is premised on the inherited apartheid innovation system (Kahn, 2013). It is not surprising that the country's system is historically grounded because the system of innovation approach emphasises the critical importance of path dependency in the evolution of systems.

According to Scerri (2009a), South African system of innovation is premised on the typical historical mode of the system. This means innovation systems tend to follow the historical

norms and interactions of the established systems even when it comes to innovation agents, environments or countries (Foster & Heeks, 2015). This system persists as the new democratic government has not yet succeeded in establishing, initiating and implementing relevant policies and programmes capable of redressing the injustices and defects of apartheid (Maharajh, Motala & Scerri, 2011).

According to Scerri (2009b), the country's historical political economy derives from foundational elements of colonialism, the post-colonial segregation period and the apartheid system. This political economy has over the years suppressed and disenfranchised the majority of the population. The majority of the population that suffered severe suppression of racial capitalist accumulation and segregation are the African black people (Maharajh, 2011). It is no wonder that the country's system of innovation is still not fully inclusive to accommodate most African low-income groups to participate in innovation activities.

It should be noted that the evolution of the country's system of innovation in the post-apartheid era has not achieved adequate structural transformation to accommodate lower income groups from previously disenfranchised communities. Some of the prevailing evidences attributed by the partial inclusion of these groups are the growing unemployment and inequality. Unemployment is perceived to have been increased by the socio-economic distortions that the new democratic government failed to rectify. Although some of these problems are still seen to have been inherited from apartheid, they are prevalent in the modern South African economy and labour market and the new government continues to fail to address them properly (Malakwane, 2012).

Spatial economies of apartheid

Research indicates that the spatial planning systems in South Africa have over many years been shaped by different governments based on their daily challenges and the needs of that particular period. South African economic space on both the macro and micro levels is still characterised by uneven and ineffective spatial frameworks that hinder economic development and have exacerbated the inherited inequalities of the apartheid planning philosophies (Mashiri *et al.*, 2017). The country's uneven economic development in many sub-national economies or provinces or homelands is perceived as the legacy of the apartheid policies (Cameron, 2005). Effective spatial planning can help lock a region into fixed infrastructure and networks, with proper utilisation of land, water and other basic services such as energy and carbon emissions.

Spatial planning is key to promoting investment, strengthening economic growth and building social coherence. It can also help direct the policies towards promoting more efficient utilisation of scarce resources and provide opportunities for establishing a sustainable and equitable socio-economic and environmental space that is well structured and developed (Mashiri *et al.*, 2017).

The apartheid era has largely been a stumbling block to the development of the country's system of innovation. Apartheid resulted in the creation of homeland states with separate political economies delinked from the urban or industrial economies (Scerri, 2010). The separation of these political economies grounded in ethnicity is perceived to have hampered the diffusion of innovation activities and networking among agents of innovation systems. It further blocked the human capital development elements of the national system of innovation by isolating different innovation agents based on ethnicity and region.

It is important to note that the isolation of the country's spatial economies has harmed the learning capabilities and opportunities of such innovation agents. Most African ethnicity populations were left with poorly developed infrastructure, limited opportunities to innovate and inadequate financial systems to support innovation. The black population for many years were subjected to deliberately orchestrated poor or average educational systems and discriminatory labour laws and regulations. The above-stipulated acts further hindered them from enjoying economic opportunities equal to those of the white population, as some racial laws prohibited them from trading their labour freely in metropolitan and urban areas (Malakwane, 2012).

During the apartheid period the country had a sophisticated economy with highly connected metropolitan cities, as well as secondary and also smaller service centres that were linked through rail and road networks. But this modern economy also had spatial arrangements that reflected and reinforced social inequality and the uneven access to the economy (Harrison & Todes, 2013). According to Scerri (2010), this uneven spatial planning caused development disparities between the different homelands and the urban areas. Poor economic opportunities and forms of social structuring were the result of the unequal distribution of socio-economic opportunities between the different provinces and populations. These provinces were formed on the basis of the different homelands (Malakwane, 2012).

Under apartheid, several policies deliberately limited and constrained the migration of African people to urban areas and further encapsulated them within their homelands (Harrison & Todes, 2013). The apartheid government used different laws to relegate the majority of the population to the peripheral areas of rural and urban settlements. The Group Areas Act of 1950, the Pass Laws Act of 1952 and the Native (black) Urban Areas Act 21 of 1923 are some of the laws used to plan and demarcate homelands while reserving jobs and cities and towns for the white population. By relocating the majority of the African population from big cities to ineffective and unproductive and unviable homelands, the apartheid government further excluded the majority from accessing and participating in innovation activities (Scerri, 2010). Laws such as the Group Areas Act of 1950 were used to relocate black people to the periphery of the urban areas where they were compelled to incur huge transport costs to access urban amenities and socio-economic opportunities (Harrison & Todes, 2013).

The creation of these homelands and subsequent structural re-mapping of the country's geography into 9 provinces caused divisiveness (Scerri, 2010). The spatial planning under apartheid of the economic space of the country led to uneven development. The urban areas during the apartheid era were well planned and modern, with substantial investment, sophisticated infrastructure, good amenities and better economic and social opportunities (Scerri, 2010). Under apartheid the social inequalities and spatial inefficiency within the South African spatial economy worsened (Harrison & Todes, 2013), while the homelands were established with different political isolation and independence trajectories. The homelands were ineffectively planned and were deliberately left with poor infrastructure, unskilled labour and a scarcity of economic opportunities (Scerri, 2010). This left a majority of the population with little infrastructure relevant to innovation. The apartheid era's fragmented spatial planning systems left most homeland areas with social inequality, lack of innovation capabilities and fewer economic opportunities (Joscelyne, 2015).

Subjecting most if not all homelands to uneven development and growth had the effect of derailing the country's system of innovation and associated resources and opportunities. Poor infrastructure, limited investment and weak human capital development were elements of a system of innovation that severely suffered under the apartheid government. According to Scerri (2010), the political-economic stance of apartheid that relegated almost all black people to peripheral areas of the economy either through job reservation or uneven spatial planning for several decades contributed to depriving the majority of the population from participating

and engaging in the modern economy. The uneven structuring of the economy and spatial planning under the apartheid regime not only affected the utilisation and resources of the land but also the country's economy through its divisions based on racial grounds which further impacted the country's system of innovation. Research studies state that NSI is by results considered a sector of the economy (Scerri, 2010). This confirms that the racial and disproportionate spatial planning under apartheid further hampered the innovation capabilities of majority populations.

Since the advent of democracy in South Africa, spatial planning and other policy frameworks have undergone tremendous changes (Du Plessis, 2014). There is no doubt that the country's transition to a democratic government under the leadership of the ANC reformed its structural planning, as well as policies like the Integrated Sustainable Rural Development Strategy (ISRDS), Urban Renewal Strategy (URS), Industrial Development Zones (IDZs), Spatial Development Initiatives (SDIs) and Integrated Development Plans (IDPs) (Cameron, 2005). It is argued that urban policies in South Africa should be directed at freeing and facilitating accessibility to the benefits that emanate from living in cities and towns (Harrison & Todes, 2013), although it is said that these reforms do not sufficiently challenge the persistent uneven inheritance and ineffective apartheid spatial systems. There is evidence of little progress in the social and economic integration of cities, especially with a focus on the informal sector functionality in orthodox spatial planning processes (Du Plessis, 2014). Although these spatial planning transformations differ in magnitude and pace, most of the strategies and their implementation bring people, jobs, wellbeing opportunities and other services into close alignment (Harrison & Todes, 2013).

Globalisation effect on homelands (later provinces)

Globalisation has shown that the South African economy is not positioned to compete internationally, as it has a singular uncompetitive type of labour force. The country was excluded from the Commonwealth. Many of the country's homelands and now some parts of provinces which are labelled as poor, are left with fewer resources and ineffective systems of innovation. The region's and province's viability of national systems of innovation in terms of their ability to reproduce, grow and adapt have been awakened by the opening of the market after the unbanning of the country (Scerri, 2010).

The Convention for a Democratic South Africa (CODESA) negotiations resulted in the re-mapping of the country's regions or provinces from 4 (formerly Transvaal, the Orange Free state, Natal and the Cape Province) to 9 provinces. The hotly contested decision meant that the former white four regions (provinces) were socially, environmentally and economically positioned as advantageous urban areas well equipped with modern systems, infrastructure, a diversified economy and skilled labour ready to compete globally (Scerri, 2010). It is within this ideology that the issue of provinces having different viabilities of systems of innovation and networks prevails. Gauteng, KwaZulu-Natal and the Western Cape are better positioned, with better innovation system viability than other areas (Scerri, 2010). These white urban provinces are sophisticated and have good resources and a competitive edge over other provinces and are likely to secure more investments (Scerri, 2010). These provinces are the heartlands of the four white provinces that were established under apartheid.

As most of the provinces are poor and still have problems sustaining themselves, they also have weak systems of innovation. These provinces are more likely to exclusively focus on addressing issues of social rather than economic growth and seek innovation than the urban provinces that are well equipped with sophisticated cities, urbanisation and innovative capabilities (Scerri, 2010). Given that most rural provinces lack the viability and credibility of innovation systems, these provinces are not diversified in terms of their sub-national economies. Scerri (2010) proposes that in this case, the issue of re-mapping should be revisited. The re-mapping may be argued on the basis that in South Africa the huge disparities were perpetuated with the creation of a new provincial map. South Africa's spacial economy, even after several reforms, still reflects apartheid elements and traits (Harrison & Todes, 2013).

The South African innovation system has been nationally concentrated since its inception. It is still narrowly defined, focusing mainly on research and development (Raphasha, 2016). It is thus not surprising that the marginalised and low-income people are not perceived as beneficiaries and contributors to innovation evolution. The country's innovation system is narrowly focused on science and technology inherited from the apartheid regime and in the post-democracy era the majority of black African people are still not included in innovation activities. Innovation is an integral element of attaining and building a competitive edge and boosting economic growth. It can facilitate the process of catching up to other economically advanced markets (Booyens & Hart, 2019). The exclusionary impact of innovation on social wellbeing may contribute to the exclusion of marginalised and low-income people from

benefiting from such innovation. It is no surprise that the country's system remains unfairly coordinated and fragmented, which contributes to its ineffectiveness in promoting inclusive innovation (Raphasha, 2016). This fragmentation of the innovation system emanated from the racial segregation model of capitalism initiated during the valuable minerals rush, from when the Union of South Africa was established up until the end of the apartheid regime.

Modes of innovation and viability of apartheid NSI

South Africa as the first country in Africa to adopt a national system of innovation as a framework or approach to planning is said to have effectively built its innovation system on the bases that are desired globally (Kahn, 2013). South Africa possesses a solid science and technology foundation when compared broadly to other developing countries (Gerryts, 2008). The term viability as applied within this research paper signifies the capabilities of the system to adjust to and cope with different situations. It succinctly depicts the evolutionary path of the NSI over a certain time span, dealing with forces of an either internal or external nature (Scerri, 2020c).

The issue of the viability of the apartheid national system of innovation is a controversial and confusing one. This is simply because the NSI under the auspices of the apartheid regime evolved specifically in terms of science and technology systems. According to Kahn (2013), under the apartheid regime the country managed to establish sophisticated and globally admired science and technology systems together with some globally innovative products and procedures such as heart transplants. This cannot be disputed when the perception is exclusively applied to science and technology systems; for example, the country produced some global clinical medicines and animal and plant sciences in the apartheid era.

It should, however, be noted that the broad version of the concept of a system of innovation goes considerably beyond science and technology. According to Scerri (2009a), the state policy founded on the base of racial hierarchies led to the development of modern systems of science and technology while also holding back the evolution of the country's system of innovation. This simplify means that the developed system of innovation and its innovation approach was never inclusive. This is due to the logic of apartheid which by definition excluded the majority of the population from meaningful participation in the national system of innovation (Scerri, 2009b). Effectively, the apartheid government promoted modern science and technology to

serve the minority white people, while excluding the majority of the population. The viability of the sophisticated systems of innovation should be judged on their positive impact on the lives of the majority. Since its inception in the 1980s, the innovation system framework has been used in the context of analysing the innovation process and guiding policy making (Cassiolato *et al.*, 2014). It reflects the political and economic affiliation which has the power to either promote or hinder innovation (Maharajh & Pogue, 2008). The NSI can only be judged if it is fairly established and constructed to create an enabling environment that allows the conversion of output-produced knowledge, products and processes to be commercialised and to effect social change (Kahn, 2013).

The long-term viability of the NSI depends on its ability to secure quality of life for the general population and keep improving it (Maharajh, 2005). In South Africa, social wellbeing premised on innovation is either lacking or progressing too slowly. Those who were previously marginalised and excluded are yet to reap the benefits of innovation and the majority does not participate in innovation direction and policies.

The organisations that represent the marginalised people, such as labour unions, are still excluded or have limited participation in the design of systems of innovation, even in post-apartheid South Africa (Scerri, 2019). Developing countries are persistently faced with the challenges of governance, shortage of resources and lack of proper modern infrastructure which are important to enabling viable innovation systems (Raphasha, 2016). The historical system of innovation in South Africa may be perceived to have been far from viable as it solely focused on a narrow version of science and technology which excluded most black African people from participating in the innovation process. This was initiated by racially depriving them of the opportunity for human development through access to universities to develop their skills.

The economic policies that broadly incorporate the interests of all agents of innovation contained within the country's system of innovation tend to be successful (Paul *et al.*, 2012), although it should be noted that there are different views globally about how innovation benefits can be harnessed. Some authors advocate the trickle-down effect of innovation which prioritises economic growth that will lead to social wellbeing (Hart *et al.*, 2014). This narrative is founded on the capacity of innovation to effect economic growth and social wellbeing which in South Africa have not yet benefitted those previously excluded. This is advocated on the basis that in South Africa the majority of the population was never provided with equal status

to the white population due to the enactment of racial capitalism and a segregated political economy. Research indicates that a link between innovation and economic growth is globally recognised. What is left out and not widely recognised is the link between innovation and poverty and inequality (Kraemer-Mbula *et al.*, 2015).

Human capital development

If the country's economy is established with quality higher education graduates it is a reflection of its ability to organise and mobilise human resources. But it is not only the higher education and training graduates who are important for knowledge-intensive employment opportunities: a primary and secondary school trained and literate population is also relevant to building a sophisticated economy. This economy will have a sufficient human resource pool to fill the requirements of the economy and transform it to compete in global markets (Maharajh & Pogue, 2008). According to Cassiolato *et al.* (2014), knowledge is important when it comes to the implementation of technology and the adoption, use and interpretation of local or external knowledge.

However, it is unfortunate that the South African economy is still marked by an imbalance in human resources due to its failure to redress past racial segregation in political, economic, environmental and social systems. Educational systems established during the apartheid era were also based on racial segregation and had a huge impact on learners and graduates with different education skills levels. This was openly entrenched in the South African Constitution Act 105 of 1984, which explicitly established a racially based educational system. Institutions of higher learning were categorised based on ethnicity, with separate institutions for white, coloured, Indian and African people (Bunting, 2006).

Innovation and social capital/cohesion

Research indicates that innovation is capable of addressing the challenges of development such as poverty, poor economic growth, inequality and social exclusion (Foster & Heeks, 2015). This does not automatically mean that any innovation and its model can solve the above-mentioned development challenges. Research studies indicate that innovation may lead to inequality. This concept is supported by the model of innovation that solely benefits innovators and their customers (Phiri *et al.*, 2013). Innovation activities that widened the inequality gap

between the beneficiaries—such as innovators and customers—and those that were marginalised and excluded prevailed during the South African apartheid era. There is no doubt that the country's racial capitalist mode of innovation during the first years after the establishment of the Union of South Africa cemented the circular flow of economy that protected minority white people with limited factors of the economy while excluding the large African population (Scerri, 2009b).

Inclusive innovation depends on the adopted model of innovation and how it is linked with the country's economic and social goals. Some innovation, particularly mainstream innovation, tends to push solely for economic growth which will result in trickle-down effects on social wellbeing. In most cases, it fails to solve social issues (Phiri *et al.*, 2013). Mainstream innovation mostly contributes toward widening the gap between innovation beneficiaries and those suffering from inequality and poverty, specifically those previously excluded from such innovation activities. Foster and Heeks (2015) state that at present innovation that seeks to close or narrow the gap between economic growth and social impact is being hampered. This type of innovation is called inclusive innovation. Research indicates that developing countries should drive inclusive innovation which is capable of decoupling economic growth, increasing inequalities and growing poverty (Sengupta, 2016). Innovation is inclusive when it contains elements, tools and strategic models that are relevant and suited to including those previously excluded from mainstream innovation activities and its benefits, according to Foster and Heeks (2015).

Conclusion

The political, social, economic and legislative activities that unfolded during the periods under the dominion of Dutch and British settlers strongly impacted the socio-economic systems of the country. The negative effects of these activities surpassed the positive actions that arose out of such activities. This is about racial unfairness and segregationist acts that were directed toward African black people (Scerri, 2016). It is also argued that the country's economic growth does not directly contribute to the elimination of inequality and poverty. This is empirically supported by the trickle-down effect that is associated with neoliberal policies which failed to effect positive social change or wellbeing in South Africa (Booyens & Hart, 2019). According to research, South Africa established a modern infrastructure with a large services sector and

an industrialised economy when it comes to innovation processes. Yet the country continues to be confronted by growing inequality and poverty (Cassiolato *et al.*, 2014).

The mining and other industrialisation activities impacted the country's system in several ways. The following offers a snapshot of the affected domains of the NSI (Scerri, 2016).

- The country's mining activities that unfolded during these times shaped the country's system of innovation through positioning it to adopt, adapt and imitate the imported foreign technologies.
- The country's system of innovation was boosted by international skilled personnel with diverse key mining areas of expertise to achieve a competitive edge and also facilitate the extraction processes.
- Regional knowledge received a massive boost with modern scientific and technological expertise in fields other than the natural domain.
- The establishment of a modern system of innovation not only improved the country's economic output but also revoked and disrupted the traditional innovation systems with restrictions under the modern system imposed on the African people. These restrictions were demonstrated by less skilled personnel with fewer opportunities to fit into the modern systems.

The South African political and economic history commencing with the formation of the Union of South Africa was a painful story that the majority of black people were subjected to. This unbearable and racially designed political economy that favoured white populations severely hampered the country's NSI evolution. It further narrowed the concept to the linear mode of innovation while also concentrating on the ownership and control measures of innovation. Yet science and technology systems of the country are conceived to have been well developed during these periods of racial capitalism and apartheid. That does not atone for the damage such racial measures inflicted on the people of Southern Africa and how a system of innovation was narrowly encapsulated, compared to other nations. The issues of having low-skilled personnel as well as unequal access to financial systems that are key to supporting innovation activities are still prevalent and hampering such innovation activities. The 20th century is characterised as the period that advanced and promoted the use of science and technology systems in the country, while also reversing the systems of innovation to the early industrial period.

CHAPTER 4: AN OVERVIEW OF THE POST-APARTHEID SOUTH AFRICAN INNOVATION SYSTEM

Introduction

South Africa is a complex country with a typical historical background of colonialism, apartheid and democracy. It is a country where the majority of black people are still trapped in peripheral areas with severe socio-economic challenges. It is the country with the highest inequality in the world, despite being considered a middle-development country with the largest economy in Africa. The country's economic sector is divided into formal and informal economies. The formal economy is shaped by sophisticated technological infrastructural systems such as banking, finance and ICT, to name but a few. This formal economy is recognised as the innovation hub for many African technological innovations (Phiri, Makelane, Molotja & Kupamupindi, 2013), while the informal economy is characterised by informal institutions, lacks adequate infrastructure for a system of innovation and is mostly dominated by informal non-technological innovation processes.

The advent of democracy in South Africa in 1994 provided the first democratic government with a huge opportunity to formally recognise and support the science and technology system. The compilation, publication and adoption of the 1996 White Paper on Science and Technology in South Africa remains a remarkable step undertaken by the South African government in transforming the country's national system of innovation (NSI). It is within this context that the 1996 White Paper, together with its successors in the form of white papers on science, technology and innovation, other strategic policies and theoretical frameworks, is explored and discussed. This exploration, review and discussion cover a selection of strategic policies premised on neoliberal macroeconomic policies and some form of evolutionary school of economics.

National system of innovation (NSI)

There is no exclusive universal general definition of a national system of innovation. An innovation system approach is seen as a comprehensive understanding of the process by which society and the economy learn, adapt and diffuse innovation capabilities and produce innovative products or services. The system of innovation can also be perceived as the value

chain of innovation which if narrowly defined within the boundaries of a linear model of science and technology may or will result in innovation outputs, innovation actors and innovation outcomes (Cassiolato, Pessoa de Matos & Lastres, 2014). As this research project is premised on a broader innovation system approach, the following definition is adopted as relevant for the purpose of this research study:

The NSI is a group or system of diverse institutions or organisations that together contribute to the development of innovation and learning capacity of countries, regions, localities and economic sectors. This system entails a series of elements and relations that are associated with the production, assimilation, use and diffusion of knowledge generated by the system (Cassiolato, 2014).

The NSI conceptual framework emerged during the 1980s; it was triggered by the search for an alternative economic analysis model that would provide a holistic explanation of what determines variations in countries' economic development and wealth. The newly sought economic analysis model had to be better than the mainstream neoclassical economic model. The search for alternative economic analysis models was triggered by the failure of traditional neoclassical models to explain the variations in the economic growth of countries (Scerri, Soares & Maharajh, 2018). It is this theoretical limitation of the neoclassical economic analysis model that resulted in its downfall and the emergence of an evolutionary system of innovation approach to economic planning and analysis.

One can deduce from the above context that the NSI gained popularity simply because of its holistic and multidimensional approach to economic review, analysis and explanation. An NSI better depicts how countries can build a competitive economy where extensive exploration of science, technology and innovation can be promoted and effectively used to tackle socio-economic development challenges (Scerri, 2016).

In South Africa it is unfortunate that the adoption and use of the concept of NSI within the political and economic landscape happened when neoliberal policies dominated. These neoliberal policies, better known as the Washington Consensus policies, were globally praised as the only policies relevant to addressing countries' economic development challenges. It is within this context that South African economic planning in the democratic era was based on the foundational elements of neoliberal principles (Maharajh, 2011). The co-existence and adoption of the NSI approach premised on the foundational elements of neoliberal policies

somewhat curtailed the functionality of the NSI in South Africa. It also contributed to the stagnant or slow economic growth and development amid the existence of sophisticated innovation systems within the country (Scerri, Soares & Maharajh, 2018).

With the adoption of the NSI conceptual framework approach in South Africa even amid macroeconomic policies such as neoliberal policies, the country witnessed some improvement in its development and innovation drive. This entailed enhanced quality of life for the majority of those previously excluded, better coordination of the system of innovation, the promotion of investment in science and technology and greater development of human capabilities. However, these benefits are not fully realised as the country's NSI is not wholly inclusive, due to its operation within an environment premised on neoliberal elements and policies. These policies and elements continue to limit the systematic nature and operation of the country's NSI (Maharajh, 2011).

The concept of NSI recognises the specificity of a country and how it differs from other countries. It takes into account that every country has its specific historical background and environment of operation. The country's system of innovation differs in terms of its systematic nature, elements or components and how it is linked with other systems of innovation. These dynamics and uncommon systematic elements of the NSI also influence the country's economic structures, institutions and innovation directions (Lundvall, 2016). This clearly explains why the South African NSI is different, owing to its historical background and the current typical context of high unemployment, inequality, etc.

Empirical evidence shows that South Africa as a country adopted an NSI approach that was narrowly defined and mainly focused on exclusively advancing investment in science and technology systems. More importantly, its inputs were premised on research and development, science and technology, while minimally recognising the non-technological innovation process and its knowledge input (Baskaran & Muchie, 2010). As the country is divided into formal and informal economies, the government has not sufficiently invested in promoting the informal economy compared to the formal economy. The country's NSI approach has managed to capture and recognise the formal innovation processes and actors within the formal environment of the system of innovation. This approach has to a large extent excluded the majority of the black population from inclusion and participation in innovation activities and from further benefitting from its economic impact.

The dawn of the new dispensation

According to Kraemer-Mbula (2006), the government is in a good position to play a critical role in installing, influencing, transforming, managing and promoting an equal, justifiable, viable and inclusive political economy. Empirical evidence shows that it is the democratic government in South Africa that initiated the country's structural transformation and reformed the country's NSI. This started with the advent of democracy in 1994 through the general elections that brought the ANC to power. The country's democratic government formally restructured, transformed and coordinated the country's political and economic systems. This led to the adoption of policies and institutions that sought to advance the country's NSI. According to Scerri (2016), the democratic government adopted a developmental state model well equipped with relevant resources to create an enabling environment for innovation activities through providing a direct, indirect and flexible regulatory framework of incentives and disincentives for innovation. The country continues to investigate and refine policies to promote the development of a national system of innovation (ASSAF, 2013).

The adoption of new macroeconomic policies

The ANC in 1994 put together the first democratic strategic plan to uplift the spirit of the majority black disenfranchised population. This plan is better known as the Reconstruction and Development Programme (RDP). The RDP was aimed at addressing major development challenges such as the past injustices and unemployment. This plan sought to align all government budgeted activities with those of the ruling party (Kahn, 2006). The RDP served as a beacon of hope for many previously marginalised people who experienced hardship and inequality in accessing socio-economic opportunities (NACI, 2006). The RDP as green paper was foundationally based on Keynesian economic theories. It was centred on the radical transformation of the poor living conditions of those previously disadvantaged or excluded. Scerri (2020b) argues that this was a prerequisite for the provision and attainment of the planned and desired structural transformation of the South African economy (Scerri, 2020b). However, the country was exposed to the global financial volatility of the time and suffered an economic downturn, which cut short the lifespan of the RDP. The RDP office was closed because of the tensions it had with the Department of Finance (Treasury) over the control of donor funds. It was during this period that the austerity measures which curtailed the objectives of the RDP (ASSAF, 2013) gained popularity. However, it should also be noted that the RDP plan was eclipsed by the Washington Consensus policies.

The democratic government adopted structural adjustment policies (SAPs) that sought to reduce government expenditure, drive down inflation and stabilise the country's currency (Kahn, 2006). These policies supported privatisation, market liberalisation and globalisation, based on the assumption that the market sector through a trickle-down effect would be able to address the country's development challenges. Privatisation in South Africa, however, dates back to the period of apartheid when the state-owned oil company SASOL was formed (Kahn, 2006). Later the ANC continued with the privatisation of state entities. These market favouritism policies in South Africa failed to initiate a relevant structural transformation process to allow excluded groups equal access to socio-economic and innovation opportunities. The market-led growth policies were not sufficient to eliminate poverty and reduce inequality. The systemic exclusion of those previously excluded and the inadequate provision of water and other basic services remain important elements of underdevelopment (Van der Merwe, Grobbelaar & Bam, 2020).

The 1996 white paper on science and technology

Science and technology are important components of a country's economic growth and sustainable development. Countries can use science and technical knowledge to build the capabilities and competitive advantage of their economy (Maharajh, Sall & Karuri-Sebina, 2012). The formation of the Department of Arts, Culture, Science and Technology (DACST) was considered a step closer to promoting the country's system of innovation. The DACST was tasked with the alignment and coordination of science and technology within one department. The DACST adopted the 1996 White Paper on Science and Technology (Flowerday, 2015; Kahn, 2006), which is regarded as a milestone in promoting the formal use of science and technology in the country's economic system (Grobbelaar, 2007). The decision by the government to establish the DACST as the sole custodian of science and technology was subject to much criticism. Some scholars argue that the formation of the DACST and the adoption and publication of white papers on science and technology with no mention of innovation as a crucial element for development are questionable. These criticisms are without substance, as they are based on the fact that the budget of the DACST allocated a minimal amount to advancing science and technology.

Secondly, the failure to recognise innovation as part of the science and technology domain restricted the country's NSI approach to the narrow perspective. This had a huge negative

impact, excluding the majority of lower incomers and new groups of lower incomers and making the economy heavily reliant on minerals. The competitive nature of the economy is limited to formally established sectors as a result of a narrow approach to the NSI.

According to Scerri (2016), the primary objective of the establishment of the 1996 White Paper on Science and Technology was to build an environment where people would enjoy equal rights and equal opportunities to participate in the economic environment and share economic opportunities and other social benefits, as enshrined within the Constitution of South Africa (Act 106 of 1996). This is considered to be an enabling environment for innovation and its activities. It contains relevant human resources, promotes innovation, creates employment, improves the quality of living conditions and encourages knowledge diffusion. According to Maharajh (2011:180-181), the main objectives of the 1996 White Paper on Science and Technology were:

- To establish an efficient, coordinated and integrated system of innovation that is likely to contribute towards the development of a knowledge economy where technical and social innovations are equally diffused amongst innovation agents.
- To build a culture of valuing knowledge and science and its impact on economic growth and development.
- To promote innovation in all economic and social sectors to ensure sustainable development and employment creation, improve quality of life and redress the socio-economic injustices of the past.

The 1996 White Paper played a significant role in advancing and promoting the science and technology system in South Africa. It put the country in a better position to compete in the global market and to provide adequate and quality services beyond racial elements (Maharajh, 2011).

There are several criticisms from different authors and policy makers regarding the credibility of the 1996 White Paper and its contribution to the evolution of South Africa's system of innovation. The major criticism of the White Paper is its failure to recognise other national systems of innovation dimensions apart from science and technology. The entire White Paper focused on science and technology, seeking promotion for formal science and technology and research and development. The White Paper dates from the period when neoliberal policies

dominated, which negatively impacted its evolution. It is within this context that the 1996 White Paper's objectives and vision are considered narrowly formulated in terms of its focus area. It failed to recognise important innovation dimensions such as non-technological innovation, political elements, financial aspects and the broader based human capabilities. Some of these will be discussed and briefly defined in the later stages of this research paper. These innovation types remain pressing challenges (Flowerday, 2015).

Research data shows that South African efforts to promote NSI in the democratic era has been dominated by the narrow perspectives of the NSI as enshrined in and advocated by the White Paper (Mphahlele & Scerri, 2016). One may even equate science and technology elements with the broader innovation system, which would be misleading. It is the definitions of some scholars that serve to limit this concept of the NSI to an exclusive science and technology (S&T) system. Manzini (2012) defines the NSI as the philosophical structure that provides countries with organised, collective and integrated efforts in science and technology. Within this definition, the NSI is again equated to elements of science and technology that foster technological innovation. Using the NSI and S&T system interchangeably is one of the reasons behind equating the narrow promotion of science and technology to the broader NSI.

The 1996 White Paper on Science and Technology underwent several reviews and revisions. This is shown by the succeeding White Papers, such as the 2019 and 2021 White Papers. The significance of these White Papers on science, technology and innovation is that they holistically considered the components of the innovation system and were not limited to science and technology only. These White Papers extended the range of the NSI beyond just science and technology. This provided a holistic understanding of the country's innovation system and which measures were required to capture innovation performance and output.

A move away from RDP to GEAR

It is important to highlight that the RDP office closure paved the way for the establishment of the 1996 White Paper on Science and Technology which co-existed with other macroeconomic policies based on neoliberal policies like the Growth, Employment and Redistribution (GEAR) policy. South Africa, just like Latin American and other developing countries, experienced severe pressure and had to deal with the instability of its currency just after the advent of democracy. Due to their popularity, the Washington Consensus policies were introduced mainly to address the country's budget deficit and development issues. The GEAR policy

became the country's strategic plan for national economic and development planning. GEAR as a strategic policy aimed to mitigate the challenges of the volatility of the Rand currency, restore confidence and enhance credibility (ASSAF, 2013).

Authors and scholars such as Maharajh, Motala and Scerri (2011) argue that the GEAR policy and its programmes gained ascendancy simply because of two reasons that are well known. First, there were concerns about the state of the public fiscal resources which were severely compromised during the apartheid era through extreme waste of resources. Second, there was the need to follow the global recommendations of the World Bank and International Monetary Fund on approaches to fiscal and other macroeconomic policies aimed at standardising the global hegemonic application of liberal ideologies.

GEAR was adopted during the era of the hegemony of the Washington Consensus policies which pushed for market liberalisation to be accepted as the country's economic strategic policy that was globally prescribed. These policies advocated the liberalisation of the market with the anticipation of a trickle-down effect that would address the inherited inequalities of income, wealth and opportunity (Scerri, 2020b). The market, with the support of neoliberal policies, failed to live up to expectations (Scerri, 2020b). The implementation of neoliberal policies is common in developing countries even though they do not effectively address the pressing development challenges (Vasen, 2017). It is no surprise that South Africa adopted GEAR and other neoliberal policies as the foundational base of economic planning and social advancement.

It should be noted that GEAR is not the only Washington Consensus policy that the South African government adopted; additional policies and strategic plans include the National Growth Path (NGP) and National Development Plan (NDP), to mention but a few. Some policies may not be exclusively discussed; however, they are also part of the neoliberal policies that the South African government adopted and used for national planning. These policies include some policies such as Accelerated Shared Growth Initiative South Africa (ASGISA) and National Research and Development Strategy (NRDS), while some are considered not to fit the primary purpose and aim of this research study.

The GEAR policy was also embedded in the strategic vision proposed by RDP. It sought to advance the Washington Consensus's macroeconomic objectives. It focused extensively on the

development and support of industrial innovation (science and technology system), while lacking support for a broader NSI. Its support for industrial innovation programmes had a huge impact on domestic innovation (ASSAF, 2013).

The 2001 review and outcome of the GEAR policy showed several shortfalls of the policy even though positive fiscal disciplines were witnessed in some areas. The fundamental transformation of the country's economic structure had not been initiated. It became evident that the problem of unemployment had worsened along with poverty during the GEAR era. The country's inherited skills shortage remained uncorrected through the implementation of GEAR and the economic structure had little absorptive capacity for low and unskilled labour (Osha, 2014). The skills generation and development amongst the previously disadvantaged groups remained inadequately initiated and promoted (Kahn, 2006). This curtailed the efforts to address the problems of unemployment, poverty, inequality and the continued exclusion of some groups from mainstream development.

In South Africa, the application of neoliberal policies such as GEAR continues to impede development and the building of an inclusive innovation system (Phiri, Makelane, Molotja & Kupamupindi, 2013). These policies continues to fail to adequately address the development challenges of South Africa (Scerri, 2020b).

Impact of other macroeconomic policies on the NSI

The South African government launched its New Growth Path (NGP) plan in 2010. This plan stressed the importance of an innovation policy which, among other issues, proposed the promotion of small or incremental innovations. These are innovations that entail few adjustments or modifications to existing products, processes and services. The plan aimed to create 100,000 new jobs in the knowledge-intensive sectors of ICT, higher education, healthcare, mining, pharmaceuticals and biotechnology by 2020. It emphasised the importance of emulation and adoption and the diffusion of existing technologies that would support large-scale employment creation, intending to improve the welfare of the previously and currently marginalised people (ASSAF, 2013). This policy failed to achieve its main purpose of generating employment for previously marginalised people; part of the reason was the lack of skills in either science and technology or non-technological skills and knowledge. The Department of Science and Technology (DST) ministerial review committee was dismissive of the capacity of these macroeconomic policy plans (Scerri, 2020a).

Some policies that succeeded GEAR were AGISA (Accelerated and Shared Growth Initiative for South Africa) and the Joint Initiative on Priority Skills Acquisition (JIPSA). These policies and strategic approaches were formulated to strengthen and coordinate strategies designed to address the shortage of skills due to the failures of GEAR (Scerri, 2020a). The National Development Plan was another revised and reformulated policy based on the theories of the Washington Consensus. It was announced in 2012 to serve as a new blueprint for South Africa, eliminating poverty and significantly reducing inequality by the year 2030. It was centred on the effectiveness of the economy (ASSAF, 2013). It advocated measures such as austerities, stabilising the budget, privatisation of state assets and liberalisation of the market. This resulted in the deterioration of social welfare safety nets due to the reduction of government expenditure caused by the scaling down of government services provision. However, the NDP remains robust in terms of promoting a knowledge society through education, training and innovation. Research indicates that without proper and well-planned quality education, training, research and innovation systems, achieving inclusive economic growth with full employment will remain difficult to achieve (Awuah, 2019).

Several studies indicate that the fundamental base of any country's development planning is the proper and radical systemic transformation of the country's economic structure. The structural economic transformation is important as it will lead to sustainable economic growth and development (Scerri, 2016). It is not surprising that key visionary priorities of the NDP have not been attained and that some remain a dream. The NDP set very good developmental goals for the country to address development challenges ranging from having a stable legal system to corruption, the rise in unemployment and the heavy inflation that deprives the majority of the opportunity to save their earnings. The capital formation of South Africa is low and this negatively impacts the NDP and its objectives.

South African national system of innovation

The South African 1996 White Paper on Science and Technology formally established the NSI concept in the country's public policy discourse (Manzini, 2012). The NSI approach was adopted to transform the country's public resources such as research, development, science and technology and innovation. Establishing universities and increasing enrolment were key considerations and represented the government's formal commitment to building and

promoting science and technology in South Africa. Their roles and interactions within the system are mainly to drive economic growth, ensure employment, reduce poverty, change knowledge, develop human capabilities and improve the lives of people.

The South African innovation system has always been fragmented, benefiting the minority white population while excluding the majority of the black South Africans. South Africa's NSI contains constraints that are mostly imposed by the past apartheid effects. This is attributed to the persistent failures of the current democratic government to reform it (NSRC, 2008). Its path-dependent features, its legacy of the apartheid system and the racial segregation systems that preceded it all contributed to the misalignment and hindrance of NSI evolution. The prevalence of inequalities in the economic and social domains continues to curtail the efforts to build a viable and inclusive NSI. The constraints that are directly linked to human resources (low levels of education and poor skills for the majority of the black population) keep the country from achieving policy goals and transforming its NSI (NSRC, 2008).

It is not surprising that the country's infrastructure and core institutions such as Transnet, the South African Airways (SAA) and Eskom are failing to cover the broad spectrum of the country with adequate functionality. Some dimensions of this system are obsolete and now collapsing. Corruption is also seen as a major contributor to the collapse of the system. Lack of relevant skills due to brain drain is another key factor in the collapse of many public institutions. The educational and training systems are also blamed for failing to develop relevant skills to address societal issues within their operational areas. These elements are discussed in detail in the coming subtopics of the study. Another form of infrastructure and innovation system institution that is collapsing is the South African post office which faces liquidation due to its operational failures.

Evolution of South African innovation policy

The timeline below shows the duration of South African innovation policies adopted between the years 1996 and 2019 and the improvements and reviews undertaken since the formal establishment and use of the NSI in the democratic era.



Figure 5: Evolution of South African innovation policy

Source: Mamphiswana (2022)

South Africa has a sophisticated science and technology policy framework with clear directions and a formal commitment to ensuring the coordination and promotion of science and technology. The country is equipped with major strategic measures such as incubator schemes, centres of excellence and investment programmes. The country's innovation framework is adequately designed to fit the formal structure of the economy. The informal part of the South African economy is, however, mostly excluded, which is considered as a failure of the adopted innovation policy framework and approaches by the democratic government.

According to research, the country's innovation framework has no measurement for the non-technological innovation output of the informal economy. The informal sector is mainly where the marginalised lower-income populations are found (Maharajh, 2011). The exclusion of the informal sector from an innovation perspective is the exclusion of the marginalised people, which results in severe socio-economic problems. Thus it is not surprising that the country continues to be confronted with development challenges. The inclusion of the previously marginalised and lower-income population mostly relegated to the informal economy in South Africa holds the potential for skills development, income generation and social cohesion (Kraemer-Mbula & Sehlapelo, 2016).

South Africa's innovation system needs to be inclusive to cover the informal part of the economy. Since the advent of democracy innovation policies have been established and reviewed, yet these policies have barely addressed the innovation impact on the social elements of society. Most innovation policies target the small formal economy and its institutions. Manzini (2012) argues that the country's informal innovations and the informal institutions

within the informal sector continue to be unmeasured and unrecognised as components of the innovation system. The dualism of the formal economy and informal economy with different resources and functionalities serves as a hindrance to building a knowledge economy where innovation activities can flourish (Sibisi, 2019).

Knowledge economy, entrepreneurial state and innovation

In spite of persistent efforts to drive innovation, South Africa has failed to generate the much-anticipated innovation benefits for the larger country (Sibisi, 2019). It is within this context that there are frequent calls for the South African government to assume responsibility for not only a developmental state but also a knowledge economy which will function as an entrepreneurial state. An entrepreneurial state is defined as a state that can accept higher risks and failures with the primary goal of making a profit. These risks are by definition uncertain in nature and they need to be comprehended and accepted rather than avoided. Once the state is willing to accept all these risks, it will be better positioned to support innovation by investing in it. The entrepreneurial characteristic of the state is the continuous accumulation of failures which are regarded as a learning curve (Watkins, Papaioannou & Kale, 2015). It is within this context that the state is advised to be patient while innovators are gaining capabilities through their cumulative failures.

According to Sibisi (2019), the innovation performance and output of South Africa are still small and lagging behind those of its counterparts in BRICS and European countries. One of the major causes of its low innovation output is the role that the government chooses to play. The democratic government has since its ascendancy to governance adopted a market fixer role in innovation activities rather than an engineering role. Taking up an incentive provision or funding role is not enough for the government. The government should play a direct role in innovation processes by assuming an entrepreneurial stance. It needs to build a close intact relationship with all innovation actors within the knowledge economy.

It remains uncertain if the South African government is willing to take up the entrepreneurial role. This is because the government fails to recognise the informal economy as a promising innovation actor. The government has not formally budgeted for informal innovation activities. The government's failure to recognise the informal economy as an important element of the innovation system has broader and deeper negative implications for the country's system of

innovation (Scerri, 2016). There is no doubt that the informal economy innovation activities are uncounted and unrecognised. This economic space in South Africa employs the majority of the lower-income and less-skilled population. This government negligence reflects how such an economy is unregulated and how innovators within such a space struggle to secure funds or capital due to the risky nature of the environment.

In a world dominated by codified universal exchange and accessibility of knowledge, it is the tacit knowledge that is diffused more easily in an established web of values and norms exclusively linked to an innovation system. It is within this context that the South African government should use informal institutional arrangements to access the market similar to the use of formal institutional arrangements. The informal market is the economy that the codified knowledge mostly fails to reach. It is within this context that the innovators within the innovation system will be better positioned to initiate the structural transformation of the economy (Scerri, 2016). For the government to better capture this part of the economy, it needs to play an entrepreneurial role within the knowledge economy. The South African government has not adopted the role of being an entrepreneurial state and has not built the knowledge economy that is desired.

Innovation system and innovation actors

The NSI is inclusive when all innovation institutions are equally included within the system and the established institutions—either formal or informal—also apply fairly to the entire institutional system. It is inclusive when all innovation agents are equally benefiting from such a system and are free to interact and enhance their capabilities through learning within the system. There are no universal standard components of an effective innovation system because countries differ in specificity and components, historical background and context. However, the system may include innovation agents such as the private sector, universities, workers, labour unions, the unemployed groups, the government, civil society and those below the poverty line which constitute the components of the innovation system. They are institutions within the innovation system that are involved in the innovation process and activities. This is important and relevant in addressing the issue of who should benefit from innovation activities, particularly looking at those previously marginalised people and lower-income populations. The key elementary factors of the innovation system are the inclusion and interaction of all innovation actors (agents) within the system (Cassiolato, Pessoa de Matos & Lastres, 2014).

It is not clear whether South Africa has developed an inclusive innovation system that allows interactions amongst all innovation actors. This is because those previously excluded groups and lower-income earners still lack the human capabilities required by the innovation system. The NSI emphasises that the system has a diversity of institutions that play a critical role in advancing the innovation performance of a country. These institutions are driven by different agendas and are either small or big. Evidence highlights that in developing countries like South Africa, many small institutions of innovation systems operate in the informal economy (Manzini, 2012). The activities of these institutions are mostly not recognised by the formal measurement of the innovation performance of the country.

According to Cassiolato, Pessoa de Matos and Lastres (2014), the systemic nature of the innovation system entails its abilities and capabilities to include a diverse network of innovation actors in its innovation processes. This resonates with the elements outlined below which are important for a functional and inclusive innovation system. The International Development Research Centre of Canada identified three elements that are important to building an inclusive and well-functioning system of innovation (ASSAF, 2013), namely:

- It is built out of processes that involve interaction and exchange of knowledge among diverse actors within the system.
- A knowledge-based innovation system should entail a broad spectrum of knowledge that covers both tacit and codified knowledge.
- There are social networks of innovation agents within the innovation system.

The South African re-mapping and its impact on innovation

The democratic re-mapping of the country's economic landscape into nine provinces resulted in some residual elements of apartheid that continue to negatively affect mostly marginalised poor people. These populations generally reside in informal dwellings that were deliberately positioned far away from industrial areas, businesses and services (Scerri, Soares & Maharajh, 2018). These houses and informal dwellings are indirectly affecting the evolution of the country's NSI due to being positioned in areas with poor infrastructure. Most people in these areas are excluded from the formal innovation system and its activities. These areas continue to lack relevant and sufficient innovation infrastructures as required by the NSI.

The continuation of these dwellings in South Africa demonstrates the democratic government's failure to implement structural transformation to facilitate the country's NSI evolution. These residual effects continue to undermine the country's human development and the productive capabilities of the NSI. In a country dominated by unemployment, lack of economic opportunities and mostly lower-income earnings, the innovation performance and output will likely be negatively affected (Maharajh, 2011).

Since the re-drawing of South Africa's spatial area into 9 provinces after the advent of democracy, some provinces have lagged behind in innovation activities. Few provinces have established an effective and viable system that may to some extent be perceived as a provincial system of innovation. Some provinces are better equipped with capital cities that are well-resourced for the effective functioning of the system of innovation. These cities, for example, are Pretoria, Durban, Cape Town and Johannesburg. The fact that major large provinces were left with poor infrastructure, poses a huge challenge to the viability of the NSI. The distances and unequal resources among these provinces complicate the evolution of the country's NSI. This severely affects the interaction, learning activities and opportunities of innovation agents within the NSI (Maharajh, 2011).

According to Manzini (2012), the country's networking and interaction activities of the NSI are currently skewed due to the geographical separation of rural areas and urban areas. The interaction and networking activities of institutions and their functionality are affected. Some rural institutions continue to experience high costs in transactions and networking activities which serve as a hindrance to the optimal functionality of the NSI. It is within this context that the apartheid segregation and the democratic re-mapping of the country's spatial area are perceived as major impediments to the evolution of the country's NSI. This further affects the country's economic system in general and its economic outcomes.

The reality in South Africa is that many provinces are currently facing major development challenges that hinder their active participation in innovation activities. Some of these problems mainly derive from disparities in the re-mapping the country's economic space, which relates to their existence as viable provincial systems of innovation. These entail the legality of the formation of such provinces, their structural abilities for viability and also the resource containment within such provinces. Clearly the re-mapping of the country's economic landscape into nine provinces was done without proper skills and the prerequisite elements.

These elements refer to human capabilities required for the effective functioning of such subsystems of innovation. Gauteng, Western Cape, KwaZulu Natal and Free State have systems of innovation that evolved during the colonial, segregationist and apartheid areas. This is because of their natural resource endowments and strategic location. While Gauteng attracts more migrants with expectations for future jobs which in some instances do not materialise, it is important to note that Gauteng and the Western Cape are the recipients of the outflows of human capital of other provinces (Scerri, 2010). The human capability and its development in African countries, including South Africa, still lag behind the developed world.

The skills shortage in developing countries and more specifically in sub-Saharan countries, including South Africa, constitutes a major stumbling block to economic development (Scerri, 2019). These countries remain trapped by the severe deficit of resources, such as human capabilities and physical capital. There are many contributing factors to these shortages of human capabilities and physical capital. One of the key contributing factors is the poor educational systems. The brain drain caused by developed countries and regions is another major factor (Oluwatobi, Ola-David, Olurinola, Alege & Ogundipe, 2016). The skills drain in Africa is considered a major problem because of the continent's inability to retain such valuable skills. Developing countries in Africa are currently losing the skills that are relevant to and important for the evolution of their countries' NSI.

Evidence from literature review shows that skills drain on the higher end of science and technology such as scientists, doctors and engineers mainly occurs in Africa. This is due to the prevalence of poor infrastructure and high levels of poverty, political instability, ethnic fights, imbalances and failure of recognition. This is also caused by diverse elements such as religious and ethnic differences, unemployment and income inequalities in many countries. Where income inequalities are low, emigration tends to be among the higher skilled and driven by career choices; where inequalities are high, there is an increased incidence of lower-skilled migration mainly driven by necessity (Scerri, 2019). In South Africa the issue of Gauteng and other big cities benefiting from the migration of resources from other rural regions correlates with the preceding research study evidence.

Developing countries suffer from persistent high levels of socioeconomic inequality and poverty. These challenges represent obstacles to sustainable development and desired innovation performance outcomes (Zapata-Cantu & González, 2021). South Africa is no

different to these countries as it continues to experience high levels of income and social inequality. These socio-economic challenges affect the country's level of human capabilities development which subsequently affects the country's innovation performance and economic development (Scerri, 2019). These problems negatively impact the country as a whole and further reduce the country's investment in human capabilities formation and development. This then leads to a shortage of the human capabilities required for the evolution of the country's NSI and economy at large.

Some provinces were mainly established to secure political bargaining power (Scerri, 2010). There is no doubt that the reconfiguration of these provinces is a prerequisite for capacity building and economic development. Matters of legality, networking and the flow of resources for these provinces need further review. Resources in these contexts refer to financial capital, labour and human capital and physical capital. The flow of these various types of resources can be an indication of the existence or non-existence and the viability of a sub-national system of innovation (Scerri, 2010), although it is important to understand that human factor resources are the most important elements of an innovation system. A province with a positive balance of migration of human resources has adequate human capabilities and the capacity required for the evolution of the innovation system and its ability to attract such elements.

Lee, Florida and Gates (2010) maintain that cities should function as innovation incubators for the generation and testing of new ideas and for innovation. These cities should function as open systems that can attract talented resources from various backgrounds. This explains Gauteng and Cape Town's dominance in securing the relevant capabilities from various backgrounds compared to cities in rural provinces.

South Africa's economy is regarded by the United Nations as the most vulnerable due to its heavy dependency on agriculture and its weak adaptive capacity (Pegels, 2010). Empirical evidence shows that South African economic production is based around six urban areas. Johannesburg is the country's financial and services hub and Pretoria is regarded as the administrative seat of the government. Ekurhuleni is the historical manufacturing area, while Cape Town is the country's seat for tourism and parliament, Durban is the trade port and the automotive manufacturing hub and lastly, Port Elizabeth houses the small industrial and services sectors (Scerri, Soares & Maharajh, 2018). These areas and their respective provinces are mostly connected with national and global innovation systems and their innovation actors.

Income inequalities that favoured savings promoted growth during the industrialisation era due to heavy reliance on physical capital formation favoured by income savings. During these times the prevalence of income inequality supported more saving and resulted in more investment in physical resources.

In the contemporary context (post-industrial era) in South Africa the prevalence of income inequality now hinders development processes, with harmful effects on the formation of human capabilities (Scerri, 2019). This is due to human capabilities replacing the old physical capital accumulation which favoured savings through the creation of income inequality. With a poorly developed urban industrialised sector and the rural sector dominated by landowners, there is a systemic disincentive for human capabilities formation. Most of the country's provincial spatial economies still show a high level of asymmetry in the distribution of ownership and control of resources. These factors delay human capabilities formation for the primary purpose of retaining the existing patterns of privilege. It is within this context that one may argue that South Africa has not fully captured the use of the country's human resource factor in its development process and innovation activities. The majority of low-income groups are still excluded from innovation activities and this automatically leads to the slow innovation performance of the country and the economy remains uncompetitive (heavily reliant on natural resources).

Government role and innovation policies

Evidence indicates that the structural inequalities that emerge in economics and some of the geopolitical relations are the main causes of poor development. This backwardness calls for government intervention to reform the country's structures to eliminate inequalities (Cassiolato, Pessoa de Matos & Lastres, 2014). Government policies can balance innovation activities among the innovation actors and promote their innovation performance. Institutions and policies are means to influence and promote innovation performance and outcomes. Government can use institutions and policies to build an environment conducive to innovation processes (Mytelka, 2016). However, in South Africa the government has not yet succeeded in formulating policies or bringing about adequate and inclusive institutional reforms to address the country's innovation problems (Clark, 2016).

According to Kraemer-Mbula (2006), the crafting and adoption of innovation policies that are aligned with the needs of the country's system of innovation remains a huge problem in developing countries. It is not surprising that most innovation policies in South Africa are rooted in neoliberal ideologies which do not address the prevailing challenges of the economy. Research indicates that the evolution of a country's economic system should be marked by the continuous destruction of the older economic structures and its institutions while simultaneously creating new ones (Cassiolato, Pessoa de Matos & Lastres, 2014). It is within this context that the NSI conceptual framework can help reform the entire economic system. The South African innovation system is currently not inclusive and this can only be addressed through transformed innovation policies and approaches. The government should revisit the adopted innovation policies and models without being tied to the neoliberal foundation. The country should introduce policies that can promote an inclusive innovation system that also recognises the majority marginalised population as active innovators.

Governments in both developed and developing countries should promote and foster an innovation climate ecosystem in which innovation activities can flourish. Governments may assume the roles of being a regulator, coordinator, service provider, financier, research performer and even innovator (ASSAF, 2013). There are **five actions**, according to ASSAF (2013:30), that the government must undertake to build a well-functioning, viable and inclusive innovation system, namely:

1. "Setting the framework conditions, macroeconomics stability, regulations, mechanisms for privatization, agenda-setting and conditions, maintenance of standards regimes, protection of intellectual property rights and provision of direct and indirect innovation incentives such as funding.
2. Ensuring the supply and mobility of knowledge networks which entail human resource development, immigration law and other networking mechanisms.
3. Promoting knowledge integration and exchange: This entails mechanisms for knowledge exchanges and technology diffusion and transfers such as codified and tacit knowledge and mobility.
4. Providing knowledge infrastructure: Public research organizations, provision of scientific and technical services, provision of research and communication infrastructure.

5. Engaging in the policy of learning entails measurement, monitoring and evaluation, the impact of assessment, foresight study and utilizing evidence-based decision-making and consensus conferences”.

The above roles of government in creating an innovation ecosystem where innovation can flourish will assist in reviewing the South African NSI. Strenuous efforts have been made since the advent of democracy with the introduction of different macroeconomic policies that sought to build, strengthen and contribute towards the evolution of the country's NSI. The following strengths and weaknesses of the South African NSI were extracted from review papers of the South African NSI. It should be noted that that the information below may not be a true reflection of today's weaknesses and strengths given that these outcomes were for the period mentioned.

The weaknesses and strengths of the South African NSI

After the first OECD review of the South African NSI in 2007 the following strengths were identified (Scerri, 2016):

NSI strengths

“South Africa has resource-based industries and other business services that are knowledge intensively based.

- The country has proper knowledge infrastructures which are considered small when compared to the population size of the country.
- The country’s business enterprise accrues higher expenditure when it comes to Research and development spending (BERD) and Gross expenditure in research (GERD)
- There is a traditional link between knowledge infrastructure and major business industries.
- There is an international network between industries and academics.
- There is solid political support for the importance of science, technology and innovation for the primary purpose of sustaining growth and development.
- The country has relevant measures that strengthen and ensure coordination among the departments” (Scerri, 2016:207).

NSI weaknesses

The major weaknesses and challenges identified by the OECD are still prevalent in the country's science, technology and innovation sectors. These weaknesses include the creation of knowledge and diffusing it to yield useful concepts and objectives (Scerri, 2016). The weaknesses continue to hinder the evolution of the South African NSI. The following are some major weaknesses identified by NACI, Walwyn and Boraine (2006:79-86) that need to be urgently addressed if the country's NSI is to display the characteristics of a viable and inclusive innovation system:

- “The provision of human resources
- Rigidities in financing
- Rigidities in the domain of knowledge production
- The role of S&T in poverty reduction and the review of its effect”.

Some of the above weaknesses are explained in detail below.

Human resource factor pipeline for NSI

Human capital

This section succinctly sets out the concept of human capital by looking into its narrow meaning and its transition to broader meaning termed human capabilities. It should be emphasised that this study adopted the use of the concept of human capability to review, explore and analyse the South African NSI and its relationship to economic development. This section first defines human capital, its premised roots and its limitations. Later human capability is defined and an explanation provided of how this fits into a review of South Africa's NSI.

Human capital is now globally considered an important determinant of economic growth, social development and a competitive economy. It is not only the main source of socio-economic development but also the driver of innovation outcomes (Oluwatobi, Ola-David, Olurinola, Alege & Ogundipe, 2016). It is important to note that there is no general consensus on the definition of human capital. This is because it is a very confusing and ambiguous concept with many dynamic meanings and measurement mechanisms. It is a deceptive concept that within its broader approach signifies the quality of life of a population. Human capital is now

considered the main element of the competitive advantage of firms, individuals and countries. It is the means of achieving economic growth and development (Scerri, 2010). Human capital is a concept that is narrowly defined as a set of skills, knowledge, attributes and capabilities inherent in human beings. Empirical evidence shows that human capital can only be considered of value if it can successfully convert into quality goods and services and lead to economic growth and development (Cabrilo, Grubic Nestic & Mitrovic, 2014). The country's effective human capital is likely to build the capacity of the nation to absorb, generate, diffuse and organise knowledge and innovation (Lenihan, McGuirk & Murphy, 2019).

However, it is important to understand that the concept of human capital originates from the conventional dominant neoclassical school of economic thought. The concept is narrowly defined and refers to skills, knowledge and attributes that are embedded in human beings and built on by the educational system (either primary, secondary or tertiary). The adoption of these neoclassical assumptions and general equilibrium frameworks is subject to severe criticism and are far from being realistic. Scerri (2019) argues that the adoption and use of the concept of human capital with the lesser systemic deployment of human capability(ies) are controversial and ambiguous and the interpretation misleading. The equation of human capital with other forms of production capital is problematic and poses theoretical problems (Scerri, 2019) associated with the breadth of the country's national system of innovation which narrowly relies on science, technological capabilities and R&D. Technological capabilities relate to the use of science and technology as the main determinant of the capabilities and innovation. The human requirement of this model signifies scientists, engineers and technologies within the formal R&D institutions mostly focused on the production sector and managerial capabilities to help translate innovation into production.

The NSI approach that is narrowly defined is considered a web of formal institutions that are involved in the development of science, technology and research and development (R&D). This approach relates to the system of innovation that is directly engaged in R&D and a formal production system. The web of formal institutions may also be extended to cover other formal institutions that are not directly concerned with science and technology. These refer to formal rules and regulations that control the behaviour of those formal institutions (Scerri, 2010). It is within the limitation articulated above that the concept of human capital is replaced with human capabilities in this study; when human capital is referred to below it signifies the broader concept of human capabilities.

Human capabilities and institutions

Countries that invest in human factor development that goes beyond skills and competencies embedded in human beings have over time witnessed economic development and leveraged innovation processes. This is because focusing on human capital as the sole element of NSI capacity is not enough to cover the broader spectrum of human capabilities required for evolutionary NSI and economic development. Globally there are developments regarding the concept of human capital that go beyond the narrow concepts of skills and competencies embodied in people. The concept of human capital has transitioned to human capability which now covers diverse elements such as people's personality traits, work attitudes, values, creativity, resilience and self-efficacy (Lenihan, Mcguirk & Murphy, 2019). This resonates with a national system of innovation that takes into account several national institutions that transcend education and training to include infrastructure such as networks for the transportation of people and commodities. Based on this, the study adopted human capabilities as the relevant concept to review broadly the systemic nature of the country's NSI status.

The concept of human capabilities is far broader than, and contrary to, the narrow neoclassical concept of human capital. Human capabilities go beyond the skills, knowledge and attributes that are embedded in human beings as detailed in the definition of human capital. The skill set of human capabilities is also codified while others are tacit. Some of these capabilities can be acquired through a formal education system (Scerri, 2019). This means others may be acquired outside the formal educational system. The concept of human capabilities refers to substantive freedoms which are defined as capabilities that people have to live the kind of lives they wish and have reason to value. This includes avoiding starvation, undernourishment, diseases and premature mortality and further includes the enhancement of freedoms, right to literacy, ability to participate in the political and socio-economic process, means to positively influence one's work and work conditions, entrepreneurial freedom and possibility to take economic decisions of different kinds (Johnson, Edquist & Lundvall, 2003).

Human capabilities are defined as the ability of human beings to lead the lives they wish to live and have a reason to value and enhance the choices they have. Due to the systemic and complex nature of innovation which is characterised by constant and unpredictable changes, dynamic human capabilities are important. This is advocated by Scerri (2019), who states that human capabilities are likely to lead or contribute to a country's NSI evolution. This is because the development of the NSI requires constant systemic adjustment of all elements that determine

its evolution. Human capabilities are no doubt important elements in the evolution and functionality of the NSI. This further allows innovation agents to interrogate their resources and propose new resource configurations. These capabilities would enable the nation, individuals and firms to continuously monitor the changing needs of the different stakeholders, develop opportunities and take innovation opportunities from such constantly changing expectations of institutions (Zapata-Cantu & González, 2021).

The democratic government in South Africa has been instituting measures to support and promote human capabilities development, innovation activities and their outcomes. For example, the Skills Development Levies Act of 1999 and Skill Development Act 97 of 1998 represent concrete steps towards human capabilities development and the promotion of innovation (Grobbelaar, 2007). These Acts support continuous learning within formal institutions through compelling organisations to invest specific amounts in their workforce skills development. The country further supports many industry clusters and institutions that play a crucial role in building effective national human capabilities through the diffusion of relevant knowledge and skills and incentives such as tax breaks, stimulus funds and the financing of other innovation activities.

Legislation such as the Public Finance Management Act 1 of 1999, Employment Equity Act 55 of 1998 and Labour Relations Act 66 of 1995 plays a crucial role in improving the institutional governance and interactions of the NSI. These laws ensure the effective management of government funds to reduce corruption and the maladministration of funds that are aimed at the infrastructural development and maintenance required by the NSI. A balance of skills from diverse ethnic groups is also promoted by these Acts. The Higher Education Act 101 of 1997 provided a good framework for reorganising the country's higher education to produce the required human capabilities, more specifically from science and technology, of the country's NSI. The adoption of the Immigration Act 23 of 2002 provided measures to secure skills and competencies through foreign recruitment, lifted the apartheid restrictions on mobility and eased the administrative workflow. It is within this context that human capabilities can be nurtured within an enabling environment supported by the right institutions for it to achieve the desired innovation outcomes (Oluwatobi, Ola-David, Olurinola, Alege & Ogundipe, 2016).

The capacity to develop, generate and deploy human capabilities in innovation processes signifies the evolutionary potential of the national system of innovation. Although lack of support for human capabilities development prevails, mostly in developing countries, which unsurprisingly correlates with the lower innovation performance of these countries. According to Scerri (2019), the systemic failure of governments and other relevant institutions to support human capabilities development continue to hinder economic transformation. This has left most of the developing countries heavily reliant on natural resources for economic performance and outputs. South Africa is no different in this regard.

In South Africa human capabilities and the country's innovation institutions are closely linked; for instance, the political, social and economic arrangements of the society largely depend on the country's institutions. Here institutions refer to both formally and informally established regulations, policies, strategies, norms or routines. These institutions have the power to improve human capabilities formation and development while also contributing towards eradicating all its barriers (Johnson, Edquist & Lundvall, 2003). There is no doubt that the lack of human capabilities development constitutes a formidable obstacle to the country's transitioning into a competitive global economy and building a dynamic economy (Scerri, 2019).

Human capabilities locality

Developing countries can address their development challenges through increasing their investment in human capabilities development. This has the potential to build the innovation capability that is required to drive economic growth and development processes (Oluwatubi, Ola-David, Olurinola, Alege & Ogundipe, 2016). The concept of human capabilities offers an integrated and multidimensional approach to various elements that determine the country's NSI capabilities and economic growth (Scerri, 2019). This approach shows that policy formulation focusing on education as the sole determinant of NSI is a problem and that the provision of housing, food schemes, free education, health services and other infrastructure are key systemic determinants of the country's human capabilities development (Oyelara-Oyeyinka & Barclay, 2004). It is the concept of human capabilities that draws attention to the specific location of human capabilities.

The family unit or household is the location of human capability. According to Scerri (2019), this family unit or household should become the focal point of human capabilities development

policies if the country is to safeguard its structural integrity and ensure a sustainable supply of human capabilities to the NSI. Watkins, Papaioannou and Kale (2015) indicate that the success of a country's economic development is attained through having an NSI that is rich in human capabilities. This will position the NSI to acquire, absorb, diffuse and use modern technologies. It is within this context that heavy investment by the government in human capabilities through the provision of multidimensional services to family units is essential and emphasised. This is because human capabilities are both public and private goods offering returns for individuals in the form of higher lifetime incomes and public returns within the context of the NSI. According to Scerri (2019), the investment period for human capabilities should normally run over a period of eighteen to twenty years, from the birth of a child to the manifestation of the first returns as income. This is because, over these periods, the human capabilities formation is subject to many disruptive factors that are likely to affect the condition of life of the individual and family units.

Taking into account the current rise in unemployment, deepening poverty levels and greater numbers of people relying on government food and social livelihood programmes, one may argue that South Africa has not fairly and adequately reformed the country's political economy. The majority of the country's lower-income, unskilled and less-skilled black population still grapple with the problems that they experienced during the apartheid era. However, this is not surprising because empirical evidence shows that the historically formed institutions of a country have failed to develop the required human capabilities. These historically shaped patterns continues to determine the evolutionary path of the country's NSI which preserves its exclusionary element of the majority of previously marginalised people (Oyelara-Oyeyinka & Barclay, 2004).

The democratic government's failure to eliminate some of the residual elements of apartheid NSI is considered one of the key elements in the continued exclusion of the majority of the black population from innovation and economic activities. The historically determined forms of discrimination based on class, gender and ethnic lines prevail within the South African democratic context and in the presence of constitutional rule (Scerri, 2019). One of the major contributors to the exclusion of the majority black population in South Africa from participation in innovation activities is the apartheid regime and its racial institutions.

According to Scerri (2010), the continued exclusion of the marginalised lower-income groups from innovation activities and economic opportunity is also considered the result of some residual elements of apartheid. The unjust and racially skewed regulations that preserved jobs for the minority whites and excluded the majority of black people during apartheid remain major determinants of today's persistent exclusion. The residual elements of these racially exclusionary measures are persistent due to the path dependency of the political system and its institutions. These elements continue to hinder the evolution of the country's system of innovation because their exclusion of the majority of black people systemically affects the development of the country's entire human capabilities and innovation system.

In South Africa social security welfare is primarily aimed at improving the lives of the South African population, which will lead to human capabilities formation and protection. Once basic needs are met, the society will achieve self-sustainability. South Africa has excelled in providing for the basic social, health and economic needs of the majority of South Africans, more specifically those in dire situations. However, this needs to be done in a well-planned manner to leverage the provision of these services. It could entail free RDP houses or subsidies for low-cost housing for renting. If the government can leverage the value of government expenditure, it will consequently benefit from such investments through huge sales and purchases of other services (Abrahams & Pogue, 2018).

Ongoing rigidities in domains of S&T and innovation capabilities

The global accumulation of science, technology and innovation has helped in transforming the livelihoods of the majority of people across the world, though the benefits of STI are not fairly shared or distributed among all the beneficiaries (Maharajh & Kraemer-Mbula, 2010). Research indicates that a huge percentage of the population continues to experience major development challenges amid the popularisation of STIs. However, the successful implementation of STI through acquisition, adaptation and absorption of technical expertise has significantly contributed towards strengthening local technical capabilities, leading to rapid economic growth and industrial development. It has also increased productivity levels, good management and the utilisation of some technical expertise, closing the technology divide between developed and developing nations (Salami & Soltanzadeh, 2012). Most African countries, including South Africa, still lack the relevant capabilities to close the gaps and overcome discrepancies in innovation performance with developed countries.

Innovation capabilities may be in the form of either technological or social capabilities (Vasen, 2017). Technological capabilities are defined as the information and relevant technical, managerial and institutional skills that allow productive firms or individuals to keep using and developing the equipment and technology. These capabilities are assessed in terms of the individual's or firm's ability to spot and identify technological needs. These technological capabilities may further be distributed or shared via training and education and through personal exchange (Oma, Takim & Nawawi, 2012). Technological capabilities are a reflection of human factors within the economic and innovation system. These capabilities are considered to be restrictive and narrowed to the skills that the country's population possesses (Scerri & Maharajh, 2013).

Social capabilities are described as the capacity to establish some form of institutional reform that is likely to determine the economic growth rate and social improvement of the population. Social capabilities are important to introduce institutional instruments that will likely allow for and facilitate technical changes in the innovation system (Freeman, 2022). It is now recognised that any technological development that fails to address societal issues is problematic (Vasen, 2017).

South African schooling system transformation and NSI

The country's heavy investment in knowledge accumulation is more important than physical capital accumulation (Freeman, 2002). South Africa has managed to reform and create linkages in the fragmented educational system to ensure equal accessibility to the education system which was racially divided during the apartheid era. Since the advent of democracy in South Africa the country's educational system has experienced radical reformation. This was shaped not only by the inherited apartheid legacy but also by the constitutional approval to transform the country's social system as a whole (Maharajh, Motala & Scerri, 2011). The provision of basic free primary and secondary education was an imperative step in addressing the shortage of human capabilities (Oyelara-Oyeyinka & Barclay, 2004).

The establishment in South Africa of the Council for Higher Education to ensure quality higher education was also a remarkable accomplishment in the effort to build the institutional capacity and capability of the country's NSI. The Higher Education Quality Council ensures the provision of a quality higher education system. While the metamorphosis of the educational

system has rightly garnered accolades, some major transformation processes are still needed to effectively address prominent societal problems.

Educational systems in Africa, including South Africa, are still linked to colonialism and apartheid and mainly produce white-collar labour for the primary purpose of administering such colonies. Investment in technical and vocational schooling and training remains insufficient. Academic education is still considered the exclusive platform for social and economic mobility (Oyelara-Oyeyinka & Barclay, 2004). South Africa yet suffers from the impact of poor educational policies that fail to build competent and skilled teachers. This is caused by the inadequate provision of relevant knowledge generation infrastructures. The tertiary educational system in South Africa remains poorly designed because it produces less competitive graduates and learners relevant to the country's NSI needs. This system is a stumbling block to the country's efforts to take advantage of the knowledge economy (ASSAF, 2013). Not only are the basic and secondary educational levels poor, but the higher education system also fails to enrol sufficient students in the science, technology, engineering and mathematics (STEM) streams. This has left the best education in the hands of a few minorities.

The government should use its scarce resources to initiate institutional reforms to reduce the administrative burden of the educational system in South Africa. This will provide the lower-income population with the opportunity to participate in innovation activities through having equal access to education systems and knowledge accumulation. The development of innovation capabilities and knowledge diffusion should be emphasised by the government, specifically for the marginalised lower-income people. It is within this context that it is important to understand that information is crucial in informing policy makers in the decision-making process (Kraemer-Mbula, 2006).

Innovation funding

Post-apartheid South Africa has done better at promoting investment in innovation than the previous government through opening up socio-economic opportunities for those previously excluded, although research studies indicate that the country's investment in science, technology and innovation is not yet ideal or even enough. Innovation funding in South Africa remains a big issue when compared to that of developed countries. The country's investment in research and development and STI is currently less than the national target of 1% of the total

gross domestic product (GDP) (NACI, 2006). The government should expand its role either directly or indirectly in the provision of innovation incentives. It is important to understand that organisations and entities require the capacity to secure and absorb such incentives. The government should provide these organisations with the relevant skills and capacities to absorb the incentives (ASSAF, 2013). The issue of financial systems is very important in the promotion of innovation activities and processes. Those developing countries that want to enjoy the benefits of technology development should rely on their financial systems to ensure that their organisations actively invest so as to allow greater returns on their investments in innovation activities (Freeman, 2002).

Innovation funding in South Africa faces several challenges and this has contributed to lower innovation performance and outputs. One of the major prevailing challenges is that most innovation funding institutions use mainstream models to define the legitimacy of knowledge. This has a negative impact in terms of what must be excluded from formal registers, laboratories and patent offices. The knowledge that mostly emanates from the society and its people in the form of indigenous knowledge or tacit knowledge is excluded from these established formal registers and will not receive funding (Mphahlele & Scerri, 2016).

Conclusion

The chapter outlined in detail the historical transitional processes of the South African national system of innovation since the advent of democracy which led to the adoption of the RDP and several White Papers on science, technology and innovation. These processes are considered to have significantly contributed to the promotion and evolution of the country's NSI. The adoption of Washington Consensus policies as the foundation of planning the country's economy has proven to be a stumbling block in the achievement of the desired structural transformation. These policies have contributed towards the narrow adoption of the NSI which focuses exclusively on science, technology and production systems. They have further curtailed the achievement of social improvements for the majority of South Africans, especially black South Africans. It is emphasised that the political transformation of a country should be accompanied by socio-economic and technological transformation (Lundvall, 2016). The chapter covered the dimensions and dynamics of the South African NSI to offer a broader understanding of how it has transformed and continues to experience challenges. This chapter

provided a holistic exploration and review of the South African NSI and how far the system is from being inclusive.

The next chapter adopts an inclusive innovation conceptual framework to provide an in-depth analysis and interpretation of the South African NSI. This will further help to answer the main research question of this research study, namely how inclusive innovation can contribute towards the development of the South African NSI, by considering some key elements of the conceptual framework.

CHAPTER 5: SOUTH AFRICAN ECONOMY AND NATIONAL SYSTEM OF INNOVATION

Research findings

From the research and data presented in this study it is evident that while there has been marked improvements to South Africa's NSI since the advent of democracy, making it more inclusive of previously marginalised groups, it still harbours major elements of apartheid and continues to protect and advance the interests of minority capitalists. The country's structural formation remains centralised and exclusive of the majority lower income communities.

Secondly, the research analyses and findings show that the adoption of neoliberal policies in South Africa have inhibited the access of the majority of the marginalised people to innovation activities and the concomitant benefits. The country's priorities and planning from a neoliberal policies base have captivated the country's efforts through the reduction of state expenditure, application of austerity measures, etc., which only seek to advance the interests of Washington policies and institutions. These policies have resulted in many marginalised people being left out of the economic opportunities flowing from them. The country's economic growth under these policies has failed to meet the target of absorbing enough labour from the previously marginalised population. Policies such as the NDP have not yielded the required economic growth and development, as evidenced by this research study.

Thirdly, it was found that the country's innovation system was still perceived to regard the government, private sector and universities as the main innovation actors. There is insufficient support for grass roots innovators that generally have no scientific knowledge. Yet these innovators are able to initiate non-scientific innovation activities that usually are better positioned to address their societal needs.

Fourthly, it was clear that the country's spatial post-apartheid economic zones perpetuated disparities in terms of resources and infrastructure for innovation activities. Provinces such as Gauteng with urban areas like Pretoria and Johannesburg, KZN with the city of Durban and lastly the Western Cape with the city of Cape Town, are better equipped with relevant innovation resources and are considered centres for South African mainstream innovation activities.

Fifthly, the efforts by the government to move away from the foreign neoliberal policies and investments of the West have resulted in stronger international relations with China and other Asian countries. This has not significantly boosted the country's economy due to the power balances between South Africa and the other nations. While major economic opportunities arose from these relationships, the importation of cheap innovation products from China and other Asian countries has collapsed many of the local manufacturing industries.

Concluding remarks

From the research study's analyses and findings it can be concluded that the inclusive innovation approach and its model provide a better framework of review to determine if the country's innovation system is inclusive or not. It is evident that the inclusive innovation approach in South Africa stands a greater chance to evolve the country's innovation system to be inclusive. This is because inclusive innovation ladders outlined in this research study better reflect key elements such as structural and post-structural levels where the country's system of innovation is found wanting. The study established that South Africa's human capabilities were captivated by human capital. This has resulted in a major focus on science, research and development as the key elements of the functionality of the NSI, while neglecting other non-research elements of innovation systems.

Clearly inclusive innovation is the innovation model most likely to expand the economic landscape of South Africa beyond mining extraction and traditional agriculture. This model, if promoted by the government, could generate substantial economic opportunities for the majority of South Africans, particularly through providing them with access to unexplored economic markets such as ocean economy, renewable energy sectors, etc.

The inclusive innovation framework provided evidence, in the form of supportive research, that the South African NSI was not fully inclusive of the marginalised lower income groups. There is still some way to go in using the knowledge of the marginalised and also in post-structural elements of the country, if the economy is to grow at a pace that would absorb the majority and improve their socio-economic status.

Recommendations

By consolidating the key elements of the research findings and conclusions drawn from this research study, it is recommended that the government, private sector and policy makers should take measures to link, or remove the separation elements of, the country's dual economies (formal and informal). This will offer a platform to capture innovation activities from both economies, thus ensuring that processes are planned to fit and benefit the economy as a whole.

To this end, it is recommended that innovation actors adopt inclusive innovation frameworks/ladders as their innovation system frame of review. This is because inclusive innovation approaches offer key conceptual elements to address exclusion from the who, how, what and where perspectives.

It is also recommended that South Africa should scrutinise the country's innovation policies to fully remove the residues of exclusiveness and ensure that innovation policies put the marginalised lower income people at the centre of the innovation process. Innovation policies and administration elements restricting the entry of small innovation actors into the innovation space need to be eliminated. An example is the relaxation of the water purification process which reduced water prices and made purified potable water accessible to the majority of South Africans, mainly those in lower income communities.

Government should allocate resources to capture innovation activities in the formal and informal economies through merging them. This is likely to expand the country's economy through the collection of revenue, mostly in informal economies where there are currently major tax loopholes.

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