# REVIEW OF THE PERFORMANCE OF ZAMBIA'S NATIONAL SYSTEM OF INNOVATION FOR THE PERIOD 2001 TO 2010

*A minor dissertation submitted in partial fulfillment of the requirements for the degree of Master of Commerce in Economic Development*


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COMPULSORY DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

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**ABSTRACT**

It is widely agreed globally that innovation, knowledge and learning is a vital part of economic development. It creates and promotes competitiveness at the firm level, national and regional levels. Furthermore, innovation processes are dependent on relationships and the interaction of various actors thus, it is necessary for policy makers to strengthen the innovative environment so that collaboration is encouraged and facilitated. However, in order to develop relevant policies, the innovation system in question needs to be reviewed; in this case, Zambia's national system of innovation (NSI).

Science, technology and innovation (STI) in Zambia is described as relatively underdeveloped. The country gained independence in 1964 and only after 32 years of independence (1996) did it draft its first STI policy document. Sound economic policy accompanied by efficient institutions plays a key role in shaping a country's economic development. Therefore, it is believed that a timely national STI policy and mobilization of supporting institutions in Zambia could have helped the country exploit its abundant natural resources, to drive sustainable economic development.

This study, which is the first of its kind, provides a review of the performance of Zambia's NSI during the period 2001 to 2010. The study starts by examining comprehensive literature on STI and NSI, particularly in relation to developing countries such as Zambia. Thereafter, key concepts from the literature are applied to the Zambian case to formulate a framework for analyzing the country's NSI. The framework involved organizing the NSI into three hierarchal levels namely; micro, meso and macro. Under these levels, system functions were selected namely; knowledge development at the micro level, business, industrial and entrepreneur activities at the meso level and resource mobilization at the macro level. Thereafter, indicators were selected to measure the performance of each system function. Subsequently, trend analysis was conducted on the set of indicators.

The results of the analysis suggest that during the period 2001 to 2010, there has been significant increase in innovation input (government funding of R&D activities) and a significant growth in output (scientific research publications) at the micro level. The rise in the ratio of input to output suggests a level of efficiency in knowledge development, because the output indicator was increasing more rapidly than the increases in the input indicator. On the contrary results at the meso level, particularly with regards to exports of goods and services, revealed comparative advantage of merchandise exports, manufactured exports and high-technology exports, suggest that knowledge and innovation is not being exploited efficiently and effectively for commercial purposes. These results imply that there are some significant constraints and factors in scarce supply. In addition, the policy environment may not be favourable. Finally despite significant growth in government funding at the macro level, the results of this study show

that it is still limited. The National Science and Technology Policy initially proposed that government allocates 3% of GDP annually as funding for science, technology and innovation activities. However, this has not been the case. The study indicates that an average of only 0.04% was annually allocated during the period under analysis.

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# ABBREVIATIONS

| | |
|---|---|
| GDP | Gross Domestic Product |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| NCSR | National Council for Scientific Research |
| R&D | Research and Development |
| S&T | Science and Technology |
| NSTC | National Science and Technology Council |
| NTBC | National Technology Business Council |
| UNIP | United National Independence Party |
| MMD | Movement for Multi-party Democracy |
| NISIR | National Institute for Scientific and Industrial Research |
| PF | Patriotic Front |
| MSTVT | Ministry of Science, Technology and Vocational Training |
| MoHE | Ministry of Higher Education |
| RSNDP | Revised Sixth National Development Plan |
| NSI | National System of Innovation |
| WDI | World Development Indicators |
| WIPO | World Intellectual Property Organization |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| OECD | Organization for Economic Co-operation and Development |
| NACI | National Advisory Council on Innovation |
| US | United States |
| UK | United Kingdom |
| TFP | Total Factor Productivity |
| R&D | Research and Development |
| ICT | Information and Communication Technology |
| IP | Intellectual Property |
| DUI | Doing, Using and Interacting |
| GCR | Global Competitiveness Report |

| | |
|---|---|
| MSMEs | Micro, Small and Medium Enterprises |
| IMF | International Monetary Fund |
| AU | African Union |
| STISA | Science, Technology and Innovation Strategy for Africa |
| 7NDP | Seventh National Development Plan |
| iit | Institute for Innovation and Technology |
| BMBF | Federal German Ministry for Education and Research |
| SME | Small and Medium Enterprises |
| CEEC | Citizen Economic Empowerment Commission |
| TDAU | Technology Development and Advisory Unit |
| ZDA | Zambia Development Agency |
| ZCSMBA | Zambia Chamber of Small and Medium Enterprises |
| UNZA | University of Zambia |
| TEVET | Technical Education, Vocation and Entrepreneurship Training |
| WITS | World Integrated Trade Solution |
| ZDA | Zambia Development Agency |
| WTO | World Trade Organization |
| GATT | General Agreement on Trade and Tariffs |
| WoS | Web of Science |
| NRDS | National Research and Development Strategy |
| GERD | Gross Domestic Expenditure on Research and Development |
| RCA | Revealed Comparative Advantage |
| CEE | Central and Eastern European Countries |
| SOE | State Owned Enterprise |
| NGO | Non Government Organizations |
| UNZA | University of Zambia |
| CBU | Copperbelt University |
| UNILUS | University of Lusaka |
| IEI | Innovation Efficacy Index |

# CHAPTER ONE: INTRODUCTION

## 1.1 PROBLEM STATEMENT

Zambia, a former British colony, gained independence in 1964. At that time the country was confronted by various challenges, which included an uneducated and unskilled labor force, and a dependence on raw material exports with very few manufacturing industries.

In 1965 an official census was conducted and it was discovered that out of a total population of approximately 3 712 000 Zambians, 94 percent were below the age of 60 years. Further, the total number of Zambians with locally obtained secondary school certificates was 1200 while the number of graduates was only 100. The country had a young and uneducated population (Sililo, 2017).

The economy of the country was predominantly in the hands of a small, privileged minority while the majority indigenous people lived in rural areas (approximately 77 percent[1]) and were largely involved in subsistence farming and unskilled labour (Sililo, 2017). Moreover, the country inherited an economy focused on the extraction and exportation of copper as a raw material, with a very low industrial and agriculture base; manufacturing constituted just 6 percent of GDP (Mudenda, 2009).

The main objective of the government was to create opportunities for the Zambian people through social services such as education and increased participation in the national economy through expanding employment. To initiate the country's development, the government launched and implemented various micro-economic development strategies with the aim of broadening the industrial base. Between 1964 and 1970 Zambia adopted an import substitution strategy for the development of its manufacturing sector, fueled by the budget surpluses from the copper exports and proceeds at independence. This policy approach involved the transfer of technology and expertise from outside Zambia and enabled the country to establish various industries and produce consumer goods such as; food, textiles, bicycles, glass, batteries and furniture (National Policy on S&T, 1996). Industrialization anchored on manufacturing was widely regarded as a vital ingredient for economic diversification, and modernization; the transformation of a low-income society using traditional technologies and predominantly producing primary commodities, into a high-income society using modern technologies to produce both primary and industrial goods (Mudenda, 2009).

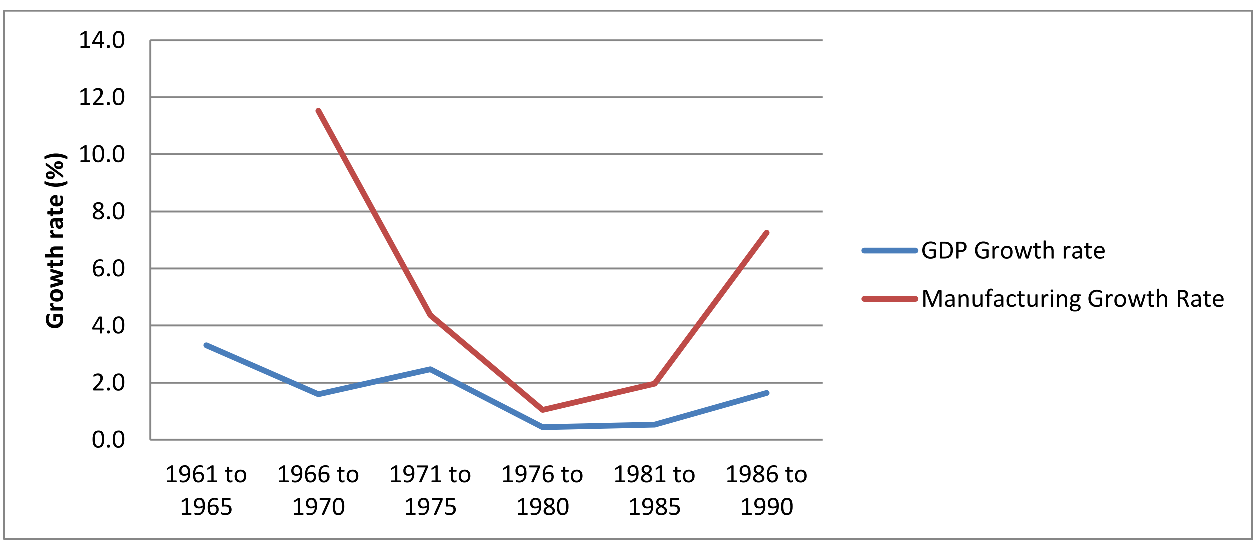
Recognizing the value of scientific research in the industrial process, the government with the help of United Nations Educational Scientific and Cultural Organization (UNESCO) established the National

[1] According to World Bank Data

Council for Scientific Research (NCSR) in 1967 by an act of Parliament (Act 236). The NCSR was tasked with prioritizing and coordinating research efforts during development plans and became the umbrella body for other research institutions, such as the research branch in the Department of Agriculture, the Central Research Station, and the Central Fisheries Research Institute (National Policy on S&T, 1996).

Industrialization cannot occur without the development of some local capacity in science and technology, (S&T) and at that time there was no effective S&T strategy for Zambia. Despite the formation of NCSR, there was no national science and technology policy. Further, the NCSR was not sufficiently performing its advisory role due to weak statutory linkages with the other research institutions (National Policy on S&T, 1996). Therefore, after 1970 the country began to experience stagnation in economic and industrial performance, despite an initial growth spurt in manufacturing dominated by food, beverages, tobacco, textiles, chemical products and basic metals. This was largely due to poor adoption and diffusion of technology, inadequate macro coordination by government and external shocks such as, the global oil crisis and falling of copper prices prices (Daka and Toivenan, 2014; Mudenda, 2009; National Policy on S&T, 1996). Between 1980 and 1990, economic and industrial performance began to gradually improve, however the country continued to experience deteriorating social infrastructure, productivity and export capacity; diminishing financial reserves, hyper-inflation and rising debt (National Policy on S&T, 1996). The economic performance of the country between the years 1961 to 1990 is shown in **Figure 1**.

**Figure 1 Zambia average GDP and Manufacturing Growth rates compared (1961 to 1990)**

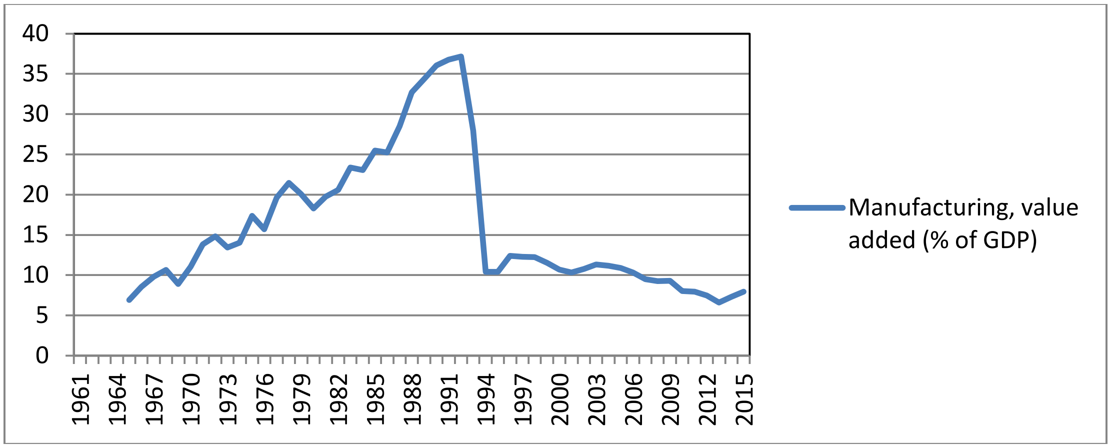



*Source*: World Bank Development Indicators 2016

In 1991 there was a change of government from United National Independence Party (UNIP) to Movement for Multi-party Democracy (MMD). The mandate of MMD embraced market-oriented policies unlike their predecessors, who favored a more socialist approach. The economy was transformed from central state control to a liberalized economy with a strong emphasis on private sector participation. The new policies included privatization, liberalization of the financial sector and interest rates, and removal of price controls and subsidies. Policy was generally aimed at reducing government's direct involvement in the operation of enterprises. However, despite this being a good development agenda there was no plan to help the country respond to the more liberalized market economic environment and therefore there were some negative consequences of these policies. For instance, the manufacturing sector faced severe competition from cheaper imported goods and services. While it could have been hugely beneficial for the manufacturing sector to have access to cheaper inputs, this was not the case due to insufficient investment in R&D into **t**he development of new products and processes to help combat global trade competition, and weak industrial linkages to enable technology and skill transfer (Daka and Toivenan, 2014). According to the Zambia Vision 2030 policy document, between the years 1990 to 2003 S&T in the country received an average funding of only 0.02% of GDP. Therefore, for the following reason coupled with implementation and governance challenges, STI in Zambia was considerably undeveloped and industries in the country were uncompetitive with declining productivity (National Policy on S&T, 1996). This trend is shown in **Figure 1.1**. It was during this period that poverty levels and unemployment increased rapidly.

**Figure 1.1** shows growth in manufacturing output of all industries in Zambia. It demonstrates that manufacturing output in nominal terms often fluctuated, but in general was growing gradually between the years 1966-1990. In 1991, manufacturing output experienced a shock and through 1991-1995 decreased sharply. This improved post 1995; however growth in manufacturing output did not recover fully to its prior growth levels pre 1990 and has generally been low.

**Figure 1.1: Manufacturing Value Added (as a % of GDP) in Zambia 1961 to 2015**




*Source:* World Bank Development Indicators, 2016

To help rectify the economic situation and begin to leverage and integrate S&T into national development processes, the first Science and Technology policy framework was drafted 32 years after independence in 1996 to revise Zambia's innovation system (Daka and Toivenan, 2014). Although the NCSR had been functioning as a policy advisor to the government and as a research centre, its biggest critique was that it had performed poorly because of weak statutory linkages with other research institutions in the country. Therefore, in 1997 the NCSR Act was repealed, and a new act was ratified to separate policy advice, formulation and direction of roles from physical laboratories. The National Institute for Scientific and Industrial Research (NISIR) was established by the Science and Technology Act No. 26 of 1997 to replace the NCSR's research functions. NISIR was mandated to conduct and promote scientific, technological and industrial research in Zambia. In addition, the National Science and Technology Council (NSTC) was established and tasked with providing policy advice, coordination, regulation and promotion of the science sector. Finally, the National Technology Business Council (NTBC) was created by the Science and Technology Act No 26 to provide a link between the research system and the productive sector, as well as commercialize proven national and international technologies for the benefit of entrepreneurs and the business community. Despite NTBC's formation in 1997, it only began to function in 2002 (National Policy on S&T, 1996; NTBC, 2017).

Before 2011 NISIR, NSTC and NTBC were all managed by the Ministry of Science, Technology and Vocational Training (MSTVT). However, when the political party Patriotic Front (PF) assumed office in 2011, government merged MSTVT with the Ministry of Education, Science, Vocational Training and Early Education. The Ministry of Education, Science, Vocational Training and Early Education was given the mandate to oversee basic and higher education, vocational training and STI in the country. In 2015 a presidential decree ~~s~~plit the Ministry into two; the Ministry of General Education and the Ministry of Higher Education (MoHE). The latter was given the mandate to oversee university education, vocational education and training and STI (Ministry of Higher Education, 2017). Thus to date, the MoHE supervises NISIR, NSTC and NTBC through its Department of Science and Technology.

The 1996 STI policy failed because government did not assume a leading role in its implementation. In addition, the policy document was too ambitious particularly because the instruments and infrastructures required were far short of capacity, underfunded and lacked resources. Furthermore, although the policy promoted knowledge and learning, it did not provide mechanisms to develop this in the long term (Daka and Toivenan, 2014)..

In 2009 the STI policy was revised to strengthen the S&T framework by fostering closer links between the programmes of the R&D community and prioritizing various sectors in national wealth creation, productivity and competitiveness. The 2009 STI policy differs from its predecessor insofar as it enhances the role of innovation based activities in the economy (Daka and Toivenan, 2014).

## 1.2 RATIONALE AND METHODOLOGY OF THE STUDY

Economic transformation of the economy through economic diversification and industrialization has been on Zambia's development agenda for over five decades now and has not met expectations. UNECA (2013) defines economic transformation as *'a fundamental change in the structure of the economy and its drivers of growth and development'*. If Zambia is to achieve this goal by 2030 as outlined in the Seventh National Development Plan (7NDP) then, inter alia, it must prioritize innovation, learning and S&T.

It is widely agreed globally that innovation, knowledge and learning is a vital part of economic growth and wealth creation for a country. It creates and promotes competitiveness at the firm, national, and regional levels. Further, innovation processes are dependent upon relationships and the interaction of various actors. Thus, it is necessary for policy makers to strengthen the innovative environment so that collaboration is encouraged and facilitated (Fagerberg, 2013). However, in order to develop relevant policies, the innovation system in question needs to be reviewed, which in this case is Zambia's National System of Innovation (NSI).

This dissertation aims to review the performance of Zambia's NSI over a 10 year period. The intention is to complement the insufficient existing literature with new insights that will serve to enlighten relevant stakeholders on the operations of the STI system. Hopefully, this research may be a point of reference for policy formulation, and open up new opportunities for research in areas of innovation study for Zambia.

Therefore, based on the above problem statement and rationale the following research questions are formulated for this dissertation:

(i) Why is an NSI important for the economic development of a developing country?
(ii) Has Zambia's NSI been effective in contributing to the country's economic development objectives?
(iii) What are the strengths and weaknesses of Zambia's NSI during 2001 to 2010?
(iv) How can Zambia's NSI be developed further?

The research objectives pursued in order to answer the research questions are:

(i) Based on extensive literature review on innovation studies, this dissertation will provide an understanding of the NSI concept and its application to Zambia
(ii) Provide a comprehensive assessment of the rationale for the adoption of the NSI approach in a developing country such as Zambia
(iii) Develop a methodology framework based on existing innovation literature to review the performance of Zambia's NSI during 2001 to 2010
(iv) Identify economic policies that address the current challenges in Zambia's innovation system

This dissertation makes extensive use of literature review. Chapters one (introduction), two (National Systems of Innovation theory) and three (the NSI in Zambia) are based on empirical and theoretical contributions published in journal articles, conference/discussion/working papers and reports. The discussions are addressed by reviewing the work of development economists, economic historians and business scholars. This provided the framework for analysis of data in chapter four.

This dissertation applies key concepts from the Technological Innovation System (TIS) approach and Multi-level perspective, to develop a framework for measuring Zambia's NSI with the aim of evaluating the country's performance for the period 2001 to 2010. In developing a method for evaluating Zambia's NSI, this study adopted the TIS method of assessment with minor adjustments; this method is outlined below:

(i) The study and innovation system under review was defined as, the performance of Zambia's NSI for the period 2001 to 2010.

(i) The structural components (actors and institutions) of Zambia's NSI were identified and discussed in chapter one and chapter three. This information was sourced from theoretical and empirical literature on innovation in Zambia namely; National Policy on Science and Technology (1996), Daka and Toivenan (2014), Institute for Innovation and Technology (2010), the Ministry of Higher Education (2017) and Sililo (2017).

(ii) The functions of Zambia's innovation system (certain processes considered important to the success of an innovation process) were mapped and indicators identified to analyze these functions in chapter three using the TIS model. These functions were organized under three hierarchal levels (micro, meso and macro) using the multi-level perspective and the hierarchal level framework developed by the Institute for Innovation and Technology (2010).

These functions included: resource mobilization at the macro (policy) level, business, industrial and entrepreneurial activities at the meso level and knowledge development at the micro level. The selection of these functions, and indicators to analyze them, was dependant on the quality of the data available. Furthermore, the indicators were selected from the South Africa Science, Technology and Innovation indicators (2014 and 2015) because these indicators are measurable over time and are relevant to policy makers. Further, South Africa is the only African country that has developed a relatively comprehensive list of adequate indicators for assessing national STI. Therefore due to the aforesaid reasons and similarities in the development context between the two countries, the South African STI indicators were considered appropriate to use in the Zambian case.

Secondary data was used and sourced from various databases such as; World Development Indicators (the World Bank), the World Integrated Trade Solution (the World Bank), World Intellectual Property Organization (WIPO) and Thomson Reuters Web of Science database. Data sourced from Zambian institutions included the Ministry of Finance and National Planning (Mofnp). The sourced data was annual covering a 10 year period from 2001 to 2010. This period was chosen because of the availability of consistent data for most of the indicators used and because it marked a real commitment to the1996 and 2009 National Science and Technology policy.

The only indicators that did not cover the entire period under analysis (2001 to 2010) were technology payments, which had data points missing for the year 2004, and Government Budget Appropriations or Outlays for R&D (GBAORD). GBAORD covered a period of 2004 to 2010 because of unavailability of data for the first three years. Nonetheless, this indicator was selected for this study because of its importance in giving an indication of government's commitment to resource mobilization at the macro (policy) level. According to OECD (2002) there are two ways of measuring how much governments spend on R&D namely, through government-financed GERD and through GBAORD. If the former is unavailable, which was the case for this study, data from a country's national budget can be used in its stead.

To compile and calculate the total GBAORD for each year, this study used guidelines from the Frascati OECD Manuel (2002). The study used final budget appropriations from national budget data sourced from the Ministry of Finance. The coverage of R&D was all intramural and extramural expenditure towards government research institutions and program activities that involved basic, applied and experimental research at the central and provincial government. Government contributions to higher education institutions were excluded from the calculations because it was difficult to identify specific R&D-funded activities. To determine government expenditure share of GDP for a particular year, the ratio of Zambia's total GBAORD to the country's constant GDP in local currency value was calculated.

(iii) A review of the functionality of Zambia's NSI to establish policy recommendations is discussed in chapter four. The data was analyzed and interpreted using Microsoft Excel to extrapolate patterns or trends in order to derive policies to enhance Zambia's NSI. In addition, strengths and weaknesses (blocking mechanisms) in Zambia's innovation system are also discussed in chapter four.

This study proceeded further, to measure the efficiency and effectiveness of government funding towards knowledge development using the Innovation Efficacy Index (IEI). The methodology used was guided by Mahroum and Alsaleh (2012). In order to calculate the IEI, an input and output indicator was selected namely, annual GBAORD and annual total number of scientific research publications respectively. The data for GBAORD and the total number of scientific research publications was normalized in order to facilitate comparison and recalibrate the indicators to fall within a range of 1 to 7, where 1 was the lowest score and 7 the highest score. The following min-max formula[2] was used to normalize the data:

$$6 * \frac{x - min}{\max - min} + 1$$

[2] The limitations of this method are that, outliers could distort the transformed data

Subsequently, total score for capacity and performance of knowledge development in the innovation system is calculated as the sum of averages for each indicator (GBAORD and total number of scientific research publications) using the formula:

$$T_i = \sum \bar{x}_i$$

Where: $T_i$ is the total score for capacity and performance

$\bar{x}_i$ is the average for each indicator

In this study the efficacy of knowledge development can be measured by one set of input and output indicators. Each indicator has a non-weighted average score with a possible maximum of seven. Therefore, the maximum possible score for capacity and performance of knowledge development is 14. The ratio of the aggregate score of the input and output indicator to the maximum possible score (i.e. 14) is calculated to indicate the level of efficacy of the system function i.e. knowledge development.

## 1.3 OUTLINE OF THE DISSERTATION

The dissertation is organized as follows:

*Chapter one*: *Introduction*

In this chapter, I describe the background of S&T policy in Zambia and the influence that S&T has had on economic policy since independence in 1964 to present day. I highlight the role of key institutions and outline the fundamental challenge with innovation policy in Zambia, which is its underrated input towards commercial trade and industrial policy. In view of this, I discuss the rationale for the study and the methodology adopted.

*Chapter two: the National System of Innovation*

I situate this study within the broader literature on innovation studies and the NSI, which includes; the historical relationship between economic growth and science, technology and innovation, the origin and development of innovation studies as a field and an introduction to the NSI concept. Subsequently, the chapter delves deeper into innovation systems literature by discussing current approaches to the NSI concept and key concepts of NSI analysis which have been instrumental in creating a framework for evaluating Zambia's NSI. While NSI literature is particularly rich in empirical research, I focus on two areas: technology innovation systems (TIS) and the multi-level perspective.

*Chapter three: the National System of Innovation in Zambia*

This chapter applies chapter two's findings to Zambia by discussing the role of STI in Zambia's past economic growth and development. Subsequently, Zambia's NSI is outlined and the role it has played in the country's broader development is briefly discussed.

*Chapter four*: *Analysis, results and discussion*

In this chapter, I analyze key input and output indicators organized into three hierarchal levels namely; micro, meso and macro levels. I use these indicators because they represent key innovation system functions that are relevant to policy makers and because they are based on high-quality data that is available. The results of this chapter provide an idea of the effectiveness of Zambia's NSI and identify areas that need improvement.

*Chapter five: Conclusion and policy recommendation*

In this chapter, I formulate policy recommendations to strengthen Zambia's NSI based on the results of the analysis in chapter 4 and briefly discuss final reflections and limitations of the study.

# CHAPTER TWO: THE NATIONAL SYSTEM OF INNOVATION THEORY

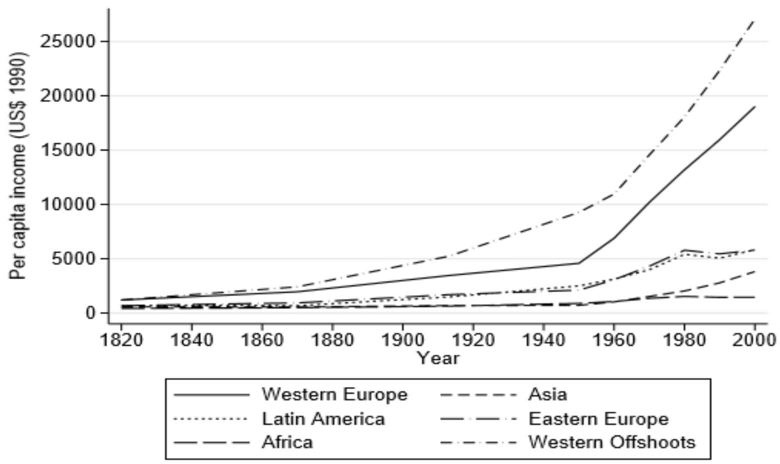
## 2.1 HISTORICAL RELATIONSHIP BETWEEN ECONOMIC GROWTH AND STI

In previous centuries, the source of economic growth was believed to have come from an increase and strengthening of a country's treasury through export surplus, a school of thought called Mercantilism. This evolved into a new ideology called Physiocracy. The main tenet of Physiocracy was that agriculture, the basic sector of the economy, was the only way for a nation to grow. At the turn of the 18$^{th}$ century, the classical growth theory was developed by Adam Smith, Thomas Malthus and David Ricardo. This theory on economic growth argued that economic growth would decline because of an increasing population and limited resources. Classical economists believed that output was related to capital, labour and land, and output growth (economic growth) was driven by population growth, investment and growth in land and productivity. They argued that temporary increases in real GDP per person would cause a population explosion that would ultimately decrease real GDP (Çaliskan, 2015). The classical growth theory was popular at a time when most of the population worked in animal breeding and agriculture. During these times, working conditions were harsh and wages were low. However, productivity in the agriculture sector increased with advances of technology around the time of the industrial revolution. Following the increase in productivity, output increased, agricultural workers began to migrate to the cities and overall wealth was enhanced. In spite of this, classical economists believed that this increase in wealth was only temporary. They were proved wrong in later years when earning power steadily increased despite a reduction in birth population growth rates in Western countries. Thus, the inverse relationship between the growth rate of real income and the growth rate of the population in Western countries did not conform to the expectations of classical economists (Çaliskan, 2015).

The criticisms of the classical growth model eventually led to the neoclassical growth theory in the late 19$^{th}$ century. In this theory, capital, labour and technology were identified as necessary factors for economic growth. Neoclassical economists believed that a temporary equilibrium can be achieved in the short-run if capital size, labour and technology is appropriately adjusted. However, this theory argued that determinants of equilibrium in the short-run differ from those in the long-run. According to neoclassical scholars, long-run growth in income and physical capital per worker is entirely driven by productivity growth; more specifically by the rate of labour-saving technological growth. Neoclassical growth models treated this growth rate as exogenous where the prime engine of income growth per worker is capital accumulation depending on rates of investment, population growth, and productivity growth rate. Therefore neoclassical growth theory predicted falling growth rates within countries over time and convergence between countries based on certain economic fundamentals. However, as shown in **Figure**

**2.1**, this was not the case. There was a long-run divergence in per capita income between major regions in the world and this roughly began in the modern era (1946 and onwards) with relatively fast growth in Western countries and slow growth in developing regions such as Africa (Grossman and Steger, 2007).

**Figure 2.1 Divergence in per capita income of World Regions, 1820 – 2001**




*Source:* Grossman and Steger, 2007

In the first half of the 20th century Austrian economist Joseph Schumpeter was one of the first economists to explain this phenomenon and promote technological development's crucial role in long-run economic growth. His research on innovation as a function of economic growth in 1939 established a foundation for various subsequent economic growth and development theories (Fagerberg, 2013).

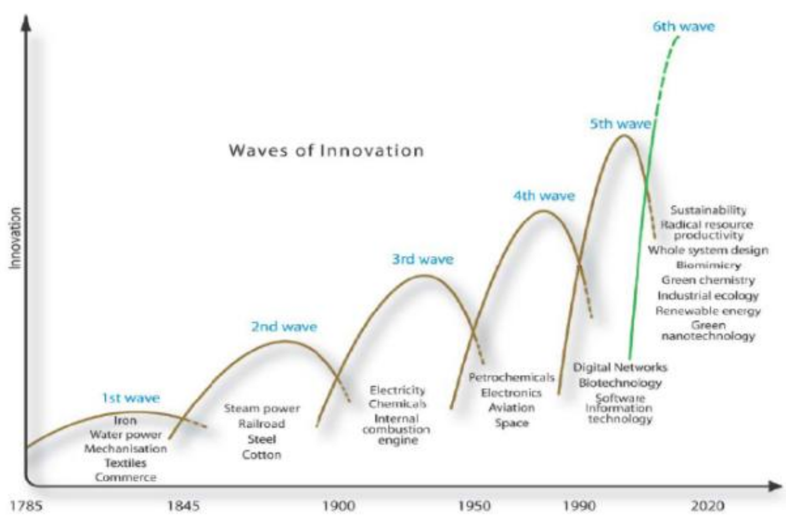
## 2.2 ORIGIN OF INNOVATION STUDIES

Prior to the 1950s, economic development theories did not recognize science, technology and innovation as major factors of economic growth. However, there was one notable exception; the theories introduced by Schumpeter. Schumpeter took a multi-disciplinary approach in his research into long-run economic and social change, which included a specific focus on the crucial role of innovation and the factors that influence it (Fagerberg, 2013).

Schumpeter identified three stages of the innovation process, namely; invention, innovation and diffusion. He defined invention as *'the first demonstration of an idea'*; innovation as *'the first commercial application of an invention in the market'* and diffusion as *'the spreading of the technology or process throughout the market'*. Schumpeter explained that usually the diffusion process is represented by an S-shaped curve characterized by the following stages; initially take-up of an innovation process or technology starts slowly, then it gathers momentum achieving rapid diffusion and finally slows down when a saturation level is reached with a focus on incremental improvements and cost reductions. The continuous cycle through the aforementioned stages is often referred to as *'the linear model of innovation'*. Thus basic research is conducted and then applied to technology development and diffusion. The model proposes that developments in scientific understanding determine the rate and direction of innovation. Furthermore, the optimal way to increase the output of new technologies is to increase the input of new inventions by simply investing more resources into R&D; a model known as *'supply-push'* or *'technology-push'*. (Greenacre, Gross & Spiers, 2012).

In addition, Schumpeter was one of the first economists to emphasize the importance of the entrepreneur and the role of large firms with the resources to conduct extensive R&D and support new technologies. He supported and built on Kondratieff's long-wave theory, which explained that new technologies and innovations foster the decline period of economies to shift to the next development stage. These waves of innovation launch technological revolutions which finally result in leading industrial or commercial sectors. The process continues in a cycle of growth and decay phases that occur every half century. The new technologies created are the key to economic progress in a country (see **Figure 2.2**). This research has been influential in motivating more recent understandings of the innovation process (Greenacre, Gross & Spiers, 2012).

**Figure 2.2 Waves of Innovation- the Kondratiev cycles**




*Source:* The Natural Edge Project, n.d.

However, some critics argue that Schumpeter focused on investigating the consequences of innovation, neglecting what causes it. The main critique of Schumpeter's supply-push model was that it ignored prices and other economic factors that affect the profitability of innovations. In the late 1950s and early1960s social scientists began to look at innovation from a demand rather than a supply perspective. The *demand-pull* perspective suggested that demand for products and services were more important in stimulating inventive activity than advances in the generation of knowledge. In this theory it was economic factors that stimulated the rate and direction of innovation. Changes in market demand created opportunities for firms to satisfy this demand by investing in innovation. However the demand-pull model also met with some criticism because it explained incremental technological change better than it accounted for discontinuous (disruptive) change which involved the fundamental innovations. Both technology-push and demand-pull models have been recognized as important in explaining certain aspects of the innovation process but criticized for being too simplistic (Greenacre, Gross & Spiers, 2012).

## 2.3 DEVELOPMENT OF INNOVATION STUDIES AS A FIELD

Innovation started to develop as a field in the late 1950s when mainly United States and European researchers, with the support of actors in the public and private sector, began to build on Schumpeter's work and address the role of innovation and diffusion for economic and social change (Feldman, 2004).

Notable amongst these researchers was Robert Solow, who created a model which promoted the view that economic growth was not only a result of an increase in factor inputs, but also the result of a country's ability to capitalize on S&T. He emphasized the importance of technology in sustaining economic growth in the long term, even more so than increases in capital or labour. Prior to Solow's research, it was believed that sustained economic growth was a result of increasing the savings rate in a labour surplus economy. This implied that nations that saved more would experience accelerated growth rates and those nations that did not would experience very little growth. Thus according to this theory, developing countries did not save enough to expand their growth (Feldman, 2004). Solow rejected this model because at the time, there were developing countries that challenged this premise and were experiencing rapid economic expansion. Further, there were clear differences in rates of growth among developed countries. Solow proposed a more flexible explanation for economic growth that comprised various determinants of growth, including technical change. However, innovation was an exogenous variable in Solow's model thus ignoring the challenges associated with inducing technical progress through the process of learning, investment in research and capital accumulation (Feldman, 2004).

There were many criticisms of the Solow model, some of which were; scholars argued that every factor that contributed to economic growth should be accounted for and explained. Furthermore, it was unjustifiable to assume a constant common growth rate of technology and a common initial level of technology in cross-country regressions because the levels and growth rates of technologies differ across economies (Feldman, 2004). Another criticism was that the Solow model was based on the assumption of labour augmenting technical progress to which there was no empirical justification (Tesfatsion, 2016).

Economist Moses Abramovitz' research bore some similarities to Solow's research. Abramovitz conducted research on the United States economy from 1870 to 1953 and discovered that the country's productivity was not only attributed to factor inputs; a large proportion of it was the result of something else. Abramovitz named this residual Total Factor Productivity (TFP) and it explained that economic growth can be a result of less input, with the same output or the same input and more output (Rosenberg, 2004; Freeman, 2002). In further research, Abramovitz explained that Western European countries were able to catch up with the United States because of their ability to import and use technologies. Thus, he concluded that developing countries would eventually converge with developed countries because their diminishing returns were much lower than that of developed countries, and therefore they had the potential to grow much faster. However, he did not consider the inability of developing countries to adapt to new technologies. Abramovitz then suggested that developing countries required legal, political and cultural institutions alongside technical advances to develop (Weinstein, 2000).

Christopher Freeman developed on Schumpeter's work and established the Science Policy Research Unit (SPRU) at the University of Sussex in 1966. SPRU recognized that science is just one of the various factors in successful innovation, and that innovation has a significant role in policy, economic and social change. For this reason the SPRU, much like Schumpeter's beliefs, had a multi-disciplinary research staff with backgrounds in economics, sociology, psychology and engineering. It attracted many scholars from other countries and inspired the formation of other similar institutes within Europe and Asia in the mid 1980s and onwards. Later, Freeman's seminal work on innovation systems was influential in developing the concept of the NSI (Fagerberg, 2013).

Innovation theory continued to evolve around the 1970s and was dominated by three approaches to understanding technological change; *induced innovation, evolutionary approaches* and *path-dependent models.* The induced innovation model explained the importance of changes in relative prices in driving the direction of technical change, while the evolutionary and path-dependent approaches focused on the importance of past decisions which may affect present innovation efforts. Some scholars believe that the theories of induced innovation, evolutionary economics and path-dependency developed in the 1970s and onwards were complimentary elements of a prospective, more general systems theory of innovation (Greenacre, Gross & Spiers, 2012).

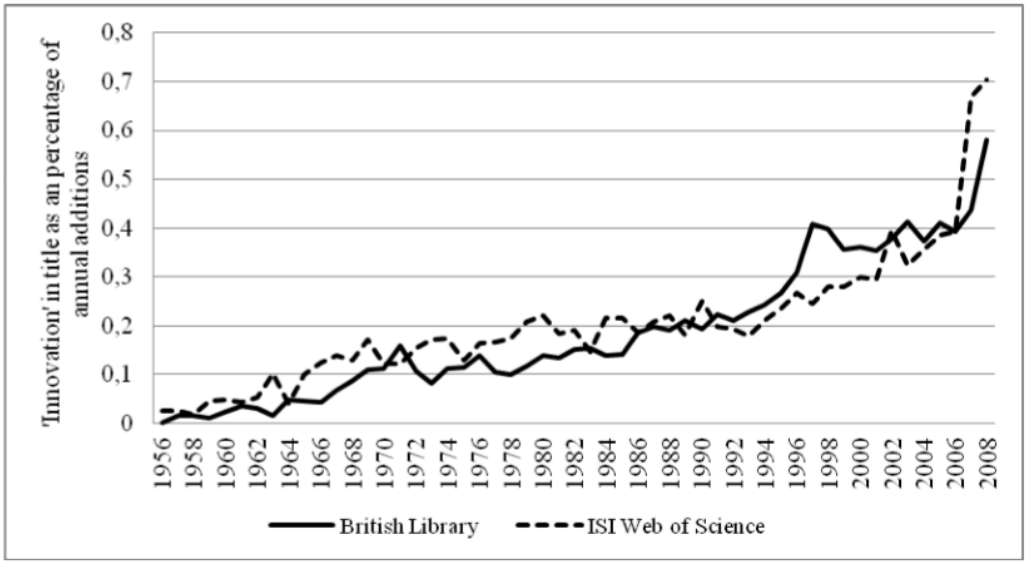
In the 1980s innovation research saw a return to the older linear model of innovation, albeit modified to reflect the complexity and interdependency of the innovation process. Several approaches to innovation were proposed, namely; the innovation system frame at the firm and enterprise level as well as at the sectoral, national and regional levels. The innovation system frame was developed by the OECD and covered technological products and process innovation at the firm or enterprise level. The OECD classified system conditions into four categories related to innovative capacity, namely;

(i) Framework conditions: the environment in which the firm is situated such as the education system, ICT infrastructure, financial institutions, legislative and macro-economic setting, market accessibility and industry structure.
(ii) Science and engineering base: S&T institutions supporting the business innovators.
(iii) Transfer factors: the factors influencing information transmission to firms and learning by firms.
(iv) Innovative dynamo: the complex system of factors that build the innovative capacity of a firm or entrepreneur.

The OECD's innovative system frame positioned the firm (entrepreneur) at the centre of the system representing it as the driver of innovation in an economy. Research on firm or enterprise innovation systems eventually developed into research on individual and comparative analysis of the innovative systems in various countries. This was the beginning of research on national systems of innovation and related literature which dominated much of the innovation field from the late 1980s onwards (Greenacre, Gross & Spiers, 2012).

**Figure 2.3** shows the growth in innovation literature, demonstrating the depth of research in the field before the 1960s, when few researchers were investigating the role of innovation in economic development, and onwards when the field began to generate more attention. There were few publications in the field as indicated from their titles before 1966. However, since then, the number of publications with innovation in the title has increased.

**Figure 2.3 Innovations in Title as a Percentage of Annual Additions[3]**




*Source:* Fagerberg, 2013

## 2.4 INTRODUCTION TO THE NSI CONCEPT

Successful innovation does not happen in a vacuum but requires participation and collaboration of various actors both in the public and private sector. When such patterns of networks collectively foster technological innovation, it is a concept known as a National System of Innovation (NSI). Whereas the linear model approach offers a static view of national innovation, the NSI model emphasizes dynamic systems of policies, networks and people that mediate knowledge flows across national borders and within domestic industries. Further the NSI approach offers a more realistic view of development processes because it views innovation efforts as intimately linked to broader macroeconomic and educational policies (Feinson, 2003).

The inspiration for the NSI concept can be dated back to as early as the 1800s but was eventually developed by Freeman and Perez in the late 1980s in a study of Japan's economic success at the time. Freeman and Perez (1988, cited in Greenacre, Gross & Spiers 2012, p. 15) defined the NSI as, *'the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies'*. Their research emphasized on the crucial role of a country's government in developing a country's technological infrastructure. Thus, while the firm was at the center of innovation in a country, it relied on the government to create an enabling environment for innovation

[3] The data is based on the number of publications with innovation in the title as a share of total annual additions to the British Library (mostly books) and the ISI Web of Science (mostly journal articles) from 1956 onwards steadily

to thrive. Freeman and Perez suggested that the government, working with industry and science, should provide;

(i) Direction and support for development and marketing of advanced technologies
(ii) An integrated approach to R&D, design, procurement, production and marketing within large firms
(iii) A high level of education and scientific culture, combined with practical training and a frequent feedback loop.

Meanwhile Ludvall (1988) and (1992, both cited in Greenacre, Gross & Spiers 2012, p. 15) focused on the design of institutions that support innovation and the process of technological learning. He emphasized the role of interactions between users and producers facilitating the flow of information and knowledge.

Ludvall explains that a distinction must be made between narrow definitions of NSI and the broad definition. The former focuses on institutions which promote the acquisition and dissemination of knowledge and are the main sources of innovation, while broad definitions recognize that these institutions are embedded in a wider socio-economic system in which political, cultural influences and economic policies aid to determine the scale, direction and relative success of all innovative activities. In such a definition, strong links between scientists and entrepreneurs is important (Ludvall, 2007; Freeman, 2002; Manzini, 2012; Fagerberg, 2013).

Further insights come from Nelson (1993, cited in Greenacre, Gross & Spiers 2012, p. 15) who pays particular attention to the role of private firms, government and universities in the production of new technology. Nelson conducted an empirical study and comparison of the NSI of 15 countries. His findings were that, *"to a considerable extent, differences in innovation systems reflect differences in economic and political circumstances and priorities between countries."* These country differences reflect variation in institutional structures including systems of university research and training, industrial R&D, financial institutions, management skills, public infrastructure and national monetary, fiscal and trade policies (Greenacre, Gross & Spiers, 2012).

The NSI approach was further developed and used extensively by the OECD following the aforesaid major studies. The OECD research on NSI strongly recognizes the firm as the founding unit of the innovation system and draws on the concept of clusters of innovating firms and involved entities (Greenacre, Gross & Spiers, 2012).

In order to analyse the concept of NSI further, it is useful to examine the connotative meanings of some of the components of the term. In recent times of globalization where free market philosophy takes precedence and modern science limits the role of the nation state, it may be peculiar that the NSI framework has gained popularity among theorists and policy makers, particularly because it advocates for the active role of government. However, while firms and the business sector may be the main actors in innovation and learning, the ability to develop the networks that facilitate this process resides with the government. Therefore, the *'nation'* remains a justifiable unit of analysis for describing the nature and performance of innovation efforts globally. The nation state provides a supporting environment for innovation and learning through institutions, policies, infrastructure, logistics, technology, culture, communications, marketing, knowledge production, business environment, entrepreneurship, intellectual property protection (IPP) and information and communication technology (ICT) connectivity. Thus, it can be suggested that the promotion of innovation within a country cannot succeed without the involvement of central players especially in the context of developing countries (Manzini, 2012).

Private firms and businesses are often drivers of innovation within an economy because the production of new products, services and processes keeps them in business. Competitive advantage at the firm level is created and maintained by innovation and learning, thus private firms spend large amounts of resources on R&D. However, firms cannot innovate in isolation but need to access knowledge and technological inputs from other actors. Interaction and collaboration between firms and all relevant actors is crucial to provide useful feedback for future innovations. Therefore the linkages of institutions and actors should form a network which constitutes a *'system'*. The strength of an industrial economy does not only rely on the core competence of individual institutions but also on the strong networks that exist between them (Manzini, 2012).

In recent years, developments in innovation system theory have gradually moved closer to a fully systemic, dynamic, non-linear process involving a range of interacting actors. Recent theories emphasize the knowledge flows between various actors such as firms, governments, private and public research councils and education institutions. Therefore while conceptual and methodological specifics differ, these more recent innovation system approaches tend to emphasize the role of several agencies and distributed learning mechanisms in technological change. The focus has shifted from all-powerful firms and unidirectional knowledge flows to inter-organizational networks and feedback loops. These innovation system theories still acknowledge the existence of stages of technological development but also attempt to include this in the broader context. A well functioning system requires feedback (both positive and negative) between different parts of the system and links between technological and institutional change. Further, a well functioning system increases the chances for a technology to be developed and diffused.

Therefore, the guiding principle of innovation studies is discovering which activities and contexts promote or impede innovation within innovation systems. This will help to intentionally shape the innovation process. Research work on systemic innovation over the last decade involves *'technology innovation systems', 'technology transitions'* and the *'multi-level perspective'.* While these approaches may vary moderately, they all consider technological change as a process interacting with changes in wider socioeconomic structures and not just as a development in physical technologies (Greenacre, Gross & Spiers, 2012).

## 2.5. CURRENT APPROACHES TO THE NSI CONCEPT

The subsequent sections will provide a brief discussion on the current approaches to the NSI concept namely, technology innovation systems (TIS), technology transitions and the multi-level perspective. From these approaches key concepts of NSI analysis will be identified and used to formulate a framework for reviewing the performance of Zambia's NSI for the period 2001 to 2010 in chapter three.

### 2.5.1. Technology Innovation Systems (TIS)

The TIS approach has been developed to analyse and evaluate the development of a particular technological field in terms of the structures and processes that either support it or impede it. TIS differ from other broader national (or regional) system theory in its basic starting point. The latter begin with the premise that innovation is geographically heterogeneous while the former begins with technology and technological change at the firm level. Furthermore, in TIS the number of actors, networks and institutions is generally less complex than the national system theory. However, despite the smaller number of actors, institutions and networks involved in the TIS theory, the scope of this theory does overlap with sectoral, regional and national interactions. The interaction and knowledge flow within the actors, institutions and networks remains fundamental to the TIS (Greenacre, Gross & Spiers, 2012). The following are the three main elements of the TIS approach:

(i) The actors including firms, users, suppliers, investors and other organizations
(ii) Networks, defined as the channels for the transfer of tacit and explicit knowledge
(iii) Institutions, being the entities that shape the environment within which all actors operate

A review of an innovation system using the TIS approach involves the following;

(i) Firstly, the *structure* of the innovation system is analysed. This includes the actors, networks and institutions within the system.

(ii) The *functioning* of the system is analysed using various indicators. The TIS attempts to analyse innovation systems by assessing the *functions* of the system. Most literature discussing innovation system failure tends to focus on perceived weaknesses in the structural composition of the system. However, to determine whether an actor, institution or network is a strength or weakness, one must identify its influence on the innovation process. Therefore, both structural and process focus is necessary to innovation policy (Greenacre, Gross & Spiers, 2012).

There are various essential functions that are considered within a technological system. These functions directly influence the development, diffusion and use of new technology and therefore, the performance of the system. These functions measured using various indicators, include the following:

(i) *Entrepreneurial activities*: without entrepreneurs innovation would not take place and the innovation system would not exist. Thus, entrepreneurs are important for innovation systems.

(ii) *Knowledge development*: this includes learning by searching, learning by doing and knowledge diffusion. R&D and knowledge development are fundamental elements of an innovation system. In addition, a necessary function of networks is the exchange (diffusion) of information.

*(iii)* *Guidance of the search:* policy goals and expectations can generate momentum for change. For instance, the policy goal to increase a certain amount of R&D funding per year would grant a certain degree of legitimacy to the generation of knowledge and stimulate the mobilization of resources.

*(iv)* *Market formation:* the formation of niche markets or use of certain economic instruments such as tax.

*(v)* *Resource Mobilization:* organizing resources (financial and human) are basic inputs to innovation activities.

*(vi)* *Creation of legitimacy and counteraction of resistance to change:* in order to develop a new technology well, it needs to assimilate into the incumbent regime or overthrow it. Advocacy coalitions can function as a catalyst to create legitimacy for the new technology and counter any resistance to change.

*(vii)* *Development of positive externalities* such as technological spillovers.

The more the aforementioned system functions are fulfilled, the better performing an innovation system will be. This will result in successful development and diffusion of technology within an economy. The individual system functions and the interaction dynamics of the entire group are crucial. These interactions could either lead to a reinforcing dynamic in the system or a collapse of the system (Greenacre, Gross & Spiers, 2012).

A popular theme in TIS literature is the competition between established systems and emerging ones. On one hand, the entry of a firm is viewed as developing key functions of the innovation system such as creating new knowledge; while on the other hand, the behavioral patterns of established firms are viewed as blocking the development of such functions of the new firm. In such situations government policy is crucial to maintain the functions necessary for the innovation system to thrive, especially in the early stages of technological development (Greenacre, Gross & Spiers, 2012).

Recent research in TIS has developed methods for the analysis of specific systems and the comparative assessment of different technologies and systems. The objective of this analysis is to provide useful outputs for technology developers and for policy makers to assess performance of innovation systems and determine key policy recommendations. The following are methods for TIS performance assessment (Greenacre, Gross & Spiers, 2012):

(i) Define the innovation system taking into consideration the decisions to be made between the knowledge field and the product focus.
(ii) Identify the structural components of the TIS which include the actors, networks and institutions.
(iii) Map the functional pattern of the TIS based on the aforementioned seven functions.
(iv) Assess the functionality of the TIS and establish process (policy) goals. This step involves reviewing the performance of the innovation system.
(v) Identify inducement (strengths) or blocking mechanisms (weaknesses).
(vi) Specify key policy issues which aim to fix poor functionality by reinforcing inducement mechanisms and weakening blocking mechanisms.

### 2.5.2. Transitions Theory

Recent innovation studies have focused on detailed process of technological change which not only involves incremental change but radical (disruptive) shifts in products and processes. The transitions theory takes a multi-disciplinary approach to innovation system analysis. Therefore, it not only includes economics but sociology, history and engineering. The transitions theory is mainly used to anticipate and manage future transitions. It has developed along three main lines, namely: *the multi-level perspective of the transition process, transition management* and *socio-technical framework* (Greenacre, Gross & Spiers, 2012).

### 2.5.3. The Multi-Level Perspective

The multi-level perspective uses the idea of levels of innovation. This theory is important for understanding that innovations (particularly disruptive ones) are dependent on multiple processes in the wider context of landscapes and regimes. The development of technologies not only involves changes in technology but also changes in user practices, regulation, industrial networks (i.e. supply, production, and distribution), infrastructure and culture at three levels; macro level (landscapes), meso level (socio-technical regimes) and micro level (technological niches) (Greenacre, Gross & Spiers, 2012).

At the micro (niche) level, innovations are created. However, innovations usually go unnoticed at this level because of the incumbent blocking mechanisms at the meso level. However, some innovations manage to break out of the niche level by linking up with processes at the meso and landscape level (Greenacre, Gross & Spiers, 2012).

The meso level (socio-technical regime) involves the interaction between the actors and institutions, and the resultant routines and practices involved in creating and re-enforcing a particular technological system. Innovations at this level are often radical in nature. The regime level is comprised of a web of interlinking actors across different social groups and communities following a set of rules. Technological regimes produce technological trajectories, which are the paths by which innovation in a given field occurs. In turn, technological trajectories are located within a landscape (macro level). The landscape represents the broader political, social and cultural values and institutions that form the structural trends of society. While both *'regime'* and *'landscape'* are similar in that they are structures or contexts in which actors interact, they are different in that the former refers to social structures and rules that enable and constrain activities within communities. Thus, the *'socio-technical landscape'* combines certain features of both levels (meso and macro) to account for external factors that influence the innovation process and have an impact on its development in the short to medium term; for instance, factors such as commodity prices, economic growth, wars, emigration, cultural and normative value and environmental challenges. Technological transitions (defined as incremental or disruptive shifts in products and processes) occur when there is interplay between the three levels (Greenacre, Gross & Spiers, 2012).

### 2.5.4 Transitions Management

Transition management theory has emerged to suggest that governments promote and protect the development and use of promising technologies. This model differs from technology-push policies because of the role of the nation state. Transitions management recognizes that governments, firms and other relevant stakeholders have a central role to play in innovation system change. Therefore, this model goes beyond niche promotion at the micro level but takes into consideration the broader contexts in which niches evolve. Transitions management acknowledges the social and institutional factors that contribute to the locking-in of incumbent technological systems. The model promotes the use of specific economic instruments alongside interaction of entities, the mode of governance and establishing economic goals in developing effective innovation systems (Greenacre, Gross & Spiers, 2012).

### 2.5.5 Socio-technical framework

Another main line of research under the transitions approach is to develop a socio-technical framework. This framework describes a potential transition in terms of developing technologies, exploring potential links actors and analysis of the effects of these links on the developing technologies. Three main steps are identified in this framework, namely (Greenacre, Gross & Spiers, 2012):

(i) Characterize the key elements of existing regimes within the innovation system (actors, socio-technical regimes and landscape).
(ii) Identify key processes that influence the development of innovations at the micro (niche) level.
(iii) Specify system interactions.

## 2.6 KEY CONCEPTS OF NSI ANALYSIS

The TIS, transition and multi-level perspective theories exhibit some significant similarities. All these models attempt to create an integrated, systems-based concept of innovation in order to comprehensively understand the structures and processes involved. Four concepts connect these theories, namely:

(i) The micro level or niche (firm and various actors that support the firm such as education institutions)
(ii) The meso level of socio-technical regime (supporting innovation infrastructure and institutions)
(iii) The macro level or landscape (broader political, social and cultural institutions)
(iv) Linkages (the dynamic interaction of the three levels)

The aforesaid concepts will be used to develop a framework for reviewing Zambia’s NSI.

## 2.7 THE IMPORTANCE OF THE NSI APPROACH TO DEVELOPING COUNTRIES

The most attractive use of the NSI concept is its contributions to policy making. NSI helps to shift the focus from individual organizations to both the organizations and the interactions between them. It also acknowledges that S&T institutions such as firms and universities are influenced by a wide range of institutions and supporting organizations. Further, it not only focuses on S&T input and output but also on innovation processes and outcomes. Finally, the approach changes the focus of analysis from only looking at the internal workings of an economic system to the way that system interacts with the world. Organizations such as TRIPS and WIPO influence the R&D decisions of firms in national systems of members (Dantas, 2005).

Initially the NSI concept was quite popular in developed countries. However, it has recently come under examination in the developing country context. In developed countries innovation systems serve the role of maintaining and improving an already established level of competitiveness and growth while those in developing countries are faced with the tasks of catching up (Watkins et al, 2014).

The NSI approach was developed based on institutional structures and activities identified in developed countries such as Japan, USA, Germany and Sweden, whereas developing countries were largely absent from early literature. However, shortly afterwards the NSI concept was applied to countries termed as *Newly Industrialised Countries (NIC)* such as South Korea, Taiwan, Singapore and Argentina. Recently, the approach has been applied to emerging countries such as Brazil, South Africa, China and India; however, its application has been limited in less developed countries in sub-Saharan Africa. The gradual inclusion of developing countries within the NSI conversation has coincided with several interrelated shifts occurring in NSI literature over the past three decades; (i) a move away from macro-institutional explanations to focus on specific system processes (ii) an emphasis on the role of intermediary and non-governmental actors in this regard, and (iii) the increasing internationalization of the concept. These shifts have demonstrated the usefulness of the NSI approach in two respects; first, its ability to account for socio-economic and political specificities and secondly, its focus on power relations in discussing innovation and knowledge accumulation (Watkins et al, 2014).

Feinson (2003) explains that in arguing for the NSI approach specific to developing countries, STI policy should be demystified. It does not need to be associated with only developed countries nor viewed as an unnecessary luxury for developing countries. It is an approach suited for policy makers in developing countries because it allows them to identify leverage or weak points within the network. It champions public, private and academic collaborations to technological developments of firms through the development of human capital and appropriate economic policies designed to promote international competitiveness. The NSI approach can also be used as an analytical tool to identify obstacles to an efficiently functioning innovation system in countries where it is in its nascent stage, and can be used as a prescriptive tool for policy making. This is taking into account the heterogeneity of developing countries which may face different challenges depending on their development stage (Dantas, 2005).

With regards to Africa, NSI strategies have been championed by the AU as part of the broader socio-economic development goals. The CASTAFRICA II in 1988 organized by UNESCO and OAU (ECA) was the first conference that began to incorporate STI in Africa's development agenda. The conference brought together experts and 26 African ministers responsible for STI, to develop strategies for Africa's economic recovery. Following the transformation of the OAU to the AU in 2001 in Lusaka (Zambia), was the creation of the New Partnership for Africa's Development (NEPAD). NEPAD identified and established the Department of Human Resources Science and Technology as one of 8 technical departments of the AU Commission with the mandate to advance education, S&T and human capital development on the continent. The AU Commission established a conference of Ministers in charge of S&T to enable the union to periodically deliberate and have a collective voice on S&T issues. In 2005 the Consolidation Plan of Action (CPA) was presented as an instrument for implementing STI decisions by the AU Assembly of Heads of State and Government. The following year, at the Khartoum summit for Heads of State CPA was endorsed. The achievements and lessons learnt from implementing the CPA were the foundation for which the AU Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) was created. STISA-2024 places science, technology and innovation at the forefront of Africa's socio-economic development and growth. It was developed as a medium-term check for the broader goals outlined in the AU Agenda 2063. It is the first out of several ten year strategies to respond to the demand for science, technology and innovation in various sectors such as agriculture, energy and health (STISA-2024, 2015).

Successful implementation of the strategy required a minimum set of requirements (pillars). This included STI infrastructure development, developing technical competencies through education and research, supporting innovation and entrepreneurship by increasing networking and collaboration between education, research, private and public stakeholders at both national and regional levels and creating an enabling environment for STI to thrive (STISA-2024, 2015).

## 2.8 LIMITATIONS OF THE NSI CONCEPT FOR DEVELOPING COUNTRIES

Despite the various benefits of the NSI approach to developing countries, there are also some limitations. Gerschenkron (1962, cited in Varblane, Ukrainski & Lillestik, 2011, p. 40) was one of the earliest scholars to analyze the catch-up process using the German and Russian steel industries. He argued that latecomer firms have several advantages with regards to leaders. Latecomers can acquire and use modern technologies at a much lower cost than the leaders through technology transfer agreements, inward investment and the recruitment of skilled human capital. In addition, catch-up firms and countries do not have to face uncertainties, costs and challenges of opening entirely new markets, because world markets in the given sectors have already been created by the leading firms and countries.

Bell and Pavitt (1993, cited in Varblane, Ukrainski & Lillestik, 2011, p. 41) disputed this and argued that it is not sufficient for a developing country to acquire and use modern technologies but in addition, to also build technological capacity and wide implementation of active learning policies; for this, developing countries require an innovation system that works properly. If a country is unable to absorb the new technology then lock-in failure (capability failure) may occur.

Abramovitz (1994, cited in Varblane, Ukrainski & Lillestik, 2011, p. 41) developed Gerschenkron's latecomer advantages by accepting the potential to catch-up by latecomers but suggested that this would not be an automatic process unless certain factors are considered. He explained that the differences in countries' ability to catch up are based on two factors; technological congruence and social capability. Technological congruence involves the degree to which the developed country also known as the *'leader'* and the developing country, known as the *'follower'*, resemble in areas such as market size, factor supply and other comparable characteristics. Social capability focuses on the capabilities that developing countries have to acquire in order to catch-up; for instance education and business infrastructure. Both technological congruence and social capability are challenges for developing countries.

Freeman (1999, cited in Varblane, Ukrainski & Lillestik, 2011, p. 41) connects technological congruence and social capability with the ability to make institutional changes. He places institutional change at the root of social capability that enhances technical change (innovation systems). An example of this is the Asian Tigers. These countries experienced institutional change to bridge the *'learning divide'* and the *'technology divide'*. The Asian Tigers built innovation systems that leveraged domestic resources that were available, and diffused foreign technology to create technological capabilities and competitive products. They developed institutions to support this process; another major challenge in the developing country context today.

Freeman (2002) further suggests that developing country proximity to the leader country helps to develop the developing country's NSI more rapidly. For example, the Asian Tigers' proximity to Japan helped to develop their innovation systems. This would be a challenge for countries in developing regions such as Africa that are geographically distant from developed regions. It must be noted that the experiences of the

Asian Tigers cannot be easily replicated because the conditions for catch-up have become more demanding.

Apart from the various challenges highlighted above, one of the most common problems in building an innovation system in a developing country is the path dependency and lock-in condition as a result of historical economics. Path dependency implies that the set of decisions faced by a country is limited by the decisions made in the past, even though past circumstances are no longer relevant (Greenacre, Gross & Spiers, 2012).

The existence of path dependency does not always translate into inefficiencies. It can be divided into three categories (Varblane, Ukrainski & Lillestik, 2011):

(i) First-degree path dependency which occurs when the decision contains an element of persistence. For instance, today's conditions depend on decisions and other conditions from the past; however no mistake or inefficiency can be identified.

(ii) Second-degree dependency refers to choices made in the past; for instance, chosen paths have led to adverse outcomes that may be too costly to reverse. However, these choices cannot be considered inefficient if the lack of information in the past is taken into account.

(iii) Third-degree path dependency and the strongest form of dependency is the existence of inefficiencies implying that errors made though remediable, could have been avoided.

Varblane, Ukrainski & Lillestik (2011) further explains the effects of path dependence and lock-in conditions using case studies from Central and Eastern Europe Countries (CEE), East Asia and Latin America countries. These regions have all initiated catch-up policies. CEE latecomers' experiences are similar to past experiences in Zambia in that these countries presumed that the introduction of a free market economy and minimal role of the government would catalyze the catch-up process. However, this was an example of movement from one extreme economic policy characterized by strong government intervention to another which favoured excessive liberalism. Market-based systems are not sufficient to achieve sustained economic development because development is not a linear process but is multi-dimensional and multi-lateral; an approach which was used by the East Asian countries where governments played an active role in transforming their NSIs (von Tunzelmann 2003, cited in Varblane, Ukrainski & Lillestik, 2011, p. 44).

Dependency and lock-in conditions manifest in different ways. One way is through FDI. In their pursuit of free market economic policies CEE latecomers used FDI as a key mechanism for technology transfer and having access to global networks, thereby shifting the responsibility of innovation to foreign investors. FDI policy was not selective in CEE countries as it was in the East

Asian countries. While FDI produced short term gains during the restructuring period, policy makers are uncertain of its long-term impact to economic development. For certain CEE countries FDI threatened to lock them into a low-cost producer status (Varblane, Ukrainski & Lillestik, 2011). The experience of CEE countries with FDI is similar to Zambia's case. The country experienced restructuring based on free market reforms introduced in 1991 onwards, depending on FDI through privatization of SOEs inter alia to stimulate economic growth. Currently, the country still follows similar investment policies and is dependent on FDI (Phiri, 2011) as a means of skill and technology transfer, inter alia, as outlined in Vision 2030 (2006). However, this depends on the nature of FDI. FDI does not automatically provide local suppliers with skills and competence that meet international standards if the principal learning processes are located in the developed country. Inward FDI does not necessarily assist local firms in establishing links with global networks unless there are joint networks of public-private initiatives to support local supplier networks. Further, there should be linkages between foreign firms and domestic firms to enable transfer of skills and technology. Finally, local firms should develop capacity in order to be attractive to foreign firms (Varblane, Ukrainski & Lillestik, 2011).

Another example of dependency and lock-in condition is through confrontation between high and low tech industries. The dominance of the linear model of innovation among neoclassical economists introduced policies that advocated for the *'science-push model'* (Varblane, Ukrainski & Lillestik, 2011). According to Manley (2002) this model approach viewed the innovation process as one that begins with scientific discovery, passing through invention, engineering and finally ending at manufacturing activities. The focus of many developing countries has often been based on this strategy to create new high-technology industries (for instance ICT). Policy makers in developing countries assume that high-tech industries unequivocally lead to high value-added, high wages and economic growth. They tend to allocate a large proportion of resources into the creation of a high-tech sector at the expense of support to competitiveness to sectors (often low-tech) that employ majority of the population, resulting in a dual economy (Varblane, Ukrainski & Lillestik, 2011). This may be another challenge that Zambia faced between the periods 1964 and 2009. Existing literature implies that the development of the manufacturing sector appears to have been guided by more of a science-push model rather than principles acknowledging the dynamic nature of innovation.

As explained previously, the NSI approach was developed using the experiences of developed countries with a strong accumulated knowledge base, well-functioning market system and developed institutions and infrastructure to support innovation activities. Further, the NSI concept was developed for countries that were experiencing moderate growth. Developing countries attempting to catch up face different conditions; they have a much lower income level and less accumulated knowledge. In addition, they are extremely dynamic which produces special requirements for their NSI. Thus, it is not possible to automatically transplant innovation system concepts that have been applied in developed counties at the technology frontier to developing and transitioning countries. Such an approach fails to account for the local institutional context and its inadequacy in fostering learning and innovativeness in the innovation system. Therefore, an approach that meets the challenges of adaptation needs to be developed for countries attempting to catch up. Further the relationship between globalization and national/local innovation systems needs to be a potential point of research (Varblane, Ukrainski & Lillestik, 2011). On this point, Rodrik (2011) argues that global regulations supported by multi-lateral organizations such as the WTO may not be favourable to developing countries because these regulations do not allow for sufficient policy space to enable developing countries to catch-up. For instance, where the Asian Tigers were able to develop through STI, inter alia, because of flexible IP global regulations under GATT; developing countries lack access to that privilege because of IP restrictions, inter alia, under the WTO (GATT successor).

# CHAPTER THREE: THE NATIONAL SYSTEM OF INNOVATION IN ZAMBIA

## 3.1 OUTLINE OF THE ZAMBIAN NSI

While Zambia has recognized the need for STI in its development goals, the empirical evidence indicates that the implementation has hardly been systematic. Policy documents such as the Zambia Vision 2030 (aimed at outlining strategies to make Zambia a prosperous middle income country by 2030), the recently released Seventh National Development Plan (aimed at accelerating development efforts towards vision 2030), the National Science and Technology Policy and the Commercial Trade and Industrial Policy do not make use of the NSI concept. These documents recognize the role STI plays in the development of any country, particularly through innovation and trade but hardly recognize the need for a holistic innovation system where stakeholders interact to foster it. Thus these documents outline targets to enhance the application of STI in various sectors as well as promoting a national culture of research and innovation but do not introduce the NSI approach to coordinate these efforts.

The most comprehensive study on Zambia's NSI was conducted by the Institute of Innovation and Technology (iit). The Institute of Innovation and Technology (2010) attempted to organize, identify and provide an assessment of the determinants of Zambia's NSI, grouped into three levels;

(i) Macro Level: Innovation Policy Level
(ii) Meso Level: Institutional Support Level and Programmatic Innovation Support Level
(iii) Micro Level: Innovation Capacity Level.

The *Macro level* formulates the framework conditions for innovation as well as oversees actors operating in the NSI. Public investment in innovation relies on decisions made at a policy level. However, such political decisions may only influence the framework conditions for innovation but may not turn innovation into practice. Compared to its peers, Zambia has relatively well developed innovation friendly regulations especially with regards to IPR policies and technical and vocational training infrastructure but has weak regional and cluster innovation policies. Under the Macro Level, the main innovation system organizations in Zambia are the Ministry of Agriculture and Livestock, Ministry of Commerce, Trade and Industry, Ministry of General Education, Ministry of Higher Education and National Science and Technology Council (iit, 2010).

Institutional organizations at the *Meso Level* are Citizen Economic Empowerment Commission (CEEC), NTBC, Technology Development and Advisory Unit (TDAU at University of Zambia) and Zambia Chamber of Small and Medium Enterprises (ZCSMBA at ZDA). These institutions operating at the Meso

Level are mainly technology transfer centers, innovation service providers and funding agencies. They may be considered the relevant tools to turn policy into practice and usually provide training, consultations, applied R&D and product improvement. One of the biggest challenges with institutions operating at the Meso Level is the lack of financial resources and the failure to distribute their services to other regions in the country. Public venture capital funding at this level is restricted to CEEC; however these funds are limited. Further, NTBC also has limited funding for inventors and lacks the ability to commercialize inventions. In addition, neither publicly organized technology parks nor incubators exist as a means to support innovative SMEs. Despite these weaknesses, Zambia has relatively well developed innovation support organizations such as law offices and industry associations compared to its counterparts (iit, 2010).

The *Micro Level* comprises of the main actors and enablers within the NSI such as entrepreneurs, universities, SMEs, public and private R&D institutions (research centers) and financial organizations. Zambia has three public universities, approximately 20 technical and vocational training organizations and research organizations which form the foundation of S&T education, development and application. Education institutions are poorly funded and their international visibility is low. Fundamental research organizations are limited in number and impact. It is interesting to note however, the increase in foreign scientific researchers due to mobile phone communication over the last two decades. Institutions at the Micro Level include the University of Zambia (UNZA), the Copperbelt University, Technical Education, Vocation and Entrepreneurship Training (TEVET) and NISIR (iit, 2010).

**Table 1** provides a summary of the three levels of Zambia's NSI and their respective determinants according to the Institute of Innovation and Technology (2010).

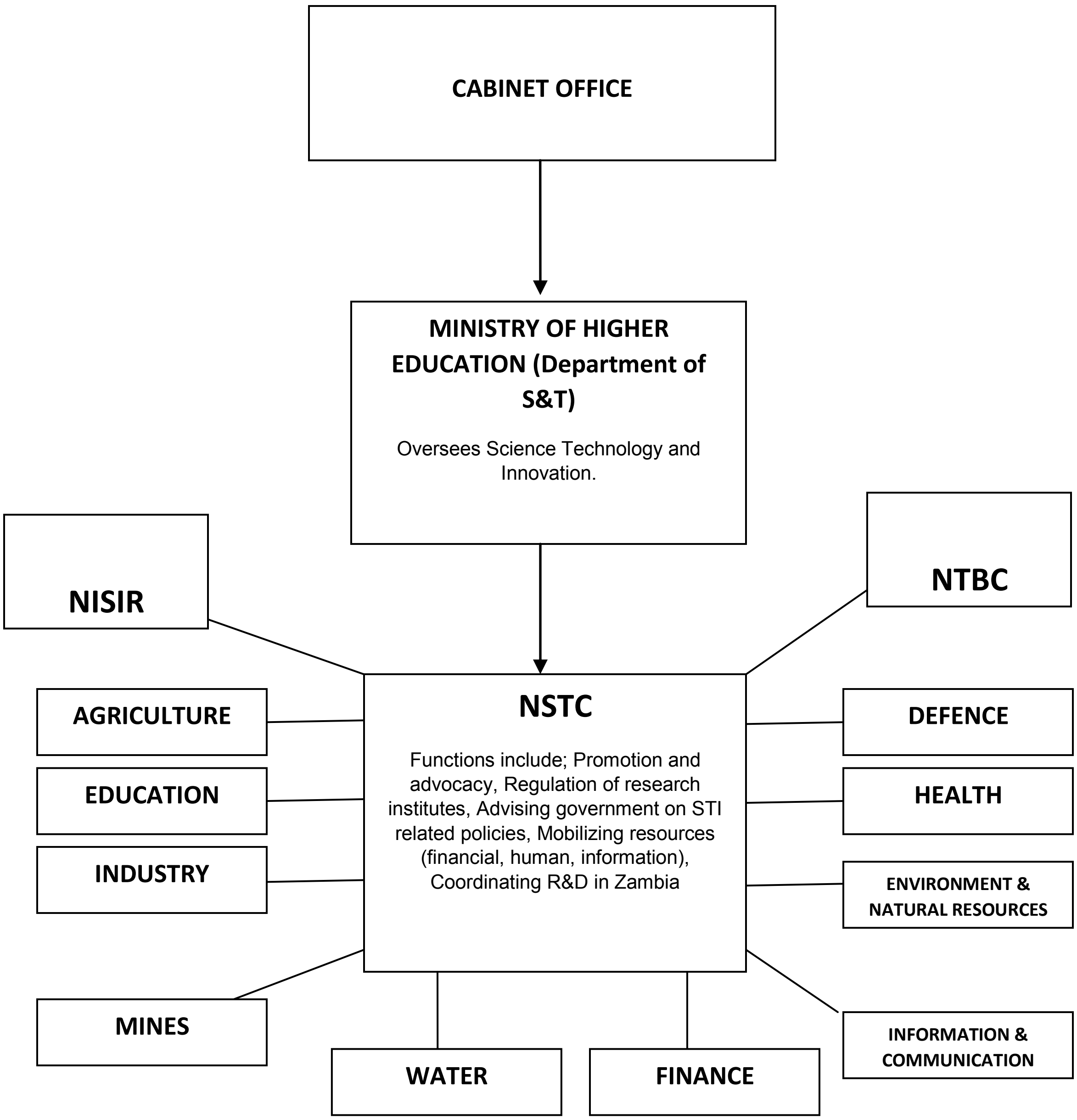
**Table 1 Main Determinants of Zambia's NSI**

| Policy Level<br>(Macro) | Institutional Innovation Support Level<br>(Meso) | Programmatic Innovation Support Level<br>(Meso) | Innovation Capacity Level<br>(Micro) |
|---|---|---|---|
| National Innovation Policy | Technology Transfer Centers | STI Funding Schemes | Universities |
| Regional Innovation Policies | Technology Parks | Fundamental R&D Programmes | Institutions for Fundamental R&D |
| Master Plans | Incubators | Applied R&D Programmes | Private R&D Institutions |
| Training and education | Clusters | Joint Funding Schemes | Innovators |
| Foresight R&D Agenda | Business Promotion Agencies | Accompanying Measures to support STI | Private Investors |
| Cluster Policy | Innovation Service Providers | Entrepreneurial Support | Entrepreneurs |
| Innovation Friendly Regulations | Funding Agencies | Cluster Development Programmes | SMEs |
| | | Internationalization Support | Large Companies |

*Source:* Institute of Innovation and Technology, 2010

**Figure 3.1** focuses on the Macro level and shows the public sector institutional chain involved in the NSI in Zambia post 1996. As mentioned previously, MSTVT was originally in charge of overseeing STI and vocational training until 2015 when the Ministry of Higher Education assumed the responsibility. NISIR, NTBC and various research departments found under the line ministries are supported by NSTC. The framework is a top-down approach where government has more authority in mandating how STI is applied (Daka and Toivanen, 2014)

**Figure 3.1 Institutional Innovation Chain in Zambia**




*Source:* iit (2010), MoHE, NSTC, National S&T Policy (1996)

While the Institute of Innovation and Technology (2010) provides a static indicator-based assessment of the determinants of Zambia's NSI according to a three-level hierarchy (Macro, Meso and Micro), this study will provide an in-depth review of the NSI in Zambia, over a ten year period to track its performance by using a similar methodology.

## 3.2 THE IMPORTANCE OF THE NSI TO ZAMBIA'S PAST ECONOMIC GROWTH AND DEVELOPMENT

National economic growth is viewed as a progression through stages of technological change and expanded productivity that includes three prominent stages; (i) factor-driven (ii) investment-driven, and (iii) innovation-driven.

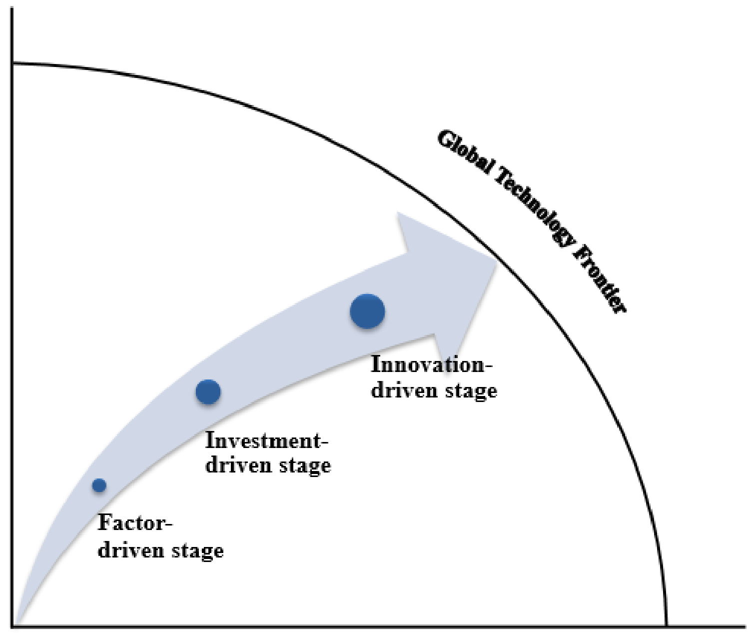
In the factor-driven growth stage, countries are mainly involved in producing raw materials from natural resource endowments with low labour costs. Firms in countries during this stage usually compete domestically and globally through resource extraction, assembly or simple manufacturing. Productivity in this stage is low. Technological learning is mainly acquired through imported technology, imitation and foreign investment (WEF, 2010; Institute for Strategy & Competitiveness, n.d.).

In the investment-driven stage, efficiency in producing products and services becomes the dominant source of competitive advantage. Investment flows into a country's economy more easily and technology, physical, and human capital are accumulated. Domestic technology is facilitated, and STI policy is implemented, encouraging applied research and productivity increases. Policy also creates a regulatory environment that supports investment and the business sector. Economies at this stage concentrate on manufacturing and on outsourced service exports (WEF, 2010; Institute for Strategy & Competitiveness, n.d.).

Finally, countries in the innovation-driven stage of growth prioritize R&D, innovation and entrepreneurship. These economies have the ability to produce innovative products and services at the global technology frontier using the most advanced methods. They create new knowledge and unique products through clusters of innovation. STI policies as well as institutions create an enabling environment for research, investment and science-based learning. STI and the ability to shift rapidly to new technologies are crucial to competition at a domestic and global level (WEF, 2010; Institute for Strategy & Competitiveness, n.d.).

**Figure 3.2** shows a country's progression through the aforementioned stages of technological change and towards the global technology frontier. A country's progress from one stage to the next involves transitioning from an economy that primarily imports technology to one that creates technology.

**Figure 3.2 Stages of Growth in the Global Technological Frontier**




*Source:* Parkey, 2012

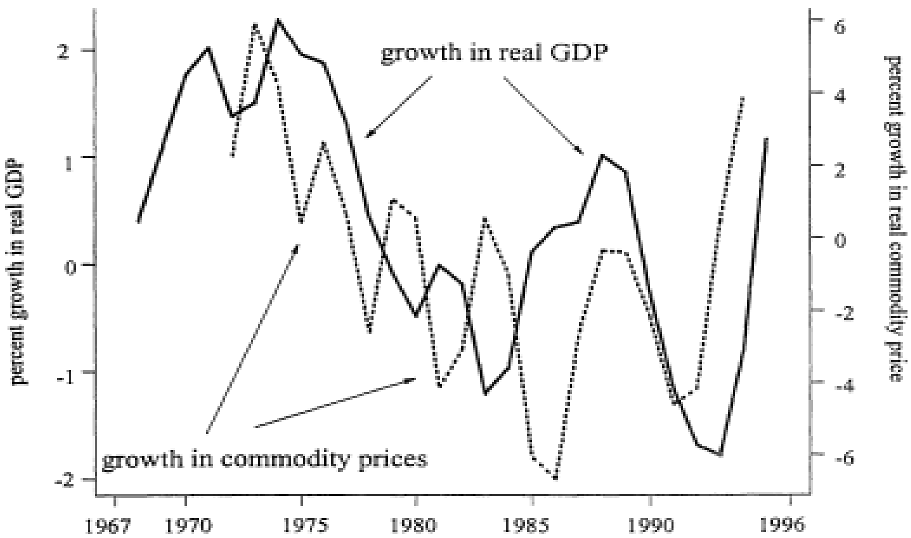
The Global Competitiveness Report 2016 (GCR) positions Zambia in the Factor-Driven Stage indicating that the country's competitive advantage is with producing primary commodities. Zambia is strongly dependent on rain-fed agriculture and mining and its major exports are predominantly mineral and agricultural commodities (copper and maize/cereals). In addition, a large part of the country's labour force (85%) is unskilled (Institute for Innovation and Technology, 2010). Only 6.8% of the working population aged 15 years and older have received skills training while 92.5% have never received any skills training; a large proportion of which are based in the rural areas (Zambia Labour Force Survey, 2012). Further, since the onset of the free market economy in 1991, the Zambian government has been actively seeking FDI. Since 2011, FDI inflows to Zambia has been accelerating, albeit mainly to the mining sector, and in 2014 the country received USD 2.48 billion making it one of the highest recipients in Africa (Santander, 2017). The Seventh National Development Plan states that one of the reasons for pursuing FDI is to enable skills and technology transfer.

According to the GCR, Zambia has not been able to attain an international leading position due to a variety of reasons such as; poor institutions, unstable macroeconomic environment, weak infrastructure, poor higher education training, low technological readiness, lack of financing and innovation. There is little empirical evidence that shows that Zambia's NSI functions effectively or that S&T have contributed to economic growth post-independence (Daka and Toivenan, 2014).

The available literature does however suggest that since independence, Zambia's economic growth has been tied to commodity prices. Therefore, growth in the prices of commodities has led to economic growth while slumps in prices have led to declines in economic growth. For instance in 1974 when the global copper prices declined by over 40%, the GDP growth rate in Zambia dropped from 4% between the years 1965 and 1974 to 0.1% between the years 1975 to 1984. Another example is the surge in the demand for commodities (metals) from China in the 2000s which contributed to increased global demand. China is Zambia's second largest trading partner and as of 2015 imported approximately USD 1.8 billion worth of commodities primarily from the country's mining sector. During this period Zambia's growth rate was an average of 7 percent per annum making the country one of the best performing on the continent. Eventually, China's growth began to slow down and this affected its global demand for certain commodities (metals). In turn to some degree, this affected global copper prices post 2010 and had a negative effect on Zambia's economic growth (iit, 2010; IMF, 2012).

Economic growth in Zambia is strongly related to international trade (Chirwa and Odhiambo, 2016). Although there are no obvious signs that high commodity prices are more of a curse than they are a blessing for commodity dependant countries, the growth of African economies is better when the prices of commodities are rising rather than when they are falling (Deaton,1999). Through research conducted by Deaton and Miller (1995, cited in Deaton, 1999, p. 32-38), the relationship between commodity prices and growth in Africa was examined by constructing for each Sub-Saharan country a specific index of commodity prices that weighted together with the world prices of the commodities, which each country exported using common prices. They fixed individual country weights, deflated by a common index of prices of manufactured imports. Deaton and Miller (1995, cited in Deaton, 1999, p. 32-38) used vector autoregression supplemented by the price indexes to examine the relationship between GDP, its components and commodity price fluctuations. These calculations used national income information from the Penn World Tables and covered the period from 1981 to 1986. In addition, they tailored the price indexes to each country.

**Figure 3.21 Economic and Commodity Growth in sub-Sahara Africa for 3 year moving averages 1967-1996**




*Source:* Deaton, 1999

**Figure 3.21** shows that there is a strong correlation between growth of real per capita GDP and growth in the commodity price indexes averaged over sub-Saharan Africa. The relationship is stronger for long-swings, but also apparent over short periods with commodity prices leading the growth. Deaton's calculations showed that for a country whose commodity exports are a third of GDP, a commodity price increase of 1% of GDP will directly increase national income by 0.015% from the induced increase in GDP. Although Deaton (1999) did not weight for the size of the economies or the heterogeneity of countries, he argues that accounting for these factors and redoing the regression analysis results in the same outcome. Further, his study does not allow for other determinants of growth in Africa. However, despite these potential problems, his study strongly indicates that the growth of economies that depend on commodities for their exports are affected by the price of those commodities; especially when they are price takers.

While Meller and Simpasa (2011) reject the concept of the curse of natural resources for Zambia, they confirm empirical evidence that shows a positive relationship between copper prices and economic growth rates in Zambia but add that overall policy response to commodity booms determines the positive or negative impact of natural resources on countries well endowed.

One of Zambia's biggest challenges is the inability to harness the abundant natural resources into wealth of which STI plays a crucial role in this process. Previously, S&T was absent in economic policy framework until 1996 when the first National Science and Technology Policy was drafted and later revised in 2009. The policies were designed to embed S&T as part of the culture in key sectors to promote competitiveness and stability in economic growth. One of the main objectives of the 2009 revised National Science and Technology policy was to *'impact on economic growth through creating wealth and jobs by supporting the creation of Micro, Small and Medium Enterprises (MSMEs)'*. However, its weakness to date is due to lack of institutional support and financial instruments to facilitate technology diffusion, transfer, innovation and commercialization (Daka and Toivanen, 2014).

## 3.3 MEASURES FOR REVIEWING ZAMBIA'S NSI

To review Zambia's NSI, the innovation system was organized into three hierarchal levels namely; micro, meso and macro. Under these levels, system functions were selected namely; knowledge development at the micro level, business, industrial and entrepreneur activities at the meso level and resource mobilization at the macro level. Thereafter, indicators were selected to measure each system function.

The following levels, system functions and their respective indicators are proposed to review the performance of Zambia's NSI system:

(i) At *macro level* an indicator that measures resource mobilization: Government Budget Appropriations or Outlays for R&D (GBAORD).

*(ii)* At *meso level* indicators that measure investment in imported know-how and technology spillovers: technology payments and FDI as a % of GDP. In addition, indicators that show trends in the export of Zambian goods and the country's comparative advantage by measuring certain business, industrial and entrepreneurial activities: trade as a % of GDP, high-technology exports as a % of GDP and the RCA index. Further, proxy indicators that track Zambia's technical progress: total number of patent applications (resident, non-resident) and total number of industrial design applications (resident, no-resident). Finally, indicators that measure enablers to innovation within the digital economy in Zambia such as internet users and mobile phone penetration.

*(iii)* At *micro level* an indicator that measures knowledge development through the total number of Zambian scientific publications generated in Zambia during 2001 to 2002. This indicator

has the following sub-indicators: total number of publications (WoS), total number of scientific publications in various fields, total number of collaborative publications.

It is important to note that indicators are pointers and do not address causal relationships. The aforementioned indicators have been selected with the following criteria:

(i) The indicators are based on high-quality statistics and robust analytical principals. Over time, they are measurable internationally with the prospects of improvement.

(ii) The indicators are relevant especially for decision makers.

While the proposed indicators do not explicitly measure linkages per se, to some degree they do give an indication of the strength of system linkages.

The **table 2** below shows a summary of the hierarchal levels, system functions and their respective indicators.

**Table 2 Summary of Hierarchal Levels and Indicators used to evaluate Zambia's NSI**

| **Micro Level**<br>*(Knowledge development)* | **Meso Level**<br>*(Business, industrial and entrepreneurial activities)* | **Macro Level**<br>*(Resource mobilizations)* |
|---|---|---|
| **Total number of Zambian Scientific publications**<br>(i) Total number of scientific publications-WoS<br>(ii) Total number of scientific publications in various fields<br>(iii) Total number of collaborative scientific publications | **Technology payments**<br>**FDI Inflows (% of GDP)**<br>**Trade (as a % of GDP)**<br>**High-technology exports**<br>**Exports (as a % of GDP)**<br>**RCA index**<br>**Total number of patent applications**<br>(i) **resident**<br>(ii) **non-resident**<br>**Total number of industrial design applications**<br>(i) **resident**<br>(ii) **non-resident** | **Total GBAORD**<br>**GBAORD (% of GDP)** |

*Source:* South African STI indicators 2014 and 2015
OECD Frascati Manual 2015

# CHAPTER FOUR: ANALYSIS, RESULTS AND DISCUSSION

This chapter provides evidence of the performance of Zambia's NSI for the period 2001 to 2010. It gives information on the status and progress of critical components of Zambia's NSI. The data is collected from a variety of sources namely, World Development Indicators (the World Bank), the World Integrated Trade Solution (the World Bank), World Intellectual Property Organization (WIPO) and Thomson Reuters WoS database. Data sourced from Zambian institutions include the Ministry of Finance and National Planning (Mofnp). This research is the first of its kind in providing a comprehensive review of the Zambian NSI over a ten year period. However, there are some indicators that have been excluded from the study due to unavailability of data namely, Gross Expenditure on R&D (GERD), the number of researchers engaged in R&D and Science, Engineering and Technology (SET) enrolments and graduations from higher education institutions.

## 4.1. MICRO LEVEL: KNOWLEDGE DEVELOPMENT

Research and innovation conducted by universities, science councils, government research departments, NGOs and the private sector have a vital role to play in Zambia's global competitiveness by creating knowledge. At this level, analysis is carried out on science output indicators. Zambian scientific publications and citations are a key measure of science output. An important component of scientific publications is the extent of collaboration. In general, co-authored publications tend to have a higher value than other publications (Smith and Katz, 2000).

### 4.1.1 Knowledge Generation: Number of Scientific Research Publications

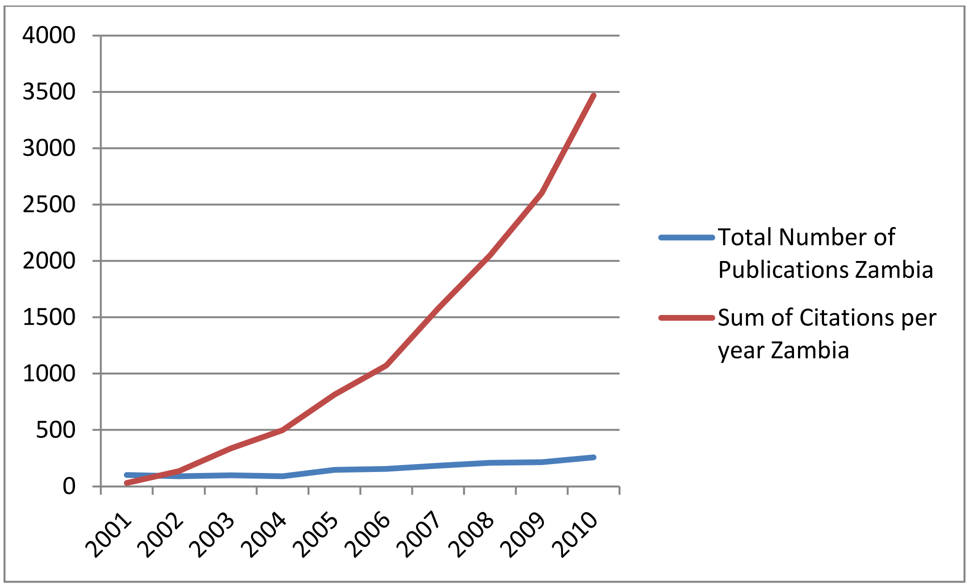
**Table 4.11** and **Figure 4.11** indicate that overall, between the years 2001 to 2010 Zambian research was growing positively. The number of research publications had risen significantly from 100 in 2001 to 256 in 2010. The increase in the number of research publications had been increasing more rapidly than the number of publications globally. As a result, Zambia's share of global publications, while miniscule, had risen very significantly, almost doubling from 0.008 to 0.015. Even more encouraging has been the increase in the number of citations from 29 in 2001 to 3,467 in 2010, a more than 27% increase in the country's total citations. Therefore, Zambia's improvement in the number of publications is accompanied by an even stronger improvement in the quality of publications as measured by the citations. Zambia had the highest level of research activity in 2010 producing a total of 256 scientific publications and the lowest level of research activity in 2004 producing a total of 89 scientific publications.

**Table 4.11 Total Number of Zambian Scientific Research Publications 2001 - 2010**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of publications, WoS | 100 | 90 | 99 | 89 | 147 | 154 | 182 | 208 | 214 | 256 |
| % World share, WoS | 0.008 | 0.007 | 0.008 | 0.007 | 0.01 | 0.01 | 0.012 | 0.013 | 0.012 | 0.015 |
| Sum of Citations, WoS | 29 | 134 | 337 | 498 | 814 | 1073 | 1576 | 2049 | 2602 | 3467 |

*Source*: Thomson Reuters Web of Science (WoS) database (2017)[4]

**Figure 4.11 Total Number of Zambian Scientific Research Publications 2001 – 2010**




*Source:* Thomson Reuters WoS database (2017)

**Table 4.12**, **Table 4.12b** and **Figure 4.12** show that the increase in Zambian scientific research is being driven by the Medical and Health Sciences field with some support from the Natural Sciences, Agriculture Sciences and Social Sciences. The increase in total scientific publications, while welcome rests on a very narrow base, the Medical and Health Sciences field. Most scientific publications in the Medical and Health Sciences were dominated by topics related to HIV/AIDS, cholera, malaria and Tuberculosis (TB) and this may have been due to the high incidence rates of these diseases in the country during 2001 to 2010. The complete lack of Humanities publications is a point for further qualitative research. It is important to note that the percentages (share of total publications in Zambia) displayed in

[4] See References for full reference of graphs and figures

**Table 4.12b** will not add up to a total of 100% due to overlap of some publications across more than one research field.

**Table 4.12a Total Number of Zambian Scientific Research Publications in Various Fields[5] 2001 - 2010**

| Year | Natural Sciences | Engineering and Technology | Medical and Health Sciences | Agricultural Sciences | Social Sciences | Humanities |
|---|---|---|---|---|---|---|
| **2001** | 28 | 2 | 84 | 25 | 2 | 0 |
| **2002** | 31 | 0 | 82 | 17 | 14 | 0 |
| **2003** | 53 | 2 | 71 | 30 | 2 | 0 |
| **2004** | 19 | 0 | 82 | 21 | 9 | 0 |
| **2005** | 62 | 5 | 142 | 20 | 6 | 0 |
| **2006** | 12 | 0 | 136 | 23 | 0 | 0 |
| **2007** | 8 | 0 | 166 | 15 | 0 | 0 |
| **2008** | 41 | 23 | 203 | 7 | 50 | 4 |
| **2009** | 34 | 6 | 227 | 32 | 23 | 0 |
| **2010** | 51 | 2 | 252 | 24 | 70 | 0 |

*Source*: Thomson Reuters Web of Science (WoS) database (2017)

**Table 4.12b Percentage Share of Total Number of Zambian Scientific Research Publications in Various Fields 2001 - 2010**

| Year | Natural Sciences (%) | Engineering and Technology (%) | Medical and Health Sciences (%) | Agricultural Sciences (%) | Social Sciences (%) | Humanities (%) |
|---|---|---|---|---|---|---|
| **2001-2005** | 36 | 1 | 87 | 22 | 7 | 0 |
| **2006-2010** | 14 | 3 | 96 | 10 | 12 | 0 |

*Source:* Thomson Reuters Web of Science (WoS) database (2017)

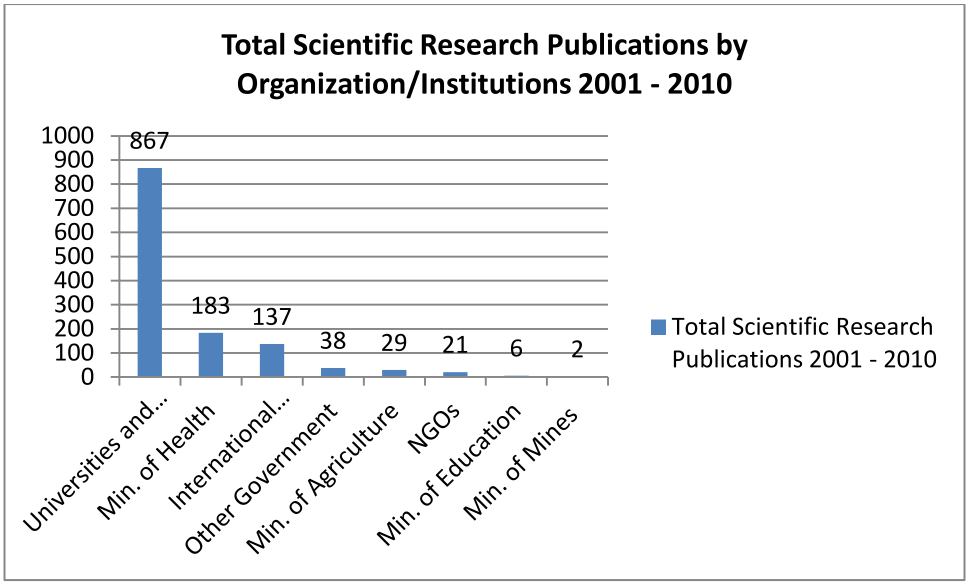
### 4.1.2. Knowledge Institutions

The organizations and institutions that contributed significantly to Zambia's research during the years 2001 to 2010 were universities and colleges with a total of 867 research publications (average of 57% of scientific publications per year), followed by Ministry of Health with a total of 183 research publications (average of 14% of scientific publications per year) and international organizations and institutions with a total of 137 research publications (average of 9% of scientific publications per year) as indicated in **Figure 4.12**. Research activity from Zambian institutions/organizations has strengthened as shown in **Table 4.13**; particularly from international research institutions/councils (from 6% during 2001 to 2005, to 12.2% during 2006 to 2010), Ministry of Health (from 7.8% during 2001-2005, to 14.1% during 2006 - 2010), Other Government Agencies (from 1% during 2001-2005, to 1.3% during 2006 -2010), Ministry of Education (from 0% during 2001-2005, to 0.6% during 2006-2010) and Ministry of Mines (from 0%

[5] The OECD Frascati Manual Classification for Fields for Science and Technology is used to compile this data

during 2001-2005, to 0.2% during 2006 -2010). Conversely universities and colleges, Ministry of Agriculture and other government agencies experienced a moderate decline in research publications in the second-half of the decade (2006-2010).

**Figure 4.12Total Number of Scientific Research Publications by Zambian Organizations and Institutions 2001 - 2010**




*Source:* Thomson Reuters WoS database (2017)

**Table 4.13** provides a more detailed examination of Zambian organizations and institutions that were involved in knowledge development. The University of Zambia was the main contributor of research publications from among higher education institutions during the ten-year period while the Centre for Infectious Disease Research (CIDRZ) generated the highest level of research from the group of international research institutions operating in Zambia. An outstanding feature is the limited research contributions by government funded research institutions and councils. NISIR generated just 0.2% of research output within the ten-year period.

Overall higher education institutions are driving scientific research in Zambia while there are relatively few research publications from government institutions. Further, organizations and institutions focused on Health sciences research output which could be a strong reason for the high number of research publications in the Medical and Health Sciences field (see **Figure 4.12** and **Tables 4.12a, b**).

International research institutions and Ministry of Health had the fastest growing research output of the decade, while universities and colleges and Ministry of Agriculture slowed down research output in the second half of the decade (2006-2010).

There was no indication of private sector participation in scientific research publications in Zambia from the Web of Science (Thompson Reuters WoS database).

**Table 4.13 Percentage Share of Total Research Publications by Zambian Organization or Institution 2001 -2010**

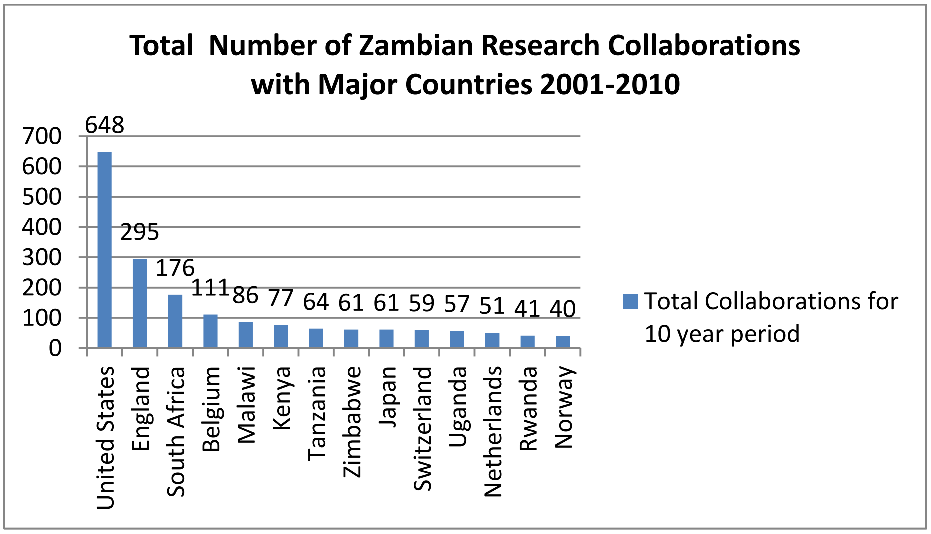
| | 2001-2005 (%) | 2006 2010 (%) |
|---|---|---|
| **Ministry of Education** | 0.0 | 0.6 |
| Ministry of Education other | 0.0 | 0.2 |
| NISIR | 0.0 | 0.2 |
| Mazabuka Research Station | 0.0 | 0.2 |
| **Universities and Colleges** | 58.1 | 56.0 |
| University of Zambia (UNZA) | 53.6 | 52.1 |
| Copperbelt University (CBU) | 1.3 | 2.6 |
| University of Lusaka (UNILUS) | 2.1 | 0.3 |
| Zambia Institute of Animal Health | 1.1 | 1.0 |
| **Ministry of Health** | 7.8 | 14.1 |
| Ministry of Health other | 5.7 | 6.0 |
| Zambia National Blood Transfusion Service | 0.0 | 3.4 |
| Lusaka District Health Management | 1.7 | 3.6 |
| Chainama Hills College Hospital | 0.0 | 0.9 |
| University Teaching Hospital | 0.0 | 0.2 |
| Ndola Central Hospital | 0.4 | 0.0 |
| **NGOs** | 1.3 | 1.4 |
| Chikakanta Hospital | 1.3 | 1.2 |
| Mukinge Mission Training Hospital | 0.0 | 0.2 |
| **International Research Councils/Institutions** | 6.0 | 12.2 |
| Centre for Infectious Disease Research in Zambia (CIDRZ) | 2.1 | 7.0 |
| Rwanda-Zambia-Emory HIV Research Group | 0.0 | 4.7 |
| The Centre for Disease Control and Prevention (CDC) | 0.0 | 0.3 |
| National Environment Research Council (NERC) | 1.0 | 0.0 |
| Zambia ICRAF AgroForestry Research Project | 2.9 | 0.2 |
| **Ministry of Agriculture** | 3.4 | 1.1 |
| Ministry of Agriculture other | 3.0 | 1.1 |
| ZARI Misamfu Research | 0.4 | 0.0 |
| **Government Other** | 1.0 | 1.3 |
| Zambia Wildlife Authority (ZAWA) | 0.0 | 0.9 |
| Central Statistical Office (CSO) | 0.0 | 0.2 |
| National AIDS Council | 0.6 | 0.0 |
| National Aids and STD Control Programme | 0.4 | 0.0 |
| **Ministry of Mines and Energy** | 0.0 | 0.2 |
| Ministry of Mines and Energy other | 0.0 | 0.2 |

*Source*: Thomson Reuters WoS database (2017)

### 4.1.3. Knowledge Networks

In this section, data is provided on Zambia's major research collaborations. Research collaboration is valuable for an economy because it enhances the quality of research through new techniques, expertise, practices, and lower research costs as well as increases knowledge capacity (Adams, 2012). Therefore, co-authored scientific publications tend to have more value. **Figure 4.13**[6] shows the major countries collaborating with Zambian universities, research institutions and the government on research output. The US and Zambia had the highest number of collaborations in the ten year period at a total of 648 scientific publications. England and South Africa follow with 295 and 176 research publications respectively.

**Figure 4.13 Total Number of Zambian Research Collaborations with Major Countries**



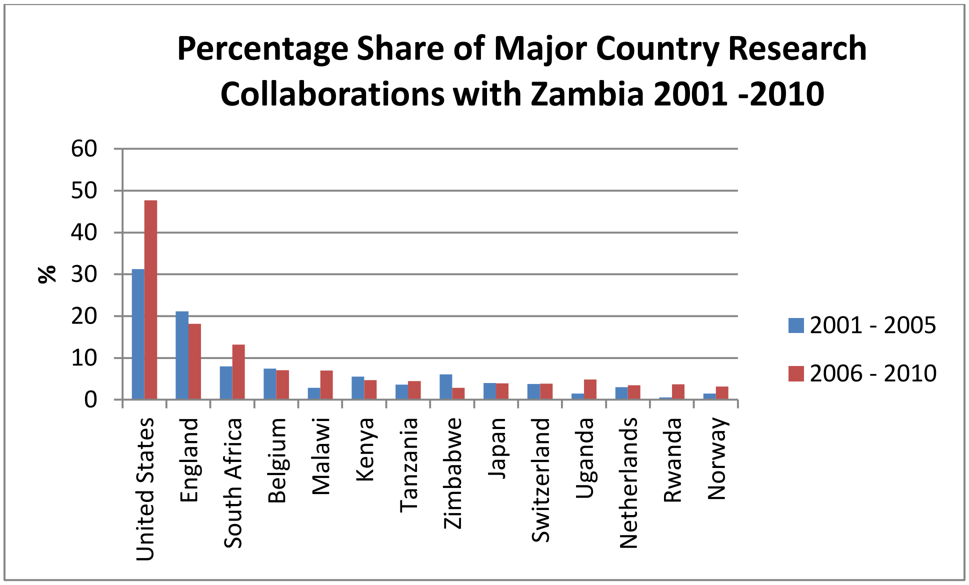

*Source:* Thomson Reuters WoS database (2017)

There were a total of 1,827 research collaborations between Zambia and its major country collaborators. Overall, the research network has strengthened between Zambia and its major collaborators as indicated by **Figure 4.14**. The total number of research collaborations increased significantly, from 527 between the years 2001 to 2005, to 1,300 between the years 2006 – 2010. This improvement in the number of research collaborations was largely driven by the United States as shown by **Figure 4.14**. During the period 2006 to 2010, US-Zambia collaborations were 48% of total collaborations as opposed to 31% between the years 2001 to 2005. South Africa is another country which had fast growing collaborations with Zambia. South Africa had 8% of total country collaborations during 2001 to 2005 which increased to

[6] Each total number of collaborations of a country represents the number of times that country appeared in a research publication(s). For instance, a research publication could have multiple contributors from the United States. Each of those contributors is a unique count to add to the total number of contributors from the United States. These contributors may come from different organizations/institutions within the United States.

13% during the years 2006 to 2010. While there has been a rise in total country research collaborations, it has largely been dominated by countries in North America, Europe and Asia. Research collaborations between Zambia and other African countries have generally been limited.

**Figure 4.14Percentage Share of Major Country Research Collaborations with Zambia 2001-2010**




*Source:* Thomson Reuters WoS database (2017)

### 4.1.4. Summary of Results

During 2001 to 2010, Zambia experienced overall significant positive growth in both the quantity and quality of scientific research. The field responsible for much of this growth was Medical and Health Sciences. Growth in this field was supported by strong research collaborations with the United States and international research institutions such as CIDRZ. Universities and colleges are at the centre of Zambian research activity. Over 50% of research activity during 2001 to 2010 was conducted by the University of Zambia which is the oldest tertiary institution in the country.

Overall during the ten-year period Zambia has significantly increased its international research collaborations, particularly with the US and South Africa. This moderately good link to global research communities has contributed to the quality of Zambian research.

However, despite positive albeit limited growth in research output, the general level of research activity in Zambia is low. During 2001 to 2010 Zambian research was a small share (an average of 0.01%) of total global research. In addition, fields crucial to the development of technology in Zambian industries such as Engineering and Technology and Agricultural Sciences had low levels of research activity (an average of 2% and 16% of total scientific publications respectively during 2001-2010). Furthermore, during the ten year period there was relatively low research activity in government funded institutions and research departments such as National Institute for Scientific and Industrial Research (an average of 0.2%), Ministry of Education (an average of 2%), Ministry of Agriculture (an average of 2%) and Ministry of Health ( an average of 14%). Other publicly funded research institutions relevant to Zambia's innovation system such as National Science and Technology Council (NSTC) and National Technology Business Centre (NTBC) had no recorded scientific publications during 2001 to 2010. Finally, there were no indications of scientific research publications from the private sector.

## 4.2. MESO LEVEL: BUSINESS, INDUSTRIAL AND ENTREPRENEURIAL ACTIVITIES

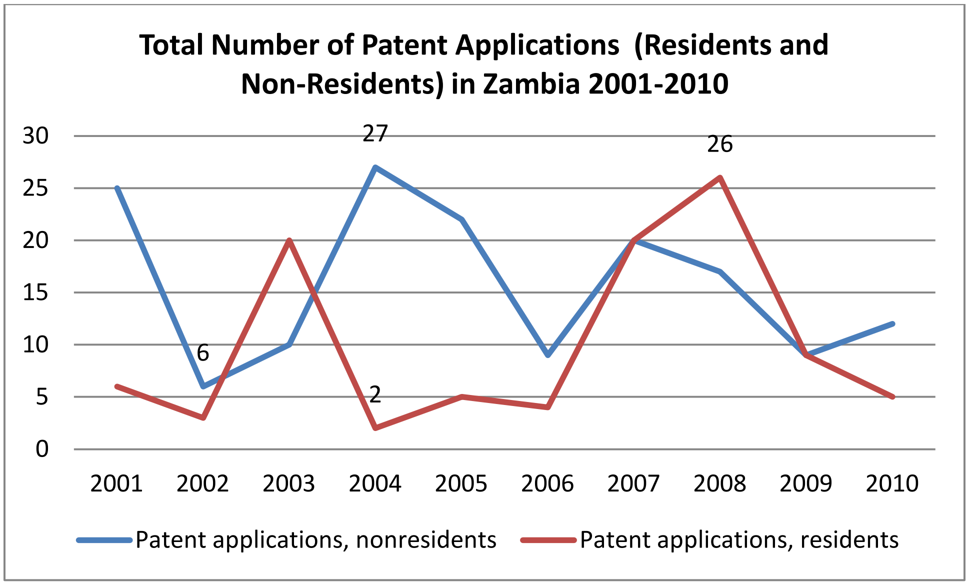
As Zambia participates in the global economy, niche markets need to be indentified in which international competitiveness can be improved. One crucial way this can be achieved is through increased investment and productivity. To aid these objectives knowledge needs to be generated and exploited. The following section presents various proxy indicators at the meso level that measure business, industrial and entrepreneurial functions of the Zambian innovation system during the period 2001 to 2010. Collectively, these are indicators that show the effectiveness of Zambia's NSI over time in enhancing its technological output. Knowledge production and exploitation requires protection through intellectual property so that firms and individuals can reap the benefits of their inventions; thus, patents and industrial designs are output indicators and intellectual property tools used to protect knowledge production and exploitation as well as used to foster innovation (Jaiya, 2003). In addition, technological payments and inflows of FDI are indicators that are used to evaluate technological spillovers from imported-know how. Finally, the trade indicators represent key business and industrial activities that show whether investment in STI has been beneficial to Zambia's commercial activities (NACI, 2014).

### 4.2.1. Patents

Patent analysis offers a number of advantages which can be used to facilitate their universal use as indicators of performance. They are reliable because they are well defined, not ambiguous and facilitate detailed categorization. Finally, they can be used to make international comparisons (NACI, 2015). Research studies reveal that patents are the most preferred IP rights vis-à-vis technological innovations. The number of patents owned by an enterprise or produced in a country is often used as one of the main indicators for determining innovation intensity. Further, patents are used as a measure for output of innovation (Kalanje, n.d.).

**Figure 4.21** shows the trend in patent applications from Zambian residents and non-residents. There were strong fluctuations in both domestic and international patents, with no clear trend. Furthermore, there were a total of 257 patent applications from 2001 to 2010. Residents[7] filed a total of 100 applications while non-residents filed 157 during the ten-year period. This suggests that non-residents were driving technical progress in Zambia during the years 2001 to 2010. It is interesting to note that there was a sudden and significant increase in local patents after 2006, but then a rapid decline after 2008.

**Figure 4.21 Patent Applications by Zambian and Non-Zambian Inventors 2001-2010**




*Source:* WIPO IP Statistics database (2017)

In addition, patent applications peaked in 2004 for non-residents at 27 applications and in 2008 for residents at 26 applications as shown in **Figure 4.21**. It is interesting to note that the data shown by patent applications contrast the positive growth of scientific publications in the country shown earlier in **Table 4.11**.

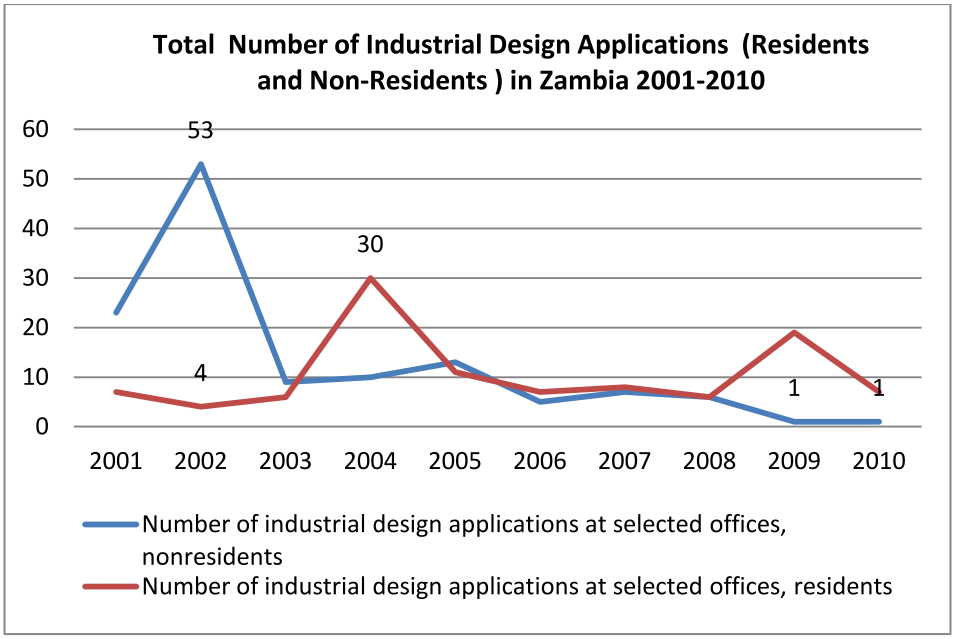
According to WIPO data (2017), the top technology field with the highest proportion of patents applications in Zambia during the period 2001 to 2015 was other special machines (56%). WIPO (IPC) classifies '*other special machines'* as machinery used in agriculture (equipment and tools involved in production, harvesting and food processing), mining and the construction industry. Other top technology fields with the highest patent clusters in Zambia were organic fine chemistry (11%), pharmaceuticals (11%), chemical engineering (11%) and machine tools (11%).

[7] Patent applications from residents include total applications filed in Zambia by residents and applications filed by residents at an IP office abroad

### 4.2.2. Industrial Designs

Industrial design is an IP tool that deals with protecting *'the ornamental or aesthetic aspect of an article'* (WIPO, 2017). In addition, industrial designs are usually applied to products that are manufactured on a mass production scale and can be used as a good proxy indicator to assess commercial innovation activity within the private sector.

**Figure 4.22 Total Number of Industrial Design Applications by Zambian and Non-Zambian Inventors 2001-2010**




*Source:* WIPO IP Statistics database (2017)

**Figure 4.22** shows that during 2001 to 2010 there were a total of 233 industrial design applications, of which 128 were filed by non-residents and 105 were filed by residents. The data shows that in the first half of the decade, there were more industrial design applications filed by both resident and nonresidents in Zambia, relative to the second-half of the decade. Furthermore, the data suggests that overall nonresidents were driving industrial design applications in Zambia during 2001 to 2010.

Despite the initial peak in 2002 at 53 applications, non-resident applications declined and were trending downwards thereafter, such that there were virtually absent during 2003-2010. In the same regard, resident applications peaked at 30 in 2004 and then had a significant decline and thereafter, were trending downwards such that there were virtually absent during 2005-2010.

#### 4.2.3. Technology Payments

Imported technologies and know-how are crucial to meeting changing international and local needs. This section uses technology payments and FDI inflows in appraising the usage of foreign technology and know-how in Zambia.

Technology payments in this context represent Zambia's expenditure on the right to use intellectual property from other countries. This intellectual property is a valuable input into the country's own technological development. Technology payments give an indication of the proportion of imported technology in relation with domestic R&D efforts (OECD, 2017).

**Table 4.23 Charges for the Use of Intellectual Property (Payments), Zambia 2001-2010**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Technology payments (US$)** | 400,000 | 400,000 | 400,000 | | 400,000 | 400,000 | 1,172,724 | 1,289,996 | 444,400 | 548,844 |
| **Technology payments as % of GDP** | 0.010 | 0.010 | 0.008 | | 0.005 | 0.003 | 0.008 | 0.007 | 0.003 | 0.003 |

*Source:* WDI database, the World Bank (2017)

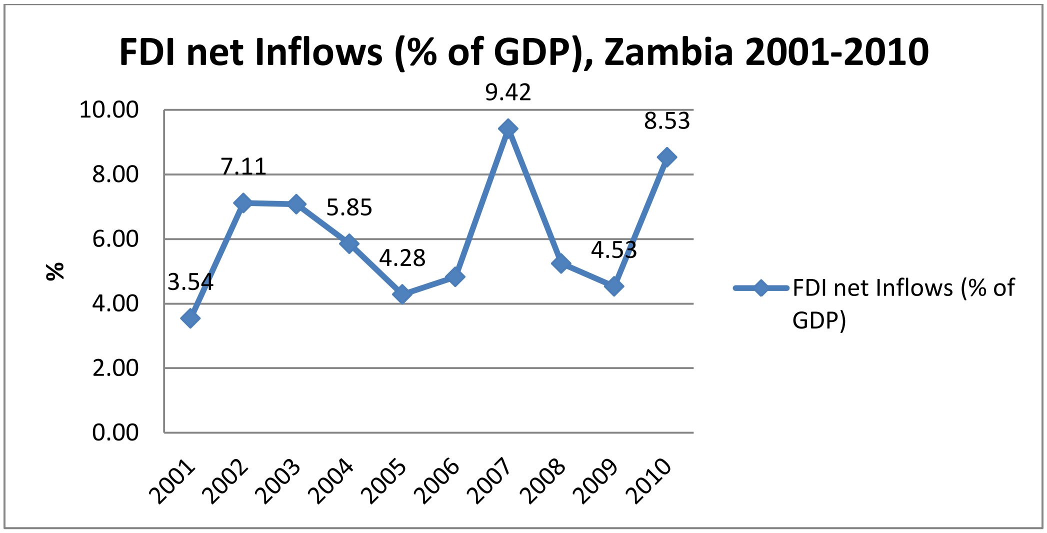
**Table 4.23** shows that between the years 2001 to 2005 technology payments remained somewhat constant at USD 400 000; however technology payments surged in 2006 to USD 1, 172,724 and began to decline thereafter reaching USD 548,844 in 2010. The growth rate of technology payments as a percentage of GDP decreased significantly during 2001 to 2010. Technology payments as a percentage of GDP declined from 0.01% in 2001 to 0.003% in 2006 and from 0.007% in 2008 to 0.003% in 2010. Further the proportion of technological payments as a percentage of GDP is miniscule. The implications of this is that overall, importation of technology was limited during 2001-2010 showing that Zambia had less of an appetite for technological know-how.

#### 4.2.4. Inflow of Foreign Direct Investment

There are different approaches used for technology catch-up strategy. In addition to technology payments, inflows of FDI can serve as a measure for a country's local technological capability, the ability for a country to apply knowledge into products and processes as well as to create technology, through technology spillovers (OECD, 2002).

The use of FDI inflows as an indicator of technological progress has been met by mixed reviews. Some schools of thought are opposed to using it while others are in support of using it. This study realizes the importance of FDI inflows as an important indicator to evaluate technological progress because it can be a powerful medium for transmitting technology to developing countries by financing new investment, communicating information about technologies to local firms, transferring skills and facilitating the diffusion of technology domestically (World Bank, 2008). However, this study also realizes that the effectiveness of FDI inflows to Zambia is dependent on its nature, sound economic policies and good governance. **Figure 4.24** shows the cyclicality of net inflows of FDI as a percentage of GDP. Zambia has a high level of foreign investment flowing into the country. During the years 2001-2010 the growth rate of FDI inflows was higher than the GDP growth rate. FDI inflows to Zambia peak in 2007 at 9% coinciding with the global commodity boom but decreased sharply in 2008 to 5% after the onset of the 2008 global economic recession, and continue to fall in 2009. However FDI inflows pick up in 2010 at 8.5% of GDP. Overall, the data suggests that Zambia has a strong link with global economies. Further, depending on its nature, FDI may have offset the poor performance of technology payments.

**Figure 4.24 Trend in Zambian Inflow of Foreign Direct Investment as a Percentage of GDP 2001-2010**




*Source:* WDI database, the World Bank (2017)

### 4.2.5. Exports of Goods

The Zambian Vision 2013 policy document seeks to ensure that there is a rising share of Zambia's diversified exports outside of the mining industry through non-mineral manufacturing and services. It is expected that this diversified trade will reduce dependency on commodity cycles and Zambia's vulnerability to the associated volatility in exchange rate earnings. This proxy indicator shows whether R&D input is being exploited and transformed into the production of goods and services for trade; and whether Zambian industries are becoming more knowledge intensive. This section focuses on technological trends in the export of goods and the Revealed Comparative Advantage (RCA) on various sectors which is a proxy indicator for technological intensity defined as, '*the degree to which scientific research efforts contribute to an industry's productivity'* (Palda, 1986).

As shown in **Figure 4.25** Zambia's trade fluctuated during the period 2001 to 2010. The country's trade as a percentage of GDP reached its peak in 2004 at 71%. Exports of goods and services represent just less than half of the trading activities. In addition, there has been some increase in exports of goods and services (as a percentage of GDP) starting in 2001 at 24% and peaking at 34% in 2005. However, export of goods and services begins to decline in 2008 reaching 29% in 2010. This data on exports of goods and services coincides with the global commodity boom of the 2000s and the onset of the 2008 recession.

**Figure 4.25 Trends in Zambian Trade and Export of goods and services as a % of GDP 2001-2010**


*Source:* WDI data, the World Bank (2017)

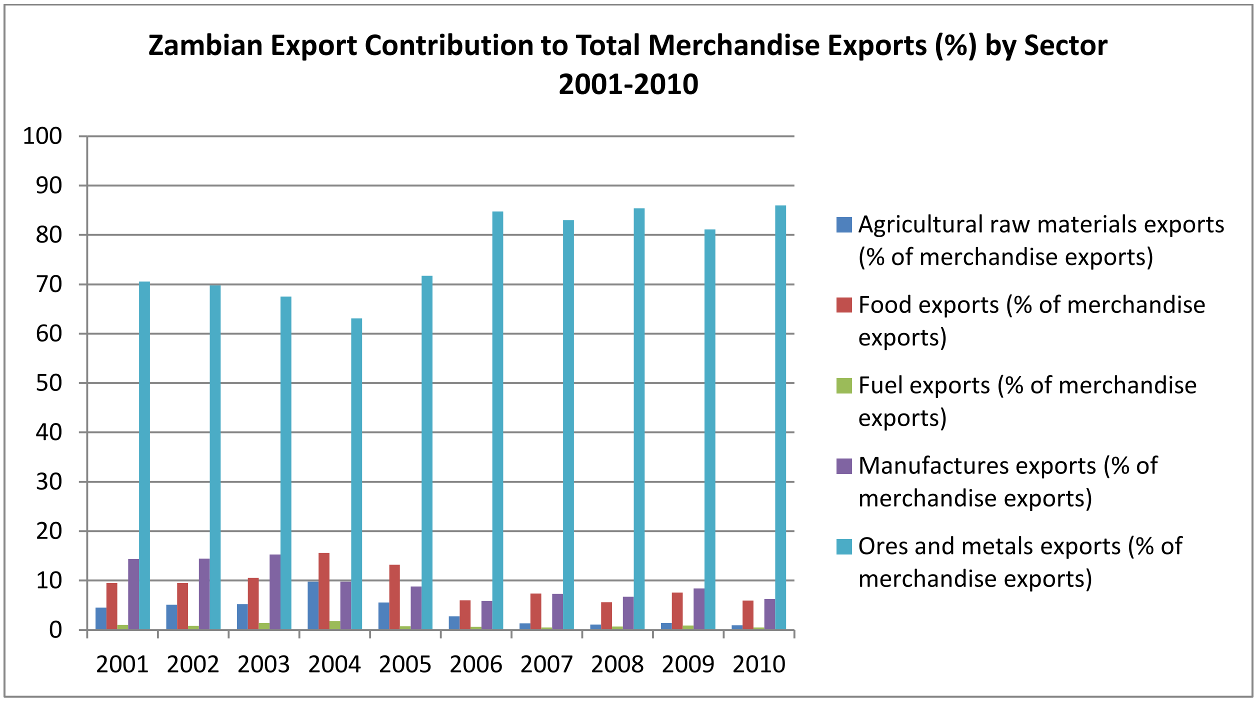
The actual values of Zambian merchandise exports are shown in **Table 4.25** whereas the trend in sectoral contribution of these merchandise exports is shown in **Figure 4.26**. Most of the merchandise exports in Zambia during 2001 to 2010 have been in ores and minerals (an average of 76% of total merchandise exports) followed by manufacturing (an average of 10% of total merchandise exports), food (an average of 9% of total merchandise exports), agriculture (an average of 4% of total merchandise exports) and fuels (an average of 1% of total merchandise exports). Overall growth in merchandise exports such as ores and minerals increased during the ten period from 71% in 2001 to 86% in 2010. However growth in the following merchandise exports weakened significantly towards the second half of the ten year period; food (16% in 2004 to 6% in 2006), agriculture (10% in 2004 to 3% in 2006) and fuel (and 2% in 2004 to 1% in 2006). In addition, overall growth in the manufacturing sector as a percentage of merchandise exports declined significantly from 15% in 2003 to 6% in 2010, with the exception of 2006 and 2009 when it slightly improved. This indicates that government's objective to diversify the economy and lessen dependence on primary products is not succeeding. Furthermore, it also indicates that the technological capacity of Zambia has not been increasing since non-traditional exports tend to be more tech intensive than other activities. Finally, the share of high-technology manufacturing exports to total manufacturing exports has been stagnant for most of the ten year period at an average of 1% **(**see **Table 4.25)**.

**Table 4.25Contribution to Zambian Exports by Key Trade Indicators 2001-2010**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Trade (% of GDP)** | 65 | 65 | 62 | 71 | 62 | 58 | 66 | 59 | 56 | 68 |
| **Export of goods and services (% of GDP)** | 24 | 25 | 27 | 26 | 34 | 31 | 33 | 34 | 29 | 29 |
| **Agricultural raw materials exports (% of merchandise exports)** | 4 | 5 | 5 | 10 | 6 | 3 | 1 | 1 | 1 | 1 |
| **Food exports (% of merchandise exports)** | 9 | 9 | 11 | 16 | 13 | 6 | 7 | 6 | 8 | 6 |
| **Fuel exports (% of merchandise exports)** | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Manufactures exports (% of merchandise exports)** | 14 | 14 | 15 | 10 | 9 | 6 | 7 | 7 | 8 | 6 |
| **Ores and metals exports (% of merchandise exports)** | 71 | 70 | 68 | 63 | 72 | 85 | 83 | 85 | 81 | 86 |
| **High-technology exports (% of manufactured exports)** | 0 | 0 | 1 | 1 | 1 | 2 | 3 | 3 | 1 | 1 |

*Source:* WDI database, the World Bank (2017)

**Figure 4.26 Trends in Zambian Export Contribution to Total Merchandise Exports (%) by Sector 2001-2010**




*Source:* WDI, the World Bank (2017)

**Table 4.26** indicates that the major destinations for Zambian merchandise exports during the period 2001 to 2010 were high-economy countries followed by the rest of Sub-Saharan Africa. Initially, merchandise exports to high-income economies were high in the years 2001 to 2002 (64% and 60% respectively) but plunged in 2003 to 48%. However, trade picked up in 2005 at 56% and rose steadily with minor fluctuations during 2006 to 2010. Conversely, merchandise exports to Sub-Saharan economies initially rose consistently from 31% in 2001 to 49% in 2004; however began to decrease in 2005. In 2010 merchandise exports from Zambia to other Sub-Saharan African countries were just 19% of total merchandise exports. Further, there has been consistent and significant growth of merchandise exports to developing economies in East Asia and the Pacific from 1% in 2001 to 21% in 2010. Therefore, the data shows that during 2001 to 2010 there has been a dominance of Zambian exports to developed countries but this tended to decline overtime and furthermore, there has been a significant increase in exports to developing countries in East Asia and the Pacific. Finally, trade between Zambia and other sub-Saharan African countries has declined significantly.

**Table 4.26 Merchandise Exports to Various Economies as a Percentage of Total Merchandise Exports, Zambia 2001-2010**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Arab world** | 0 | 1 | 1 | 0 | 0 | 0 | 11 | 11 | 9 | 4 |
| **High-income economies** | 64 | 60 | 48 | 47 | 56 | 53 | 57 | 62 | 60 | 59 |
| **Developing economies in East Asia & Pacific** | 1 | 1 | 2 | 2 | 2 | 10 | 11 | 8 | 12 | 21 |
| **Developing economies in Europe & Central Asia** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Developing economies in Latin America & the Caribbean** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Developing economies in the Middle East & North Africa** | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 8 | 3 | 1 |
| **Developing economies in South East Asia** | 3 | 3 | 4 | 1 | 1 | 0 | 2 | 1 | 2 | 0 |
| **Sub-Saharan Africa** | 31 | 36 | 46 | 49 | 41 | 36 | 24 | 21 | 23 | 19 |

*Source:* WDI database, the World Bank (2017)

### 4.2.6. Revealed Comparative Advantage (RCA)

The RCA measures the comparative advantage of merchandise exports. The index is measured by the country's share of exports in the specific product group divided by a country's share of exports for all the products. The RCA index is equal to 0 when the country has no exports for the given product group and is equal to 1 when the country's share in exports for the product group equals its share of all merchandise exports and thus implies no specialization. When the RCA index is above 1 it means that there is a positive specialization.

**Table 4.27** shows that during the period 2001 to 2010, Zambia has consistently had a positive specialization in the following products: ores and minerals, agriculture raw materials, intermediate goods and food products. These are mainly primary products indicating that Zambia has not been successful at transforming its economy. On the other hand products such as hides and skins, animal products, manufacture, wood, footwear, machinery, electricity, transport equipment, chemicals, plastic, rubber and fuels have low RCA values and therefore very low specialization. In addition, **Table 4.27** shows that with the exception of intermediate goods, the competitive advantage of Zambia's products weakened in the second half of the decade (2006 to 2010).

**Table 4.27 Comparative Advantage of Zambia's Merchandise Exports 2001-2010**

| RCA | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ores and Metals | 21.97 | 22.78 | 21.97 | 20.34 | 20.32 | 18.69 | 17.23 | 17.98 | 20.6 | 17.09 |
| Agriculture Raw Materials | 3.14 | 4.24 | 4.17 | 4.45 | 3.85 | 2.39 | 1.54 | 1.22 | 1.52 | 1.21 |
| Intermediate Goods | 3.39 | 3.29 | 3.15 | 2.94 | 3.15 | 3.37 | 3.51 | 3.52 | 3.6 | 3.64 |
| Food Products | 2.48 | 2.05 | 2.93 | 2.01 | 2.79 | 2.24 | 2.18 | 2.22 | 2.18 | 1.96 |
| Vegetable | 2.52 | 2.68 | 2.44 | 2.28 | 1.75 | 0.93 | 1.49 | 0.86 | 0.64 | 0.54 |
| Textile and Clothing | 1.3 | 1.47 | 1.48 | 1.67 | 1.46 | 0.85 | 0.4 | 0.3 | 0.36 | 0.37 |
| Stone and Glass | 1.51 | 0.89 | 0.9 | 0.56 | 0.6 | 0.57 | 0.41 | 0.52 | 0.42 | 0.36 |
| Hides and Skin | 0.52 | 0.54 | 0.65 | 0.45 | 0.43 | 0.4 | 0.27 | 0.23 | 0.18 | 0.13 |
| Animal products | 0.18 | 0.09 | 0.41 | 0.07 | 0.05 | 0.06 | 0.05 | 0.05 | 0.08 | 0.09 |
| Manufactures | 0.17 | 0.18 | 0.13 | 0.09 | 0.1 | 0.06 | 0.06 | 0.07 | 0.1 | 0.13 |
| Wood | 0.16 | 0.12 | 0.12 | 0.08 | 0.07 | 0.06 | 0.16 | 0.07 | 0.14 | 0.05 |
| Footwear | 0.05 | 0.1 | 0.08 | 0.18 | 0.09 | 0.12 | 0.07 | 0.06 | 0.08 | 0.05 |
| Machinery and Electricity | 0.05 | 0.06 | 0.05 | 0.04 | 0.06 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 |
| Machinery and transport equipment | 0.04 | 0.1 | 0.04 | 0.03 | 0.05 | 0.04 | 0.04 | 0.05 | 0.08 | 0.05 |
| Chemicals | 0.05 | 0.05 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.07 | 0.05 | 0.03 |
| Plastic or Rubber | 0.02 | 0.04 | 0.01 | 0.01 | 0.03 | 0.00 | 0.03 | 0.01 | 0.01 | 0.01 |
| Fuels | 0.04 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 |

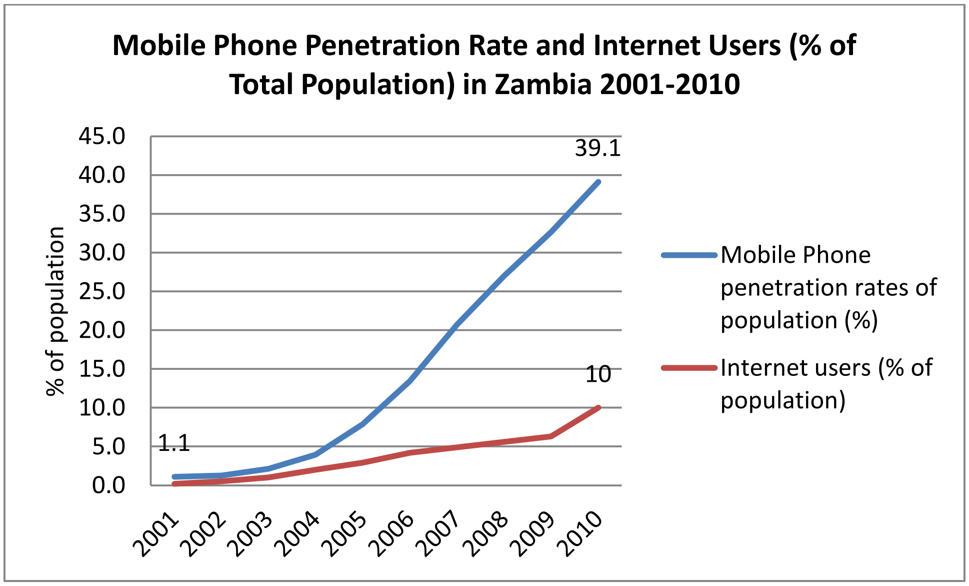
*Source:* WITS database, the World Bank (2017)

### 4.2.7. Mobile Penetration Rates and Internet Users

The digital economy in Africa is enabling smart business processes, energy, healthcare, transport, government as well as promoting financial inclusion and empowering society at large. The lack of physical infrastructure in Africa, inter alia, has led to the development of digital infrastructure which is being used to deliver basic socio-economic services through the mobile phone. Entrepreneurs, supported by telecommunication companies and financial institutions, are at the centre of these innovations. They are harnessing the power of the mobile phone to create technological services that expand access and promote inclusion. However, the digital economy relies on widespread availability of fixed and wireless broadband networks and access to affordable mobile phones, inter alia. The proxy indicators used in this section will be used to evaluate Zambia's digital infrastructure as well as the innovation system's ability to provide access to knowledge resources. Digital infrastructure is influential in enabling the development of technological services (e.g. e-Health, EduTech, AgriTech, FinTech) (McKinsey Global Institute, 2013).

According to **Figure 4.27** there has been continuous and significant growth in mobile phone users during the period 2001 to 2010. In 2010 approximately 39% of the population owned a mobile phone up from just 1.1% in 2001. Internet connectivity follows a similar trend albeit lower proportions. In 2001, 0.2% of the population was connected to the internet. However, this increased to 10% in 2010.

**Figure 4.27 Trends in Mobile Phone Penetration Rate and Internet Users (% of Total Population) in Zambia 2001-2010**




*Source:* WDI data, the World Bank (2017) and Internet Live Statistics data (2017)

The growth of mobile phone penetration and internet connectivity rates suggest the development of Zambia's ICT sector during 2001 to 2010, and therefore the strengthening of the country's digital infrastructure. Furthermore, it implies that access to knowledge resources had significantly increased during the ten year period.

### 4.2.8. Summary of Results

Technical progress in Zambia was inconsistent and largely driven by nonresidents. Overall, patent and industrial applications were low during 2001 and 2010 (total of 257 and 233 respectively). Patents were clustered in the agriculture, mining and construction industries. It's interesting to note that the increase in scientific research previously discussed was not effectively feeding into technical progress.

During 2001 to 2010 Zambia had a low appetite for foreign technology sourced from abroad. Technology payments were often inconsistent and did not keep up with the level of GDP growth (i.e. technology payments were an average of 0.006% of GDP growth annually). This may have been countered by high levels of FDI (an average of 6% of GDP annually) during the same period. The level of FDI flows to Zambia suggests strong links to global economies. However FDI inflows were concentrated in the mining sector, and even though the mining sector has a large proportion of foreign investment relative to other sectors in Zambia, weak linkages within the value chain have prevented effective technology spillovers through technical skills development and technological capacity (Fessehaie, 2012).

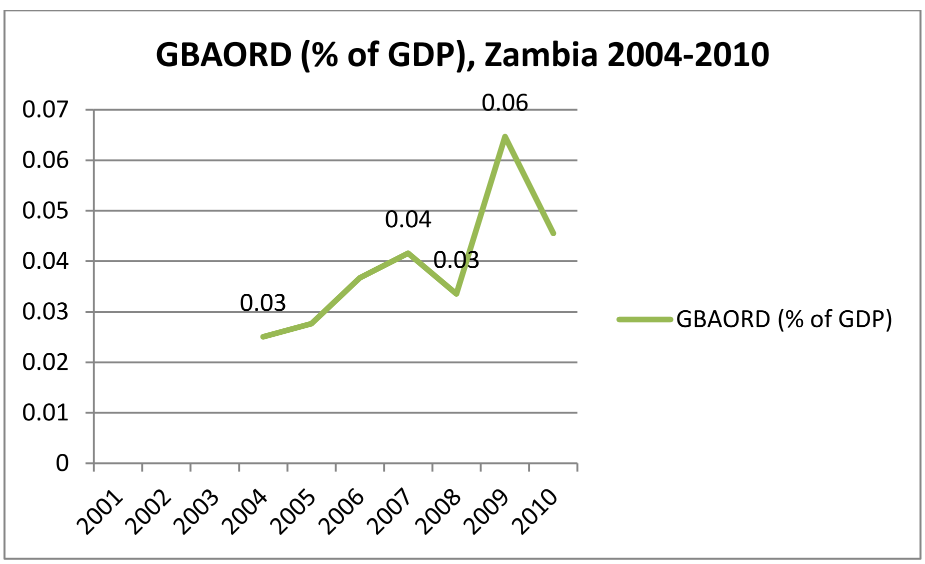
In addition, while there has been significant development in the ICT sector through strengthening of digital infrastructure as indicated by significant growth in mobile penetration and internet users, there is little evidence of this translating into high value patents or technology exports.

The analysis on innovation and technology involved in Zambia's trade during 2001 to 2010 shows that despite robust trade of an average of 63% of GDP annually and overall positive growth in merchandise exports, the country's export share of high-technology manufactured products was stagnant at an average of 1%. Manufactured products as a share of trade, declined drastically during the period. In 2001 manufacturing products as a percentage of merchandise exports were 14% and by 2010 it had reduced to 6%. Zambia's comparative advantage was with resource-based products and immediate goods and trade was directed to high-income economies compared to other African countries. This indicates that the country's efforts at industrialization and economic diversification were not successful during 2001 to 2010.

## 4.3. MACRO LEVEL: RESOURCE MOBILIZATION (INPUT INDICATOR)

The Government Budget Appropriations or Overlays for R&D (GBAORD) shows government's commitment to R&D funding. With this indicator, R&D is defined by the funder rather than the performer (OECD, 2002).

**Figure 4.3 Zambian Trends in GBAORD (% of GDP)**

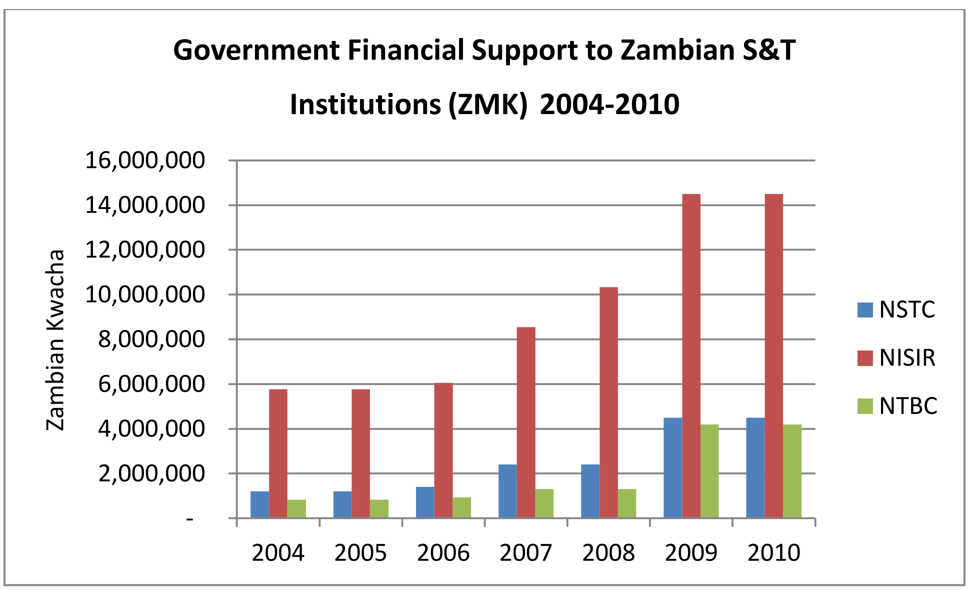



*Source:* National Budget Data, Ministry of Finance and National Planning (2017)

According to **Figure 4.3** government allocation for R&D activities has generally been rising with the largest proportion of government funding in 2009 (at 0.06% of GDP), albeit a decline in 2008 and 2010. Despite the growth in financial resources dedicated to R&D activities, the Zambian government's R&D expenditure as a percentage of GDP is still miniscule. This suggests that there was limited financial resource mobilization by the Zambian government during the period 2001 to 2010.

**Figure 4.31** further shows government allocation of funds to key research coordinating institutions in Zambia namely NSTC, NISIR and NTBC. All three research institutions experienced a significant growth in funding from the Zambian government between the years 2001 to 2010. NISIR received a total of ZMK5, 772,050 in 2004 which increased to ZMK14, 500 000 in 2010, while NSTC received ZMK1, 203,821 in 2004 which rose to ZMK4, 500, 000 in 2010. Finally, NTBC received ZMK828, 101 in 2004 which increased to ZMK4, 200,000 in 2010.

**Figure 4.31 Trends in GBAORD to Zambian S&T Institutions (NSTC, NISIR and NTBC) 2004-2010**




*Source:* National Budget Data, Ministry of Finance and National Planning

### 4.3.1. Summary of Results

Government budget allocations for R&D has risen significantly during the years 2001 to 2010 from ZMK14, 967,506.10 in 2004 to ZMK44, 254,717.56 in 2010. This suggests increasing commitment to R&D funding by government at the policy level. Consequently, this increase in R&D funding has trickled down to key R&D coordinating institutions namely, NSTC, NISIR and NTBC. However as a share of GDP, government funding of R&D activites is still limited.

According to UNESCO (2017), statistics on GERD by sector performance revealed that private sector expenditure on R&D in 2008 was just 2% compared to universities (78%) and government (19%). Therefore, the data suggests that during 2001 to 2010 government has been a key source of funding for R&D in Zambia.

## 4.4. INNOVATION EFFICACY OF KNOWLEDGE DEVELOPMENT IN ZAMBIA'S NSI

Innovation efficacy is defined as, *'the efficiency and effectiveness of innovation systems in terms of accessing, anchoring, diffusing, creating and exploiting innovations'*. Innovation efficacy takes both the structure and functions of the system into account and gives an idea of how well the different systemic components and networks work together to achieve both individual and collective goals. To evaluate the efficacy of an NSI various indices have been used such as, the European Union's Innovation Scoreboard and OECD's STI Outlook. This study will make use of a composite index called the *innovation efficacy index* (IEI) developed by Institute Europeen d'Administration des Affaires (INSEAD) (Mahroum and Alsaleh, 2012).

The IEI is a measurement tool used to measure the effectiveness of government's intervention at the national and sub-national levels. Previous theories and policies have tended to focus on the linear model of innovation, which assumes a uni-directional relationship between inputs and outputs. In doing so, the linear model has missed systemic innovation outcomes (i.e. the learning, adoption and adaptation of knowledge that occurs within innovation processes). The notion of innovation outcomes has enabled countries with modest R&D investments to reap high innovation outputs; for instance, Australia, Belgium and Canada). Furthermore, it can be used to explain why countries that make large investments towards STI and receive little return. Finally, the IEI makes a distinction between the capacity of an economy to innovate and its actual performance (Mahroum and Alsaleh, 2012).

The IEI is hinged on the AC/DC (Absorptive Capacity/Development Capacity) model. Absorptive capacity is achieved through accessing, anchoring and diffusing knowledge while Development capacity refers to creating and exploiting new knowledge (Mahroum and Alsaleh, 2012).

This study will focuses on the development capacity component of the AC/DC model by assessing the efficiency and effectiveness of government funding towards knowledge development. The two indicators used to assess the level of efficiency of knowledge development are annual GBAORD and annual total number of scientific research publications.

To calculate the IEI for knowledge development in Zambia, both the input (GBAORD) and output (scientific research publications) indicators must be normalized in order to facilitate comparison and summation across the data. Thereafter, GBAORD are converted to a scale of 1 to 7, with 1 being the lowest value and 7 being the highest. The averages of each normalized indicator (GBAORD and scientific research publications) are summed to provide a total score for the knowledge development system function. Given that each indicator (GBAORD and Scientific Research publications) is given a possible maximum score of 7, the total possible capacity and performance score for the knowledge development function of the system is 14.

**Table 4.41 Normalized Data: Zambia's GBAORD data**

| $x$ | A = $x - Min(x)$ | $B = Max(x) - Min(x)$ | $\frac{A}{B}$ | $6 * \left(\frac{A}{B}\right) + 1$ |
|---|---|---|---|---|
| 14,967,506.10 | 0 | 42,042,919.13 | 0 | 1.00 |
| 17,689,012.20 | 2,721,506.11 | 42,042,919.13 | 0.06 | 1.39 |
| 25,384,828.26 | 10,417,322.16 | 42,042,919.13 | 0.25 | 2.49 |
| 31,153,604.13 | 16,186,098.03 | 42,042,919.13 | 0.38 | 3.31 |
| 27,089,259.22 | 12,121,753.12 | 42,042,919.13 | 0.29 | 2.73 |
| 57,010,425.23 | 42,042,919.13 | 42,042,919.13 | 1.00 | 7.00 |
| 44,254,717.56 | 29,287,211.47 | 42,042,919.13 | 0.70 | 5.18 |

*Source:* National Budget Data, Ministry of Finance and National Planning (2017)

**(1)**

$$\bar{x}_{GBAORD} = 3.30 \quad (2)$$

**Table 4.42 Normalized Data: Zambia's Scientific Research Publications data**

| $x$ | $A = x - Min(x)$ | $B = Max(x) - Min(x)$ | $\frac{A}{B}$ | $6 * \left(\frac{A}{B}\right) + 1$ |
|---|---|---|---|---|
| 89 | 0 | 167 | 0 | 1.00 |
| 147 | 58 | 167 | 0.35 | 3.08 |
| 154 | 65 | 167 | 0.39 | 3.34 |
| 182 | 93 | 167 | 0.56 | 4.34 |
| 208 | 119 | 167 | 0.71 | 5.28 |
| 214 | 125 | 167 | 0.75 | 5.49 |
| 256 | 167 | 167 | 1.00 | 7.00 |

*Source:* National Budget Data, Ministry of Finance and National Planning (2017)

**(1)**

$$\overline{x}_{Scientific\ Publications} = 4.22 \quad (2)$$

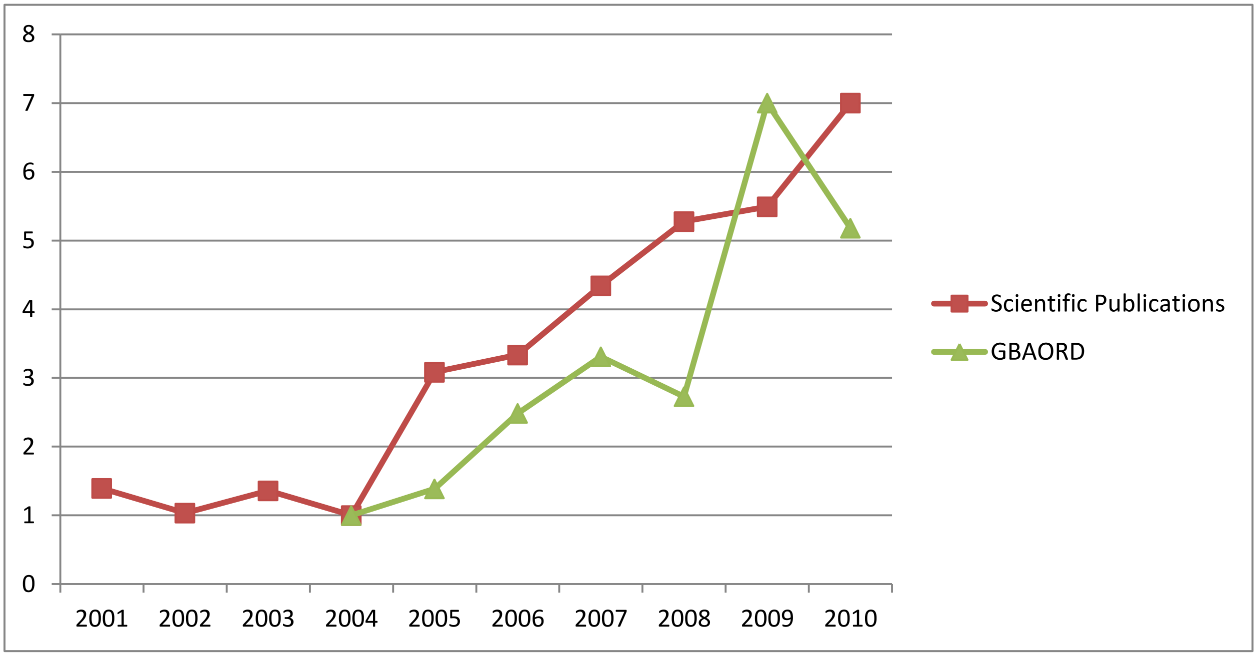
$$T_i = \frac{\sum \bar{x}_i}{14} \quad (3)$$

$$T_i = \frac{3.30+4.22}{14} \quad (4)$$

$$T_i = \frac{7.52}{14} \quad (5)$$

$$T_i = 0.54 \quad (6)$$

**Figure 4.41 Comparisons between GBAORD and Scientific Publications Using Normalized Data**




*Source:* National Budget Data, Ministry of Finance and National Planning (2017), Thompson Reuters WoS database (2017)

### 4.4.1. Summary of Results

**Figure 4.41** compares the normalized data for GBAORD and scientific research publications for Zambia during the years 2004 to 2010. The data suggest that both the level of government funding and scientific publications increased significantly; however, scientific research publications (output) was increasing more rapidly than the GBAORD (input). This suggests that government funding for research was effective to some degree despite being limited during the years under evaluation. The total capacity and performance score for knowledge development was 0.54 which further suggests that there was a level of efficiency and effectiveness in the knowledge development function of Zambia's innovation system. However, there is still scope for further improvement.

## 4.5. PERFORMANCE OF ZAMBIA'S NSI

Based on the analysis and discussion in the previous sections, the performance of Zambia's NSI during 2001 to 2010 is as follows:

(i) At the micro level, there has been significant but limited increase in innovation input (GBAORD) and a significant growth in output (scientific research publications). The rise in the ratio of input (GBAORD) to outputs (research publications) suggests a level of efficiency in the innovation system regarding knowledge development, because the output (scientific research publications) is increasing more rapidly than the increases in the input (GBAORD).

(ii) However results of analysis of various indicators at the meso level, and in particularly exports of goods and services, revealed comparative advantage, manufactured exports and high-technology exports suggest that knowledge and innovation is not being exploited efficiently and effectively for commercial purposes. The results imply that there are some significant constraints and factors in scarce supply. In addition, the policy environment may not be favourable.

# CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS

After discussing the major challenges in Zambia's NSI throughout this study, the following direct and indirect policies are recommended:

**(1) Promote Long-term Robust Innovation Policy**

The National Science and Technology Policy outlines general policy objectives, measures and strategies. It does a good job of addressing '*what'* needs to be tackled but does not adequately address *'how'* this will be done. Thus, the policy plan fails to effectively map out implementation strategies that are result oriented (Daka and Toivenan, 2014). For instance, the policy plan states that *mechanisms will be established to promote diffusion and commercialization of indigenously developed and other technologies for SMMEs through the provision of fiscal and other regulatory measures;* however, it does not explain what those mechanisms are, what institutions will be involved in this process and how this will be achieved. There is need for government to develop innovation policy that addresses both short and long-term objectives which effectively devise how outcomes will be achieved. Further, the government should consider a medium term impact assessment to track progress of implementation efforts and develop mechanisms for continuous production of information on STI policy.

**(2) Improve Policy Alignment**

At present, the MoHE is responsible for Zambia's innovation policy while the Ministry of Trade, Commerce and Industry (MTCI) manages industrial policy. The National S&T Policy and Industrial policy both state that effective inter-ministerial coordination and harmonization of policies is a key policy objective; however this is not reflected in the policy strategic processes outlined in both documents and it remains to be said whether it is done in practice. Development of Zambia's innovation system requires coordinated policy intervention both within government line-ministries (MoHE, MTCI and Ministry of Finance and National Planning) and between key STI institutions (NSTC, NISIR and NTBC).

**(3) Underinvestment in STI**

The National S&T policy proposes that 3% of GDP will be allocated to STI activities annually. During 2001 to 2010, this was far from the case; an average of 0.04% was allocated to R&D activities annually. The STI sector is underfunded. This has negatively impacted the operations of institutions such as NSTC, NISIR and NTBC, which are central to processes within the innovation system and the generation of new knowledge. Despite the presence of funding mechanisms stated within the S&T national policy, financial resource mobilization has not been accomplished successfully. There needs to be a real commitment to mobilizing financial resources from both public and private sources as well as increasing international cooperation efforts for STI in Zambia.

**(4) Coordinated Policy Intervention at all levels of the NSI**

Interactive learning networks are weak in Zambia's NSI. The findings of this study suggest that there are weak linkages between public research organizations and academia-industry cooperation. Further, there is low participation of the private sector and SMEs in the NSI (Institute for Innovation and Technology, 2010). Industrial and STI policy must specify mechanisms to enhance system linkages between the various actors, and ensure successful implementation of these mechanisms; for instance, mechanisms that incentivize private sector engagement (co-publication, co-patenting and personnel mobility) with local stakeholders (industry experts and local researchers). In addition, government should consider increasing liaisons with the private sector to identify the needs of private enterprises in order to encourage their participation in the NSI. Furthermore, the concept of innovation needs to be promoted to SMEs through the establishment of technological parks and incubation centers. Finally, institutions available for STI support such as, NSTC, NTBC, NISIR and CEEC should be marketed to the private sector, SMEs and the relevant stakeholders.

**(5) Effective System Governance**

The effectiveness of STI activities in Zambia's NSI requires coordinated policy intervention at all hierarchal levels (macro, meso and micro). It is necessary for policies (STI and Industry) and deployment of financial resources to be coordinated and synchronized across all levels. As discussed in chapter four, there are currently *deficiencies* at all levels of Zambia's NSI. However, to what extent this is negatively affecting the emergence and growth of new technologies is unclear. However, what is apparent is that policy support at the micro, meso and macro levels is deficient and needs to be improved. This improvement can only serve to strengthen Zambia's NSI. Furthermore, the participation of government at the three levels of the NSI should be coordinated and governed with significant input, specifically with line ministries and government departments concerned with STI and business development.

## 5.1. FINAL REFLECTIONS AND LIMITATIONS OF THE DISSERTATION

This dissertation underlined the importance of developing an effective NSI for the success of Zambia's economic development strategies (i.e. economic diversification, industrialization and improved quality of life for all Zambians). In order to do so, I reviewed the performance of Zambia's NSI for the period 2001 to 2010. I adopted the TIS methodology framework and drew on secondary data. During my analysis, I realized that the data for three indicators needed to be compiled namely, GBAORD and knowledge generation by scientific field and knowledge networks (country and institutional data). This required guidance from the OECD Frascati Manuel.

The major challenges I faced in conducting this research was the unavailability of data in order to provide a comprehensive list of indicators for assessing the performance of Zambia's NSI; and the lack of access to qualitative data to enhance the quality of my findings.

I recommend that future research should explore the following areas; expand on the number of functions and indicators used to examine Zambia's innovative system. Further, future research should investigate each of the hierarchal levels in detail particularly examining innovation clusters and STI labour resources, as well as investigate the ease of intellectual property applications in Zambia.

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