Mapping the National System of Innovation in Eswatini

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Abstract

This study maps the national system of innovation (NSI) in Eswatini using national research and experimental development (R&D), and innovation surveys. The study identifies the actors and activities in the NSI. It finds that investment in knowledge creation is very low; expenditure on R&D is 0.26% of GDP, while knowledge flow mechanisms between university and industry are weak. It also found that there is a low capacity of science, technology and innovation (STI) personnel in especially the fields of science and engineering. Additionally, the study found that a lack of resources, access to information and technology, limitations of policy, and inflexible regulation inhibit innovation in Eswatini. As a result, only 52% of the surveyed firms reported having come up with innovations, with more than 50% of the innovations originating from outside the country. These findings indicate that Eswatini's NSI is relatively underfunded and weak. Efforts to augment the performance of the NSI in Eswatini should focus on developing a national STI strategy and establish appropriate institutions and innovation funding mechanisms. The government should strengthen its STI governance and provide a conducive environment for innovation within an STI framework that addresses national challenges and leverages on national resources and capacities.

Keywords: Innovation; Science, Technology; Eswatini.

1. Introduction

The past decades have highlighted the pivotal role of innovation systems in long-term economic development. Illustrated by the transformative growth of Singapore and South Korea between 1960 to present, the concept of national systems of innovation (NSI) has gained popularity in public policy. Innovations assist countries to design, build, and deploy technologies that solve development challenges, empower communities, improve industrial competitiveness, and contribute to economic growth. In contrast, the application of the concept in the African continent is relatively new and continues to lag behind, despite its growing importance. For instance, literature (see for example Guimon, 2013; OECD, 2005; Arocena and Sutz, 2000; Watkins *et al.*, 2015) shows that the NSI of developing countries are weak and characterised by frail structures and institutions, inadequate infrastructure, and stagnant economies, which has resulted in low industrial and economic development. In Eswatini, economic development has remained very low over the years (CSO, 2015). The gross domestic product (GDP) of the country has declined from an average growth rate of 2.7% in the 2000s to a low 1.7% in 2015 (CBS, 2016; CSO, 2015). Edwards *et al*. (2013) relate this to a stagnant business environment. Low technological readiness and innovation are contributing to low global competitiveness (see Schwab and Sala-i-Martin, 2016). Although science technology and innovation (STI) has been acknowledged as a driver of socio-economic development in national and regional frameworks that Eswatini is a signatory to, this has not accrued to significant social and economic development gains. Poverty remains high at 63%, unemployment is at 28.1%, and food security is an issue. Similarly, the World Bank (2013) observes that Eswatini's economy is characterised by declining competitiveness and an unwillingness of exporters to invest in discovering new export products. Confounding the issue is that Eswatini's industry is characterised by a small-medium enterprises (SME) sector that is involved in low-value addition (Edwards *et al*., 2013) and dependent on government as the main consumer.

Given the economic stasis that Eswatini is in, there are many economic opportunities that could accrue to the country by developing an understanding of its NSI. This is especially pertinent given the bold steps and investment made towards using STI to drive economic and social development in Eswatini. Against this backdrop, the main goal of this study is to map the NSI of Eswatini in a bid to understand how the country can use STI to drive socioeconomic development.

The paper contributes to existing literature by providing information on the NSI of Eswatini, which has not been done before. The study identifies the key actors, interactions, and linkages in Eswatini's NSI and provides a description of the current state of the research and experimental development (R&D) system and the level of innovation. The results of the study are of immense importance to policy makers given the country's aspirations to use STI to drive economic and social development and the desire to emerge as a developed economy by 2022.

2. The National Innovation System

2.1. A conceptual framework

There are many definitions of the NSI. Christopher Freeman defines the NSI as 'the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies' (Atkinson, 2014, p. 1). Freeman emphasises the diversity of actors whose interaction and collective agency leads to a single goal, which is technological change. Bartels *et al*. (2012, p. 6) define the context of the NSI as an 'envelope of conforming policies as well as private and public organisations, their distributed institutional relations and their coherent social and capital formations, that determine the vector of technological change, learning and application in the national economy'. This definition gives meaning to the importance of national institutional frameworks, the macroeconomic environment, public and private actors, and their interactions that define the innovative capabilities, and performance of a country. The NSI underscores the process of interaction, knowledge creation, and technology transfer as embedded in the social, cultural, political, and economic context of a country. As a result, many countries are realising the need to understand and strengthen the functionality of their NSI to leverage STI for sustainable development.

The NSI describes how nationally bound institutions support and facilitate technological change and the emergence of innovations (Lundvall *et al*., 2009). Actors of the NSI support and facilitate innovation by i) performing R&D, ii) financing R&D, iii) human resource development, iv) technology transfer and diffusion, v) promoting entrepreneurship, and vi) formulating technology and innovation policy (Chen, 2010). Successful technological learning and innovation within the system emanate from the continuous feedback loops between and among the different actors and institutions in the system (Watkins *et al*., 2015; Seidel *et al*., 2013). The coherence, integration, and collective agency in the activities and functions of NSI actors are important for the efficient and
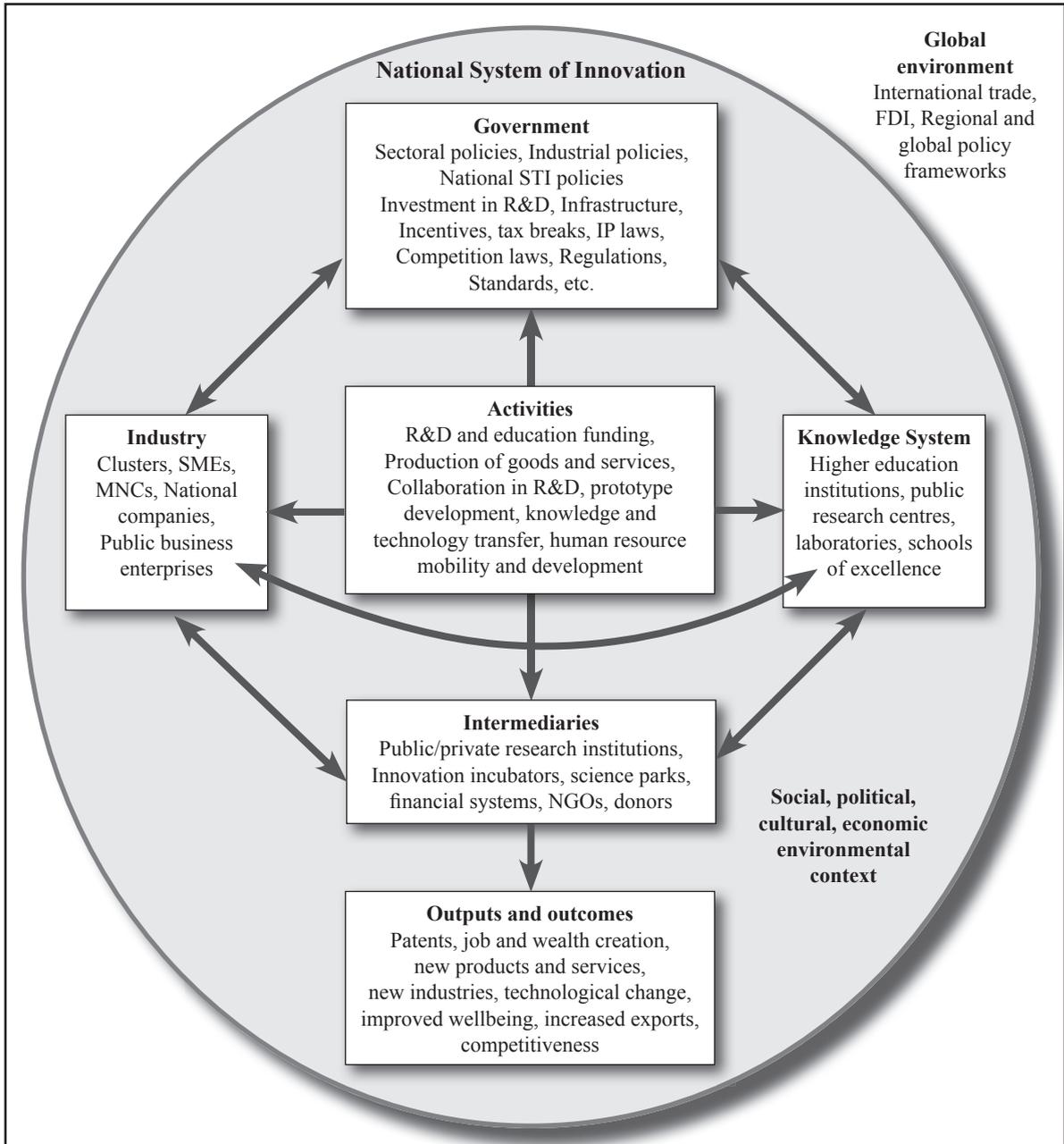
effective performance of the system. For this reason, innovation systems are based on the conceptual understanding of the elements and components of the system and the complex relationships of collaboration, communication, and interaction.

Innovation systems are important as a tool and framework for policy development (Metcalf, 1995; Teixeira, 2013; Watkins *et al.*, 2015). In particular, they assist policymakers to identify gaps in the system and leverage on areas for policy development at national level. As such, the Southern African Development Community (SADC) Regional Indicative Strategic Development Plan (RISDP) calls on countries to strengthen their NSI to drive development through STI (SADC, 2004). This is because it is the combination of a country's national policies, education system and its industrial structures, networks, and culture that influence its development (Freeman, 1995). Therefore, given that innovation is a dynamic and non-linear process (OECD, 1997) the NSI assists countries to relate STI to socioeconomic development (NPCA, 2014), and overall macroeconomic policy. Understanding such constructs enables countries to channel scientific and technological learning and solve development challenges through strategic policy frameworks.

Figure 1 illustrates a generic model of the NSI. The diagram shows the importance of institutions and organisations in supporting the activities of the NSI. The diagram of the national system of innovation is based on the Triple Helix Model (Etzkowitz and Leydesdorff, 2000; OECD, 1997; Seidel *et al.*, 2013). The model identifies government, industry and academia (the knowledge system) as the fundamental actors in the system. Intermediate institutions facilitate knowledge and technology transfer through for instance, the provision of financial and other support for entrepreneurs (Edquist and Hommen, 2008). Science parks and incubators provide platforms for the commercialization of R&D outputs and the production of new goods and services, alongside the provision of support for industrial research. The back and forth process of creating and exploiting new ideas and technologies to produce efficient businesses and production processes, and manufacture new goods and services drives economic growth. Hence, industry does not innovate in a vacuum (Mahroumn and Al-Saleh, 2013). For example, the provision of adequate skills to enable the exploitation of STI and the adoption of new technologies to improve company competitiveness and performance is usually a function of the government. To that extent, the relationship between the knowledge production system and the government is foundational for the capacity for industry to innovate. To keep

this relationship, open, governments use policies that offer the private sector a variety of incentives for engaging in R&D and other innovation activities. In this way government plays a key role in creating markets and partnerships that will create new innovations (Mazzucato, 2015).

FIGURE 1: DIAGRAM OF THE NATIONAL SYSTEM OF INNOVATION

National System of Innovation

Global environment
International trade, FDI, Regional and global policy frameworks

Government
Sectoral policies, Industrial policies, National STI policies
Investment in R&D, Infrastructure, Incentives, tax breaks, IP laws, Competition laws, Regulations, Standards, etc.

Activities
R&D and education funding, Production of goods and services, Collaboration in R&D, prototype development, knowledge and technology transfer, human resource mobility and development

Industry
Clusters, SMEs, MNCs, National companies, Public business enterprises

Knowledge System
Higher education institutions, public research centres, laboratories, schools of excellence

Intermediaries
Public/private research institutions, Innovation incubators, science parks, financial systems, NGOs, donors

Social, political, cultural, economic environmental context

Outputs and outcomes
Patents, job and wealth creation, new products and services, new industries, technological change, improved wellbeing, increased exports, competitiveness

Source: Authors' own depiction

To facilitate the importation of advanced technologies for the conduct of scientific research, governments promulgate policies that are pro-international trade, provide a conducive environment for foreign investors, and become signatories of both regional and global policy frameworks which provide a portal for any country to be part of the global innovation system (GIS). Accordingly, national innovation capacities and absorptive capabilities are vital for the effective use of modern technologies (Castellacci and Natera, 2013). From Figure 1 it is clear that knowledge production, acquisition, diffusion, and adoption are fundamental components of the innovation system. As well, university-industry linkages facilitate and increase technological growth, knowledge adoption and transfer. They foster the development of absorptive capacities for new knowledge and technology through the production of a skilled labour force, demand driven research, and spin-off companies (Guimon, 2013; Guan and Zhao, 2013). University-industry linkages have a direct impact on economic development and the sustainability of communities.

In the development of a functional NSI, the role of the government is clear: it is in the provision of policies, institutions, and a conducive environment for the efficient adoption and use of modern technologies in industry to drive economic and social development. As economies grow and diversify, the knowledge production system becomes more important in supporting the dynamism and diversity of local firms to high technological capacities (Castellacci and Natera, 2013). But, just how does a fully functional NSI look like? Alternatively, how have other countries gone about setting up functional NSIs? In the next section, the study undertakes a non-exhaustive review of the NSI in Singapore, South Korea, and South Africa with a view to providing a framework for understanding the gaps and opportunities in Eswatini's NSI.[1]

2.2. The National System of Innovation: A concept in Practice

The NSI has played a significant role in the development of South Korea, Singapore, Germany, Japan, and other countries, especially in the OECD. Wong and Singh, (2008) and Watkins *et al*. (2015) show that the development of these countries has been the result of evolving national systems of innovation. The technological acumen, global competitiveness, and the growth of these economies over time are illustrative of the importance of fully functional NSIs. Nevertheless, the NSI is not a one size fits all concept (Kayal, 2008), individual countries need to develop their own NSI based on their development goals. This

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[1] South Korea, Singapore and South Africa were selected based on distinctive characteristics of functional NSI and research systems from which lessons can be drawn.

takes into consideration the natural resources and endowments of the country, its economic development strategy and social challenges. A review of NSI in a variety of countries reveals a number of key components of the NSI from which developing countries, like Eswatini, could learn.

2.2.1. The South Korean Model

South Korea has achieved its development through a concerted policy culture that emphasised the establishment of appropriate institutions and supportive legislature to develop national STI capacity. A lack of natural resources in South Korea led the country to invest in its human capital as its primary resource (Noland, 2011). As early as the 1960s, South Korea established its first government-funded science and technology institute, the Korean Advanced Institute of Science and Technology. South Korea's education system has played an important role in the accumulation of technical capabilities at the national level. To that extent, STI policy deliberately targeted investment towards STI infrastructure, science, technology, engineering, and mathematics (STEM) education and funding R&D activities.

To illustrate, South Korea's budget under the National Science and Technology Commission (NSTC), an institution that is in charge of STI policy formulation, implementation, and coordination, was US$16 billion in 2012, which represented 1.2% of GDP. In 2014, South Korea's expenditure on R&D was 4.29% of GDP (Eurostat, 2016), compared to 2.17% in the world. South Korea's R&D expenditure consists of strong linkages between university and industry, with private sector funding 76% of all R&D expenditure in 2013 (Gupta et al., 2013). In the same year, South Korea produced 54,000 researchers per million people, with scientists and engineers making 24% of the labour force. The government, private sector, and R&D funding institutions such as the National Research Foundation of Korea and the Ministry of Science, ICT and Future Planning provide funding.

In 1999, South Korea adopted an Act that established five specialised research councils to drive the country's long-term R&D investment in especially basic research in fields such as biotechnology and robotics (Lee *et al*., 2016). In addition, the government provides incentives for universities and research councils to be competitive in research and partner with industry. As well, the country has continuously supported its industrial development and technological growth through aggressive investment in human capital to accelerate learning and the assimilation of new knowledge and investments in new discoveries and creativity to create new markets.

2.2.2. The Singaporean Model

Just like South Korea, Singapore emerged as a global player in the global innovation system (GIS). This has come about through institutional and administrative frameworks that strengthen the national economy. In 1991, Singapore set up the National Science and Technology Board (NSTB) under the Ministry of Trade and Industry (MTI), with the primary mission of raising Singapore's capabilities in science and technology (S&T). In 2002, the NSTB was renamed as the Agency for Science, Technology and Research (ASTAR) to emphasise Singapore's development to a knowledge-based economy and the development of a highly intellectual workforce. ASTAR funds R&D, supports industry, and implements STI initiatives as informed by the national economic strategy.

Singapore's public spending on science and technology was US$16.1 billion (1% of GDP) for 2011-15 under the Research, Innovation and Enterprise (RIE) 2015 plan. This was for infrastructure, R&D, and human capital development. R&D funds in Singapore are largely from national sources. Institutions' own funds followed by the government were the highest sources of funds at 54% and 37% respectively. In 2013 R&D expenditure in Singapore was 2% of GDP. Private sector expenditure was 59% followed by government and public research institutions at 24% and higher education at 17% (ASTAR, 2014).

Country efforts have led to the growth of national capacities in R&D and increased innovation activity. Singapore has a high number of researchers, at 47,275 persons in 2013 with research scientists and engineers at 31943 (68%) and 28.4% being females. This population is largely youth, between the ages of 25-34 at 47% which add to the growing technical and knowledge base of Singapore's development. The country equally benefited from cooperation with the international community, through skill and technology transfer in R&D institutions and human resource mobility. As a result, firms that conduct R&D in Singapore were 699 in 2013 with 58% being local firms. This has led to the growth of highly technological firms, and contributed US$23.76 billion (6.375% of GDP) to the country's revenue through the licensing of new technologies and patents, and the sales of commercialised products or processes (ASTAR, 2014). From Singapore's experience, it is clear that national efforts are primal to an efficient NSI, and policy implementation is futile without the relevant allocation of resources, action points, and institutions to implement policy statements.

2.2.3 The South African Model

In South Africa, over and above policies that support the attraction of foreign direct investments into the country, the Department of Science and Technology (DST)

is responsible for coordinating and managing STI activities. The Department is responsible for all issues related to financing, procurement, regulatory, governance, and other policies that influence the innovation process (OECD, 2000). Other important institutions in South Africa's NSI are the state funded research councils, such as the Council for Scientific and Industrial Research (CSIR), Council for Mineral Technology (MINTEK), which specialises in mineral research, Medical Research Council (MRC), Human Sciences Research Council (HSRC) and the Agricultural Research Council (ARC). The Technology Innovation Agency (TIA) and the National Intellectual Property Management Office (NIMPO) are also important in the NSI as they assist industries in absorbing and assimilating technologies and R&D output.

The NSI in South Africa gets support from the country's vibrant and dynamic university system that plays a huge role in the development of human resources and in conducting research. South Africa's research personnel was at 48 479 in 2014/15. Researchers with a masters, honours and bachelor's degree were 56.4%, and 29.5% had PhDs (DST, 2017). South Africa's White Paper on Science and Technology highlighted the development of a technological economy. Thus the establishment of a Council on Higher Education (CHE) in 1998, technology transfer offices, incubators, and a number of funding instruments for the commercialisation of R&D outputs, which has fostered university-industry collaboration.

Presently, South Africa's private sector contributes 40.8% to funding R&D (NPCA, 2014), which is among the highest in the African continent. R&D as a percentage of GDP was 0.77% in 2014/15 (DST, 2017). A larger portion of R&D expenditure in South Africa is applied research with higher education performing most of the basic research 54.9%. One of the goals of the South African NSI is to develop an information society. The country's investments in its higher education infrastructure, robust research system, knowledge transfer mechanisms, and intellectual property laws are a means through which this will be achieved.

2.3. Summary

From the preceding discussion, three things are discernible. First, NSIs are vehicles for the implementation of social and economic development strategies. The review reveals that in all the three countries, country priorities are explicit on the R&D and innovation agendas; hence, the deliberate allocation of resources for STI activities. Industrial development in these countries has resulted from coordinated STI policies, incentives, and institutions embedded in the

bigger economic development strategy of the country. Second, these countries have successfully put in place concrete institutional frameworks and research institutions that are responsible for the conduct and commercialisation of scientific research. These institutions provide rules and regulations, incentives, and guide technological development at the national level. Third, in all the three countries, the STI initiatives of the government are corroborated by high investments in human and knowledge capital. These countries have invested highly in their education systems and in building a labour force that is STI oriented. These observations accentuate the interdependent roles of government, the knowledge system and industry in the triple helix of national innovation systems. In the next section we discuss the method undertaken to map Eswatini's NSI.

3. Method

Studies that map the NSI employ a variety of methods including the triple helix model and survey data (Arocena and Sutz, 2000; Carvalho *et al.*, 2015). The triple helix model singles out government, industry, and academia (the knowledge system) as the fundamental actors in the system. It explains the dynamic organisation of the interactions and subsystems in the innovation process (OECD, 1997; Seidel *et al.*, 2013; Etzkowitz and Leydesdorff, 2000). This study conducts a detailed national survey of the R&D and national innovation systems in Eswatini. Methods of data collection drew from the widely used Oslo manual for the innovation survey, and Frascati manual for the R&D survey. The manuals provide standard methodological guidelines on how to collect data using the two surveys to enable comparability of the results with other countries. Innovation and R&D surveys offer a comprehensive approach to mapping innovation systems in that they provide essential information on the general patterns of technological interaction and information production in the national system (OECD, 1997). This method is suitable for explaining the NSI in Eswatini because of the absence of previous information on the country's innovation system. Moreover, the quantitative aspect of the study provides fundamental STI indicators for evidence-based policy.

3.1. Data collection

Data was collected through self-administered R&D and innovation surveys (questionnaires). The innovation survey used a stratified random sampling technique. The sample was stratified according to the location (region), sector, and the number of employees. The sample size was 228 firms, with a confidence level of 95% and a margin interval of 5%. Company registries and business

yearbooks were used to mark the target population of firms and the survey response rate was 62%.

Similarly, the R&D survey sampled 150 R&D institutions in Eswatini. National registries and profiles of public and private institutions were used to identify R&D performers in four sectors, namely: (i) the government and public research institutions; (ii) higher education; (iii) private and non-profit; and (iv) business enterprise. The activities of the institutions, size, publications, previous and present participation in R&D activities, and general potential for R&D were considered in the selection criteria. Due to the absence of recorded R&D performers in the country, a purposive sampling technique was used for R&D performers in the business and private or non-profit sectors, and a census was conducted in government and higher education. A replacement method, using mainly the snowballing technique, was used to replace organisations that did not conduct R&D in the period 2015-2016, and the response rate was 82.6%.

The final picture of the NSI is painted by the combination of the two survey datasets, highlighting the different actors, functions and activities in the innovation process. The narrative focuses on extracting general patterns like the model presented in Figure 1. A descriptive analysis is, therefore, suitable to express the prevailing system of innovation in Eswatini. This is supported by qualitative data from primary and secondary sources. Insights in the observed characteristics compared to what exists in other countries are an important consideration for policy recommendations, thus the next sections present results from the surveys, a discussion of the results and policy recommendations.

4. Results: The National System of Innovation in Eswatini

4.1. Institutions and Institutional Frameworks

To understand the structure and composition of Eswatini's NSI requires an understanding of the institutions and institutional framework that direct technological learning in the country. This section gives a description of the institutions in the NSI and present the survey data.

4.1.1. Science and Technology Institutions

In Eswatini, the Department of Research, Science, Technology and Innovation (RSTI) at the Ministry of Information Communication and Technology (MICT) coordinates STI. Advisory and policymaking institutions in Eswatini's NSI include Government Ministries and Departments. The MICT plays the leading role followed by the Ministry of Education, the Ministry of Agriculture, the

Ministry of Natural Resources and Energy, the Ministry of Commerce Industry and Trade, and the Ministry of Economic Planning and Development. The Public Policy Coordination Unit (PPCU) is pertinent as a primary unit for policy making in the country.

In addition, Eswatini has some public institutions involved in R&D. The Department of Agricultural Research and Specialist Services (DARSS) (Malkerns Research Station) under the Ministry of Agriculture is the oldest research institution in the country. It was established in 1958 and focuses on agriculture research and services. The Eswatini Economic Policy Analysis and Research Centre (ESEPARC), established in 2008[2], is another institution that solely conducts research in the country, mainly economic policy research of which science technology and innovation are inherent. The National Health Research Unit established in 2005 coordinates research undertaken in the health sector. Some government Ministries, Departments, and Parastatals conduct research as a component of the work and services they provide. These include the National TB programme – in the health sector, the Eswatini National Trust Commission – focuses on conservation and biodiversity, and soon the Royal Science and Technology Park, which has an innovation incubator and biotechnology park.

Equally important to Eswatini's NSI are the technology support and regulation institutions. These constitute the Eswatini Standards Authority (SWASSA), Eswatini Energy Regulatory Authority (ESERA), Financial Services Regulatory Authority (FSRA), National Agricultural Marketing Board (NAMBOARD), and Eswatini Communications Commission (SCCOM), which regulate the manufacturing of goods, energy, financial services, agriculture products, and communication sectors, respectively. The Eswatini Environmental Authority (SEA) is responsible for environmental protection and safety, while the Eswatini Investment Promotion Agency (SIPA) is a key player in promoting investment in technology and innovative businesses. The Eswatini Competition Commission ensures a competitive business environment. In concert, these institutions play a vital role in regulating and directing STI activities in the country, providing information and guidance for technology development and research, thus impacting industrial development. The next section provides a review of the frameworks that direct the innovation process in Eswatini.

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[2] Although ESEPARC was established in 2008, it only started operations in 2012.

4.1.2. Institutional Framework

Institutional frameworks are the overarching governance tool for the innovation process and its activities; they outline the environment in which innovation occurs (World Bank, 2010). Eswatini has not established a national research agenda presently, nor has it developed specific R&D funding institutions, especially in government budget and policy. For the private sector, incentive structures are not clear. While it is stipulated in the Income Tax Order 1975 section t(i) and t(ii) that an amount of tax will be deducted from any research and development performer, it is not clear how claims are made and how much should be deducted from tax. Additionally, local firms and other R&D institutions are not aware of this law. Whereas the National Development Strategy (NDS) highlights areas of important research, such as in agriculture, natural science, production and design technology, and health, it does not articulate how this will be carried out or funded. As a result, the direction of technological innovation is not clear. Even though research and innovation activities are recognised on national strategies and ministry-specific strategies, coordination is difficult. Recall that in section 2, it was documented that South Africa, South Korea, and Singapore have developed national research strategies, and clearly identified priorities in their STI strategies. Given the lack of national priorities for STI it is challenging for the country to coordinate STI activities. Consequently, the STI system in Eswatini can be described as fragmented and lacking coordination. Unlike other countries (see section 2), Eswatini's core institution responsible for research is hidden under MICT, underfunded and under staffed.

Making the situation perverse is that STI activities contained in other national policies are not followed by implementation strategies and streamlining with other sectors. For example, while the Eswatini National Industrial Development Policy acknowledges the need to use STI in developing the country's industrial performance, the policy is not clear about the implementation of such activities. While it aims to increase value addition and industrial production through innovation, technology transfer, and R&D in the manufacturing sector (GoS, 2015), investment in modern technologies, R&D, and a highly skilled labour force does not corroborate these efforts.

Adding to the weak institutional framework is the country's intellectual property (IP) law. At the time of writing this study, the country's operational Patent Act came into force in 1936 while the copyright legislation is from 1912. Over and above the fact that such laws are old and outdated, they have an effect on the level of innovation in the country: innovators are exploited and

unprotected. Results from the national innovation survey show that between 2014-2016, only 11% of the firms reported securing a patent, 9% registered trademarks, 5% registered industrial designs, and 9% claimed copyrights, which is very low. In contrast, the licensing of new technologies and patents, and the commercialisation of R&D output have contributed US$23.76 billion (6.375% of GDP) to Singapore's revenue, paying to updated IP laws in the country. This illustrates that the amendment of the IP law in Eswatini could be instrumental in taking forward STI development.

4.1.3. Higher Education and Training

Institutions of higher learning and training are foundational in the production of knowledge and a highly skilled workforce. In Eswatini, this sector constitutes four (4) universities, and 70 Technical and Vocational Education Training (TVET) institutions of which 27 are public and 43 are private. The country has one public university and 3 private universities. These are the University of Eswatini (UNISWA), the Southern African Nazarene University (SANU), Limkokwing University of Creative Technology and the Eswatini Christian Medical University. The TVET centres and colleges include the Institute of Development Management (IDM), the Eswatini College of Technology (SCOT), Vocational & Commercial Training Institute - Matsapha (VOCTIM), Manzini Industrial Training Centre (MITC), Ngwane and William Pitcher Teacher's Training Colleges. The University of Eswatini and IDM are the only institutions that engaged in R&D activities during the review period. UNISWA has two research institutions: The Eswatini Institute for Research in Traditional Medicine, Indigenous and Medicinal Food Plants (SIRMIP) and the UNISWA Research Centre (URC), which conduct research. UNISWA also offers Master and PhD degrees whilst the other institutions offer degrees and lower certificates. The survey data showed that the higher education sector had the highest number of qualified research personnel. There are 101 PhD holders, of which 70 are male and 31 are female, and 94 Masters holders compared to 9 PhDs and 52 Master degrees in government. Nonetheless, the standard and quality of education has recently been defined by the Higher Education Council (HEC), established in 2015 through the adoption of a national qualification's framework in 2016, unlike other countries who long established theirs – for example South Africa established the Council on Higher Education in 1998. Moreover, STI education remains underfunded in the country, with a reported lack of equipment and adequate infrastructure (GoS, 2014; MoET, 2015) in TVET and other academic institutions. For instance, UNISWA reported that due to a

lack of funds, the university fails to provide an adequate research environment as it lacks equipment and machinery (UNISWA, 2016). This impedes the actual conduct of R&D in the country.

4.2. Research and Development (R&D)

Results from the R&D Survey show that Eswatini's Gross Expenditure on R&D (GERD) is E138, 560, 250.81 (Figure 2). This is only 0.26% of the country's GDP in 2016, which is lower than the continental target of 1% of GDP. Total business enterprise expenditure on R&D (BERD) was lowest at E 1, 021,763.00 (Figure 2). Most firms did not conduct R&D in-house. Generally, firms outsource R&D because of capacity constraints and lack of finances. Others, especially multi-national companies conduct R&D at the company headquarters or group level outside Eswatini. Government expenditure on R&D was the highest, at E55, 871, 019.73 followed by higher education at E43, 143, 216.89 and the private and non-profit sector at E38, 524, 251.20 (Figure 2). Worth noting is that the government further provides funding for R&D for higher education.

FIGURE 2: RESEARCH AND DEVELOPMENT EXPENDITURE BY SECTOR
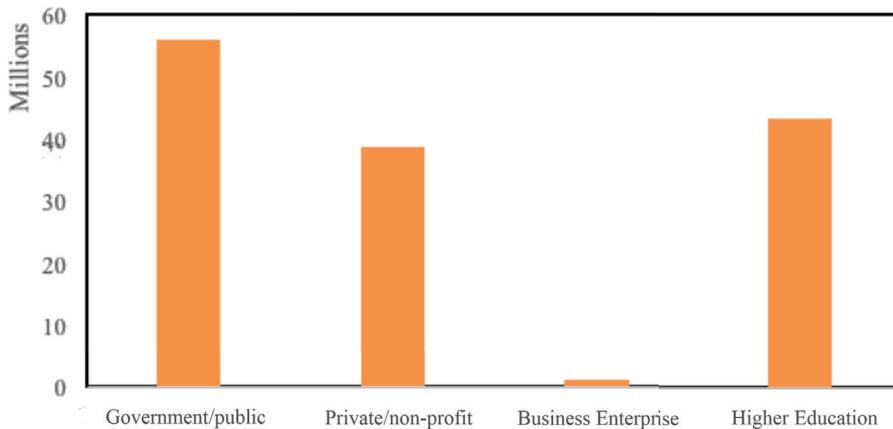
Source: Eswatini National R&D Survey (2017)

Local R&D institutions were found to be the largest contributors to the funding of R&D activities in Eswatini. Government or public institutions are the source of 41.7% of R&D funds, whilst foreign (mainly development) partners contribute (33.5%), business enterprises 1.6%, higher education 20.7%, and private or non-profit organisations contribute 2.5% of the total sources of R&D

funding. The study found that a big portion (64%) of the expenditure on R&D goes to labour costs, with low investment on capital goods like machinery and equipment at 7% and even lower on software at 1% (Figure 3).
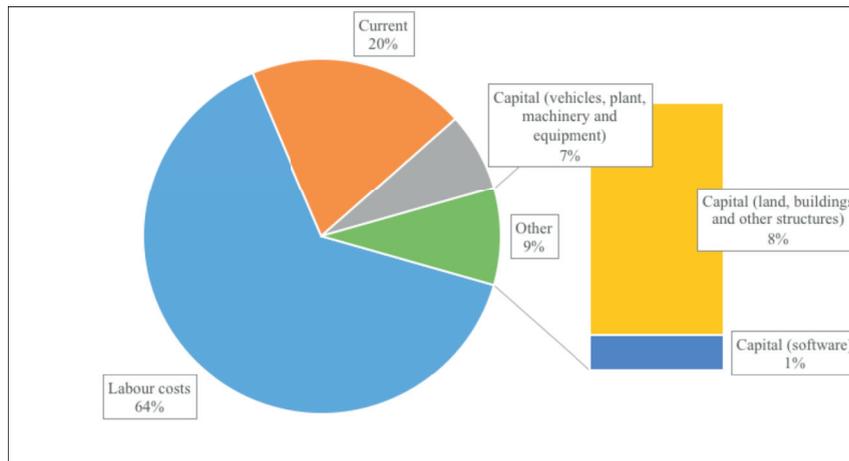

FIGURE 3: R&D EXPENDITURE DISTRIBUTED BY SECTOR AND ACTIVITY

Source: Eswatini National R&D Survey (2017)

There is a high correlation between the types of R&D performed in the country and capital investment. In particular, basic and experimental development research is associated with high investment in capital goods. Eswatini performs more applied research than it does basic or experimental development research (Figure 4). The government funds more applied than basic research, whilst higher education has relatively balanced funding in applied and basic research (Figure 4). Experimental development is very low in the R&D system in Eswatini. This could symbolise a lack of effective mechanisms and structures for the application of knowledge for the production of goods and services. For instance, the lack of subsidies could deter the conduct of experimental development R&D in the country.

In addition, the survey found that Eswatini's R&D expenditure is highest in the economic and business sector (41.13%) and lowest in agriculture at 5.51% for government and public research institutions. Private and non-profit institutions invest more in health sciences (67.16%), while business enterprises invest in electrical engineering and electronic engineering (47.5%) and agriculture (50%), and higher education in agriculture, forestry and fishery (26.36%). This suggests

that government R&D expenditure does not reflect the aspirations of the NDS which identifies agriculture, manufacturing, and services for STI development. Nevertheless, R&D is successful when coupled with a high calibre of skill and human capital.

FIGURE 4: R&D EXPENDITURE BY TYPE OF RESEARCH
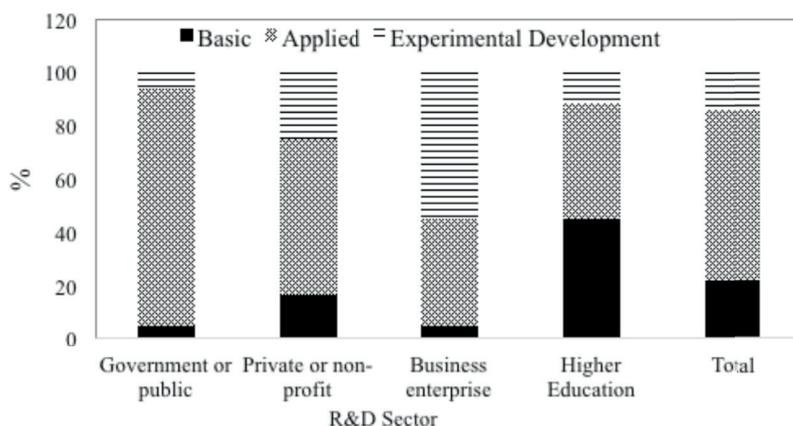
Source: Eswatini National R&D Survey (2017)

4.3. Human Capital Development

The type of R&D and work force are important in understanding the technological capabilities of a country. The innovation survey shows that firms that had innovations had a more skilled labour force (73%) than firms with no innovations (41%). The study found that there are 757 R&D personnel. Of this, 360 are researchers, 92 are technicians, and 305 are support staff. There are also more male R&D personnel than there are females, at 435 and 322, respectively (Table 1).

TABLE 1: HEADCOUNT OF RESEARCH AND DEVELOPMENT (R&D) PERSONNEL

Occupation	Male	Female	Total
Researchers	211	149	360
Technicians	52	40	92
Support	172	133	305
Total	**435**	**322**	**757**

Source: Eswatini National R&D Survey (2017)

There is a lower representation of women with postgraduate qualifications (PhD and masters) compared to bachelor's degrees (see Figure 5). In full time

equivalent (FTE), PhDs spend less time in R&D (39.92 FTE) compared to bachelors (82.51 FTE) and Master's degrees (74.36FTE). Overall, total FTE is 438.30, compared to a headcount of 757. This means that most researchers spend less time conducting research.

FIGURE 5: R&D PERSONNEL BY QUALIFICATION AND SEX
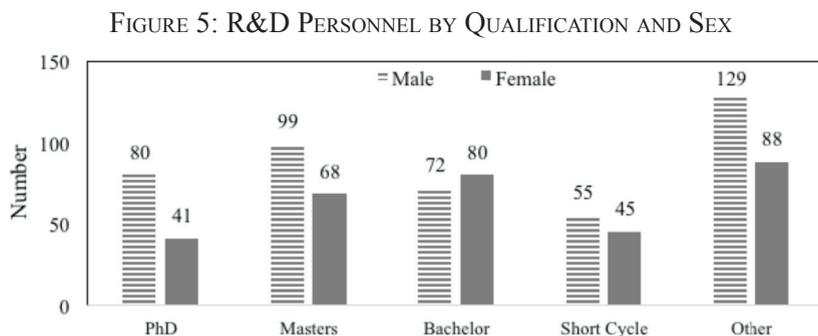
Source: Eswatini National R&D Survey (2017)

Scientists and engineers are the main players in the advancement of science and technology, especially in the development and adoption of technologies. Yet, R&D capacities are very low in engineering and natural sciences (Table 2), making 9.5% of the total R&D personnel; these figures are even lower for women. This compromises the achievement of an STI driven economy and industrial development. The largest R&D personnel is in agriculture, also reflected by its high enrolment at UNISWA. The agricultural sector is male dominated unlike the health and social sciences, which are female dominated (Table 2).

Similar to Singapore and South Africa (see ASTAR, 2014; DST, 2017), Eswatini has a relatively youthful research labour force with the largest group between the ages of 25-34 years old (43%) followed by those in the 35-44 years category (23%) (Table 3). The group under 25 years is low, at only 11%. However, the Eswatini Labour Force Survey shows that there is a low absorption of youth in industry (MoLSS, 2013) and high youth unemployment (51.6%). This is compounded by a disconnect in skill demand and supply and a reported brain drain in STI.

4.4. The innovation environment

R&D capacities and skill development are vital where knowledge and skill produce products and services that improve lives and facilitate development. As a result, governments strive to always provide a conducive innovation environment. However, the innovation survey reveals that in Eswatini no company received any form of financial support for their innovations from

TABLE 2: RESEARCH PERSONEL BY FIELD OF SCIENCE AND SEX

Field of science	Government or public			Private or non-profit			Business enterprise			Higher education			Total		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Natural Sciences	11	2	13	5	2	7	0	0	0	59	10	69	75	14	89
Engineering and Technology	2	0	2	4	2	6	14	0	14	20	10	30	40	12	52
Medical and Health Sciences	2	4	6	25	49	74	0	0	0	16	33	49	43	86	129
Agricultural Sciences	113	47	160	3	5	8	1	0	1	37	7	44	154	59	213
Social sciences	37	40	77	13	19	32	0	0	0	13	16	29	63	75	138
Humanities and Arts	2	0	2	1	6	7	0	0	0	4	3	7	7	9	16
Not specified (inter or multidisciplinary)	18	10	28	28	42	70	3	3	6	4	12	16	53	67	120
Total	**185**	**103**	**288**	**79**	**125**	**204**	**18**	**3**	**21**	**153**	**91**	**244**	**435**	**322**	**757**

Source: Eswatini National R&D Survey (2017)

Notes: M and F denote male and female, respectively.

TABLE 3: RESEARCH PERSONEL BY AGE AND SEX

Age category	Government or public			Private or non-profit			Business enterprise			Higher education			Total		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
under 25	30	24	54	6	11	17	5	0	5	4	5	9	45	40	85
25 - 34	59	44	103	54	96	150	10	2	12	33	30	63	147	172	328
35 - 44	56	23	79	15	14	29	2	1	3	42	18	60	115	56	171
45 - 54	36	10	46	3	4	7	1	0	1	38	19	57	78	33	111
55 - 64	4	1	5	1	0	1	0	0	0	29	17	46	34	18	52
65 and more	0	1	1	0	0	0	0	0	0	7	2	9	7	3	10
Total	**185**	**103**	**288**	**79**	**125**	**204**	**18**	**3**	**21**	**153**	**91**	**244**	**435**	**322**	**757**

Source: Eswatini National R&D Survey (2017)

Notes: M and F denote male and female, respectively.

government. Likewise, Figure 6 shows that the biggest barrier to innovation in Eswatini is the lack of financial resources. Other barriers to innovation in Eswatini include the lack of STI policies and regulations, and information on technology. This suggests an absence of or a lack of knowledge of initiatives supporting firm-level innovations in terms of regulation, funding, support structures, and incentives. As a result, 64% of the product and 56% of the process innovations originated outside the country while 12% of all innovative firms abandoned their innovations.

FIGURE 6: BARRIERS TO INNOVATION
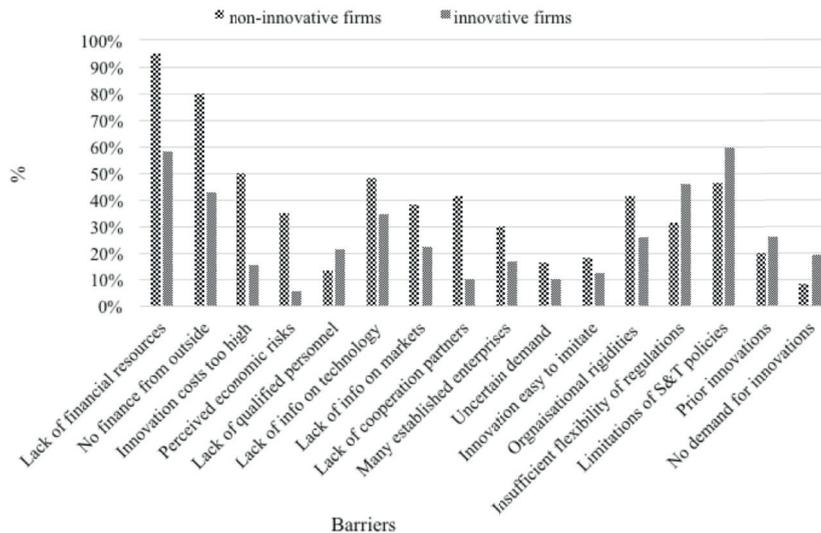
Source: Eswatini National R&D Survey (2017)
Notes: Finance from outside refers to external sources of funding which may include venture capital, partners or public sources of funding

The innovation environment in Eswatini has proven to be unfriendly to new innovators. Figure 6 shows that non-innovative firms experience more barriers than innovative firms do. For instance, the lack of qualified personnel is more of a barrier to innovative firms while the lack of information on markets and collaboration partners is more of a barrier to non-innovative firms. The survey further demonstrates that there is a lack of trust in the business environment in Eswatini, as local firms mostly developed their own innovations or worked with staff from their subsidiaries, sister enterprises or headquarters on innovations than they collaborate with other entities. Brixiova *et al.*, (2014); UNDP, (2013) and MoSCYA, (2015) identify a number of barriers that hinder entrepreneurship

in the country, including networking, regulation, lack of access to information and finance, lack of skill and a low culture of entrepreneurship which all hinder innovation.

4.5. Interactions and Linkages

Whilst interactions are essential to the flow of knowledge and skills, in Eswatini collaboration is largely one-sided, with government interacting with higher education and the private or non-profit sector. The government receives funds from the business sector but does not fund it, denoted by the homogeneity in the bars on Figure 7. Additionally, university-industry linkages are silent. Whereas countries like South Africa, Singapore, and South Korea have strong university-industry linkages that are central to efficient innovation processes, Eswatini does not. This is corroborated by the innovation survey data on Figure 8 that shows that local firms are less engaged in collaborative activities with higher education institutions, at (10%). Similarly, R&D is largely conducted in isolation. As well, research departments are either not fully operational or where they are, they focus on conducting market research. This inhibits the benefits that could accrue from interactive learning and experimentation between different institutions.
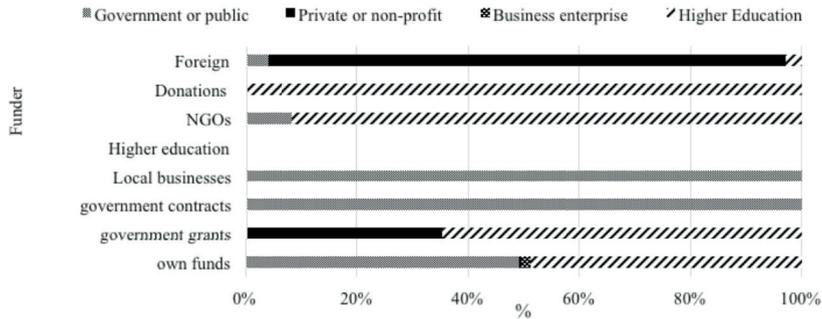

FIGURE 7: SOURCES FOR R&D FUNDING

Source: Eswatini National R&D Survey (2017)

Figure 8 shows that international collaboration in innovation activities is very weak, especially with the governments of other countries. The diagram shows that collaboration is skewed towards the rest of Africa, especially in the supply of equipment and materials, and the use of consultants and private R&D institutions. National statistics on imports and exports identify South Africa as the main collaborator in the supply of goods and services for Eswatini

(CBS, 2016). Furthermore, Figure 8 shows a lower acquisition of supplies and equipment within national boundaries. Local firms depend on the international markets to source consultation services. This signifies low industrial production of equipment and material and an inadequate supply of R&D institutions and skilled consultants locally. This is illustrative of an underdeveloped industrial sector, characterised by a high importation of inputs.

FIGURE 8: FIRMS COLLABORATIVE PARTNERS FOR INNOVATION
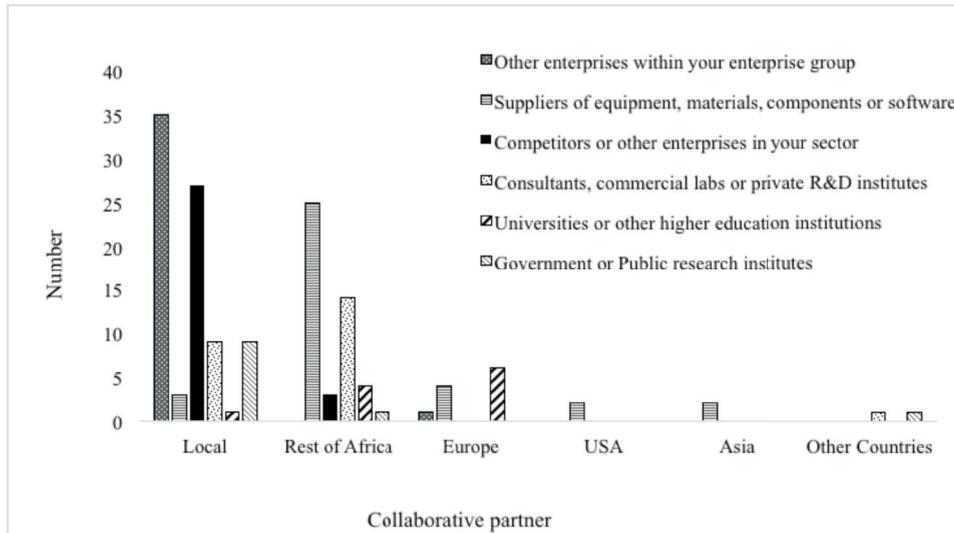
Source: Eswatini National R&D Survey (2017)

The dissemination and diffusion of knowledge is an important component of knowledge and technology flow in NSI literature (Carvalho, *et al.*, 2015). Technology flow mechanisms are strongest through knowledge embodied in human resources and organisational structures (57%). Table 4 shows that external sources such as suppliers, customers, competitors, and consultants are important mechanisms for knowledge flow in the NSI. Government institutions follow at 19% and industry associations at 17%. Plus, Table 4 shows that the use of R&D information is relatively low, illustrated by the low percentage of firms using scientific journals (8%), networking platforms (13%) and universities (15%). This has an implication on the level of firm innovation in the country.

TABLE 4: IMPORTANT SOURCES OF INFORMATION FOR INNOVATION BY INNOVATIVE FIRMS

Sources	Percentage
Internal Sources	
Sources within your enterprise or enterprise group	57%
External - Market Resources	
Suppliers of equipment, materials, components or software	40%
Clients or customers	40%
Competitors or other enterprises in your sector	30%
Consultants, commercial labs or private R&D institutes	28%
External - Institutional Sources	
Universities and Technikons	15%
Government and public research institutes	19%
External - Other Sources	
Conferences, trade fairs, exhibitions	13%
Scientific journals and trade/technical publications	8%
Professional and industry associations	17%

Source: Eswatini National R&D Survey (2017)

4.6. Level of Innovation in Eswatini's NSI

Innovative firms in Eswatini were 60% and non-innovative firms were 40%. Of the innovative firms, 52% successfully implemented an innovation during the period under review, while 12% abandoned their innovations. Further analysis of the innovative firms shows that they introduced four different innovations within the period of the survey. These are product, process, marketing, and organisational innovations. The study confirms that though R&D is a capital good in any country, it is not always the source of innovation. The innovation survey evinces that 82% of the firms that had an innovation activity had no R&D activity, while 18% had conducted R&D. This implies that innovation activities did not draw from in-house R&D activities. Figure 9 below shows that R&D measures low on expenditure while the acquisition of machinery and equipment is the highest innovation expenditure, suggesting that knowledge and technology are largely transferred through the acquisition of equipment in industry, which is further supported by training at 25%. However, the acquisition of external knowledge in these firms is minimal, and is largely characterised by a lack of highly technical skill (R&D survey, 2017) to allow for the adoption of modern technology to national production systems. Consequently, overall innovation expenditure was found to be 1.3% of overall firm turnover.

FIGURE 9: SHARE OF INNOVATION EXPENDITURE BY TYPE OF COST
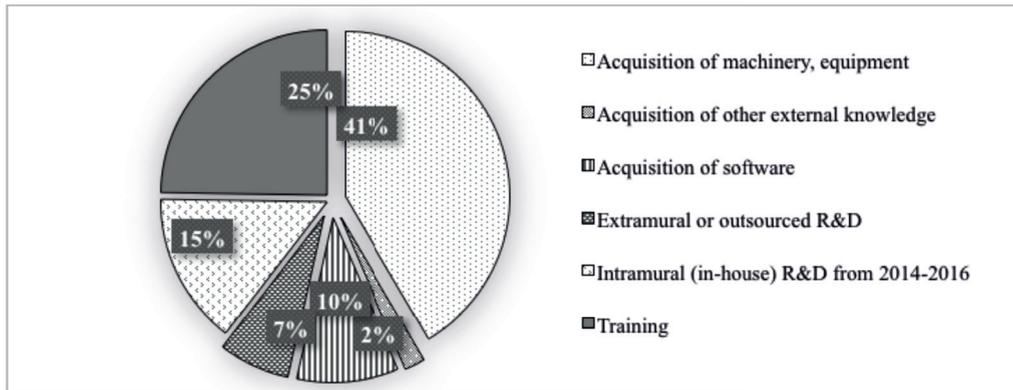
Source: Eswatini National R&D Survey (2017)

The manufacturing sector accounts for 30% of all innovations in Eswatini, making it the most innovative sector followed by the information and communication sector at 17% (Figure 10). The least innovative sectors are the health (1%), transportation and storage (2%), real estate (3%), and energy (3%) (Figure 10). These observations provide a stimulus to an innovation driven manufacturing sector as stipulated in the country's NDS. However, this is currently not possible given the lack of similar innovative efforts in other sectors of the economy, such as agriculture and energy. Alongside the low innovative efforts, the effects of a weak STI framework has continually fed into the country's slow and declining industrial development, as illustrated by the overall structure of the country's NSI.

FIGURE 10: LEVEL OF INNOVATION BY INDUSTRIAL SECTOR
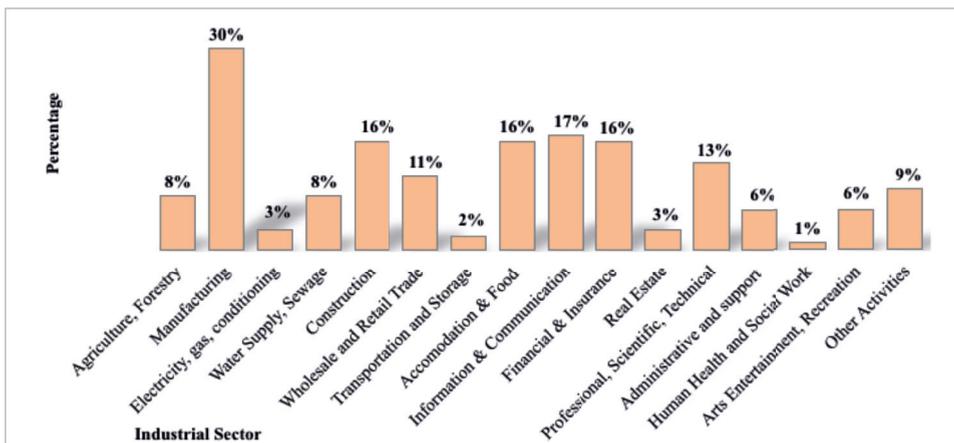
Source: Eswatini National R&D Survey (2017)

5. Discussion: Eswatini's NSI

This section discusses the results of the study and uses them to map the structure and composition of Eswatini's NSI. The results show that Eswatini has a weak NSI. Firstly, the country has weak institutional and STI policy frameworks, compared to other countries that have used STI to drive economic growth. The country does not have a long-term strategy to deal solely with STI policy and related issues when compared with countries such as Singapore, South Africa, and South Korea who have developed long-term strategies for their STI and research agendas and have established institutions that solely deal with STI policy and related issues. For instance, the DST in South Africa and the Ministry of Science, ICT and Future Planning in South Korea. In Eswatini, the RSTI is a department under the Ministry of ICT with little funding and personnel.

Secondly, there is low investment in innovation and R&D. There is no national funding mechanism and support for innovation, while only 0.26% of GDP is invested in R&D. Moreover, there is a low investment in STI infrastructure and capital goods, such as equipment and materials resulting to underemployment of qualified personnel and low skill development. Contrary to what is observed in Eswatini, South Korea has addressed this issue by allocating a specific budget to STI (which is equivalent to 1.2% of GDP) from the national budget through the NSTC, and different government ministries.

Thirdly, the results show that Eswatini has a low R&D capacity and STI personnel. The country has a low number of scientists and engineers in research. Eswatini has only 9.5% of R&D personnel as scientists and engineers compared to 68% of all R&D personnel in Singapore. The lack of researchers in the science and engineering fields means that there is low nationally directed industrial research and industry is not engaging in research that could achieve an STI powered manufacturing sector. This also compromises the country's ability to develop new products (goods and services) to drive industry. As a result, the country is largely dependent on imports and external sources for supplies and equipment. The country lacks mechanisms for technology transfer and increasing industry's absorptive capacities. It lacks incentives for technology adoption in industry and high investment in STI skills, which may be attained through high quality and skill intensive STEM-oriented TVET institutions. At the very least, the large number of young people in the country's population presents an opportunity for the development of an STI driven labour force.
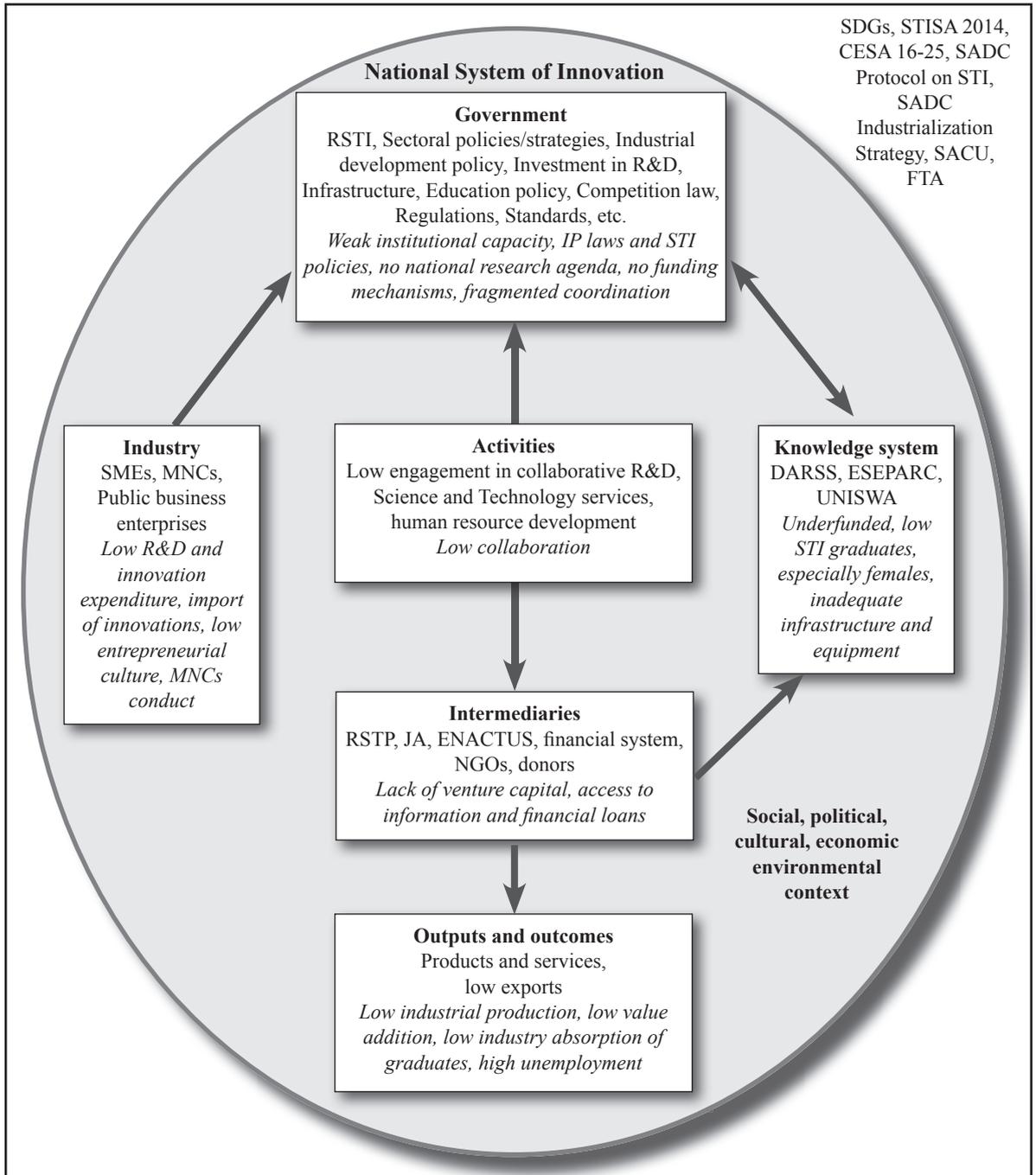
Lastly, there are low linkages and collaboration within the national system of innovation. The feedback links between and among institutions are weak, and there are no established mechanisms and incentives to work together. The industry does not consider research institutions a priority partner for collaboration. In South Africa, the government has established agencies like TIA to fund innovation activities and facilitate industry-university linkages, while NIMPO has established technology transfer offices to protect knowledge and ensure effective commercialisation of R&D output. These institutions enhance innovation and maintain continuous interaction between the three actors of the NSI.

From the results and discussions presented in this study, it is possible to develop an understanding of Eswatini's NSI. Figure 11 gives an illustrative diagram of the different actors, activities, and interactions in the NSI. The diagram shows that even though the regional and continental frameworks for STI are rich, the national institutional frameworks and capacities are weak and uncoordinated, yet they remain primal to the country's development. Eswatini needs to pay attention to the development of national capacities, enhance interactions, and improve institutions to achieve an STI driven socioeconomic development agenda. Nevertheless, the establishment of RSTI and RSTP present new opportunities to redirect STI development in Eswatini. Furthermore, opportunities exist for exploiting present industry-government linkages to grow STI driven industries. Similarly, the country should utilise already existing government-university linkages to strengthen STI focused R&D and skill development through targeted funding and long-term planning, policies, and regulation through the development and use of appropriate STI institutions.

6. Conclusion and Recommendations

This study sought to describe the national system of innovation in Eswatini. It used innovation and R&D surveys to understand the actors, activities and interactions in the country's NSI. The results highlighted in this paper show that Eswatini has a weak national system of innovation. The country's NSI is characterised by low investment in R&D at 0.26% of GDP and a lack of support for innovation activities. From the surveyed firms 60% were found to be innovative while only 52% completed their innovations. The institutional and regulatory framework was found to be a barrier to innovation. Compounding the situation for Eswatini is a lack of qualified personnel. The study found that the number of scientists and engineers in the country is very low, which is a result of low investment in STEM education. There are observed weak linkages and

Figure 11: Eswatini's National System of Innovation

National System of Innovation

SDGs, STISA 2014, CESA 16-25, SADC Protocol on STI, SADC Industrialization Strategy, SACU, FTA

Government
RSTI, Sectoral policies/strategies, Industrial development policy, Investment in R&D, Infrastructure, Education policy, Competition law, Regulations, Standards, etc.
Weak institutional capacity, IP laws and STI policies, no national research agenda, no funding mechanisms, fragmented coordination

Industry
SMEs, MNCs, Public business enterprises
Low R&D and innovation expenditure, import of innovations, low entrepreneurial culture, MNCs conduct

Activities
Low engagement in collaborative R&D, Science and Technology services, human resource development
Low collaboration

Knowledge system
DARSS, ESEPARC, UNISWA
Underfunded, low STI graduates, especially females, inadequate infrastructure and equipment

Intermediaries
RSTP, JA, ENACTUS, financial system, NGOs, donors
Lack of venture capital, access to information and financial loans

Social, political, cultural, economic environmental context

Outputs and outcomes
Products and services, low exports
Low industrial production, low value addition, low industry absorption of graduates, high unemployment

Source: Authors' own depiction

Notes: The italicised font represents the gaps identified in Eswatini's NSI in the study, while the un-italicised font are some of the institutions and activities mapped in the study.

interactions in the national system, especially between industry and universities. Consequently, the study makes the following recommendations:

• Develop a national STI strategy that is embedded in the country's national development agenda. As seen in South Korea and Singapore, where STI is a vehicle to overall national development. This should spell out the innovation and R&D agenda for Eswatini's development, priorities, funding, and available resources.

• Improve STI governance by introducing the Eswatini National Commission for Research, Science, and Technology as planned. However, the mandate, role, and influence of this institution should be considered at the level of its influence to national budgets and prioritisation of STI initiatives in the country's development agenda.

• Establish a Ministry of Science Technology and Innovation to ensure full coordination of the funding of, and support for, R&D and innovation activities. Cognisant of the need to reduce civil service this comes at a time were bold commitments and priorities need to be set and a restructuring of government could prove beneficial.

• Introduce a national PhD programme and form linkages with regional and international research institutions to expedite the development of researchers in the fields of science, technology, engineering, and mathematics (STEM).

• Deliberately target women in STI research initiatives to ensure a gendered national innovation agenda.

• Develop incentives (monetary or otherwise) to entice young researchers to stay in research.

• Provide a conducive environment for innovation by updating outdated legislative frameworks and regulatory environment for the growth of innovative firms. For instance, through the provision of tax breaks for private sector R&D, improving price controls, eliminating monopolies and setting clear output specifications in procurement and quality standards.

• Implement programmes and incentives to increase university-industry linkages and sustain a continuous engagement of the private sector in R&D and innovation activities. For instance, through the establishment of contest funds, problem-solving networks, or well-designed matching funds that support innovation.

• Increase R&D investment especially capital investments with a special focus on investing in equipment and machinery to curb underemployment of existing researchers.

- Enhance regional and international collaborations in innovation activities to foster knowledge and technology transfer and the sharing of best practices
- Reinforce efforts geared towards demonstrating the value of engaging in R&D to industry by showing the kinds of incentives that are in place to support R&D activities in Eswatini particularly given the successful completion of the Royal Science and Technology Park.
- Provide incentives to increase and foster private sector funding for education to universities and STEM skills development, especially in TVET.

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Acknowledgements

References

Arocena, R. & Sutz, J., 2000. Looking at National Systems of Innovation from the South. *Industry and Innovation*, 7(1), pp. 55-75.

ASTAR, 2014. National Survey of R&D in Singapore 2013, Connexis North: Agency for Science Technology and Research (ASTAR).

Atkinson, R., 2014. Understanding the US National Innovation System, Washington: The Information Technology and Innovation Foundation.

Bartels, F., Voss, H., Lederer, S. & Bachtrog, C., 2012. Determinants of National Innovation Systems: Policy Implications for Developing Countriea. I*nnovation Management Policy and Practise*, 14(1), pp. 2-18.

Brixiova, Z., Ncube, M. & Bicaba, Z., 2014. Skills and Youth Entreprenuership in Africa: Analysis with Evidence from Eswatini, Tunisia: African Development Bank.

Carvalho, N., Carvalho, L. & Nunes, S., 2015. A Methodology to Measure Innovation in European Union Through the National Innovation System. *International Journal of Innovation and Regional Development*, 6(2), pp. 159-180.

Castellacci, F. & Natera, J., 2013. The Dynamics of National Innovation Systems: A Panel Cointegration Analysis of the Coevolution Between Innovative Capability and Absorptive Capacity. *Research Policy*, 42(3), pp. 579-594.

CBS, 2016. 2015-2016 Annual Report, Mbabane: Central Bank of Eswatini (CBS).

Chen, S., 2010. Comparison of National Innovation Systems in China Taiwan, and Singapore: is Bayh-dole One Size Fits All?, s.l.: AUTM Technology Transfer Practise Manual 3rd Edition.

CSO, 2011. Economic Census, Mbabane: Central Statistics Office (CSO).

CSO, 2015. National Accounts: 2011 Benchmark Estimates, Mbabane: Eswatini.

DST, 2017. Main Analysis Report 2014/2015 South African National Survey of Research and Experimental Development, Pretoria: Department of Science and Technology (DSAT).

Edquist, C. & Hommen, L., 2008. Small Country Innovation Systems: Globalisation, Change and Policy in Asia and Europe. Cheltenham: Edward Elgar.

Edwards, L., Flatter, F., Stern, M. & Ramkolowan, Y., 2013. Eswatini Economic Diversification Study, Mbabane: Ministry of Finance.

Etzkowitz, H. & Leydesdorff, L., 2000. The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government Relations. *Research Policy*, 29(2000), pp. 109-123.

Eurostat, 2016. First Estimates of Research and Development Expenditure, Luxembourg: Eurostat Newsrelease.

Freeman, C., 1995. The National System of Innovation in Historical Perspective. *Cambridge Journal of Economics*, Volume 19, pp. 5-24.

GoS, 2014. A Development Strategy for Eswatini: Promoting Sustainable Development and Inclusive Prosperity, Mbabane: Ministry of Economic Planning and Development.

GoS, 2015. Industrial Development Policy: Period 2015-2022, Mbabane: Government of Eswatini (GoS).

GoS, 2016. Strategy for Sustainable Development and Inclusive Growth: The Eswatini We Want, Mbabane: Government of Eswatini (GoS).

Guan, J. & Zhao, Q., 2013. The Impact of University-Industry Collaboration Netwroks on Innovation in Nanobiopharmaceuticals. *Technological Forecasting and Social Change*, 80(2013), pp. 1271-1286.

Guimon, J., 2013. Promoting University-Industry Collaboration in Developing Countries. Washington: World Bank.

Gupta, N., Healey, D., Stein, A. & Shipp, S., 2013. Innovation Policies of South Korea, Virginia: Institute for Defense Analyses (IDA).

Kayal, A., 2008. National Innovation Systems a Proposed Framework for Developing Countries. *International Journal Entrepreneurship and Innovation Management*, 8(1), pp. 74-86.

Lee, K., Im, B. & Han, J., 2016. The Nationa Innovation System for the Catch-up and Post Catch-up Stages in South Korea. In: J. Choi, H. Kwon & M. Koo, eds. The Korean Government and Public Policy in Development Nexus: Sustaining Development and Tracking Policy Challenges. s.l.:Springers, pp. 69-82.

Lundvall, B., Joseph, k., Chaminade, C. & Vang, J., 2009. Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting. Cheltenham: Edward Elgar.

Mahroumn, S. & Al-Saleh, Y., 2013. Towards a Functional Framework for Measuring National Innovation Efficacy. *Technovation*, 33(2013), pp. 320-332.

Manzini, S., 2012. The National System of Innovation Concept: An Ontological Review and Critique. *South African Journal of Science*, 108(9/10), pp. 1-7.

Mazzucato, M., 2015. Innovation systems: from fixing market failures to creating markets. *Journal of Public Service Brasilia*, 66(4), pp. 627-640.

Metcalf, S., 1995. The Economic Foundatioon of Technology Policy: Equilibrium and Evolutionary Perspectives. In: P. Stoneman, ed. Handbook of the Economics of Innovation and Technological Change. Oxford: Blackwell Publishers.

MoET, 2015. Education for All 2015 National Review Report: Eswatini, Mbabane: Ministry of Education and Training (MoET).

MoLSS, 2013. Labour Force Survey Key Findings Report, Mbabane: Ministry of Labour and Social Security (MoLSS).

MoSCYA, 2015. Eswatini State of the Youth Report 2015, Mbabane: Ministry of Sports, Culture, and Youth Affairs.

Noland, M., 2011. Korea's Growth Performance: Past and Future, Tokyo: East-West Centre Working Papers.

NPCA, 2014. African Innovation Outlook, Pretoria: NEPAD Planning and Coordinating Agency (NPCA).OECD, 1997. National Innovation systems, Paris: OECD Publishing.

OECD, 2000. Science Technology and Innovation: Recent Policy Development in South Africa. [Online] Available at: http://www.oecd.org/science/inno/2112129 [Accessed 23 01 2017].

OECD, 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. 3rd ed. Paris: OECD Publishing.

OECD, 2012. Innovation for Development: A Discussion of the Issues and An Overview of Work of the OECD Directorate for Science Technology and Industry, Paris: OECD Publishing.

SADC, 2004. Southern African Development Community (SADC): Regional Indicative Strategic Development Plan (RISDP), Gaborone: SADC.

Schwab, K. & Sala-i-Martin, X., 2016. The Global Competitiveness Index, Geneva: The World Economic Forum.

Seidel, U., Muller, L., Kocker, G. & Filho, G., 2013. A New for Analysing NAtional Innovation SYstems in Emerging and Developing Countries Approach. *Industry and Higher Education*, 27(4), pp. 279-285.

Teixeira, A., 2013. Evolution, Roots and Influence of The Literature on National Systems of Innovation: A Bibliometric Account. *Cambridge Journal of Economics*, 1(34), pp. 1-34.

UNDP, 2013. Opportunities and Constratints to Youth Entrepreneurship: Perspectives of Young Entreprenuers in Eswatini, Mbabane: United Nations Eswatini.

UNISWA, 2016. UNISWA Annual Report 2015/2016, Matsapha: University of Eswatini (UNISWA).

Watkins, A., Papaioannou, T., Mugwagwa, J. & Kale, D., 2015. National Innovation Systems and the Intermediary Role of Industry Associations in Building Institutional Capacities for Innovation in Developing Countries: A Critical Review of the Literature. *Research Policy*, 44(2015), pp. 1407-1418.

Wong, P. & Singh, A., 2008. From Technology Adopter to Innovator: Singapore. In: C. Edquist & L. Hommen, eds. Small Country Innovation Systes: Globalisation, Change and Policy in Asia and Europe. Cheltenham: Edward Elgar.

World Bank, 2010. Innovation Policy: A Guide for Developing Countries, Washington: The World Bank.

World Bank, 2013. Institutions, Governance and Growth: Identifying Constraints to Growth in Eswatini, Washington: World Bank.