Indigenous innovation capability in Sub-Saharan Africa: a review of the Nigerian situation

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Abstract

Innovation process represents the long wave of value creation and it is the main powerful driver of future economic results of firms and nations. It therefore follows that for nations to compete successfully in the long run, they must innovate; and innovating entails building new competencies, new capabilities and new knowledge. This paper reviews the concepts of Science, Technology and Innovation and discusses the factors militating against the translation of scientific R&D outputs into innovations in Nigeria. The experiences of selected countries are reviewed to specifically highlight the importance of institutional framework and knowledge pool in the process of building indigenous innovation capability for national development. Policies, strategies and structures that could facilitate effective management of R&D and Innovation within the Nigerian knowledge system are suggested. We conclude that for Nigeria to progress in transforming R&D outputs to tangible products and services, appropriate mechanisms must be put in place in the areas of institutional framework, support structure, knowledge generation, innovation, education and technological entrepreneurship.

1. INTRODUCTION

It is generally agreed that Science and Technology (S&T) are the keys to progress and industrial growth in today's increasingly knowledge-driven world. Most countries devote an increasing proportion of their talent and resources to S&T and to the associated Research and Development (R&D) in an attempt to attain a competitive edge, or to catch up with others. Researchers in the areas of sustainable competitive advantages have come to the conclusion that the only thing that endows a competitive edge on an organisation or a nation, is what it knows, how it uses what it knows and how fast it can know something new [1]. In other words, the cause of the competitive gap between nations and organisations is knowledge [2]. Within this context, innovation can be better understood as a process in which the organisation creates and defines problems and then actively develops new knowledge to solve them [3]. Innovation process represents the long wave of value creation and it is the main powerful driver of future economic results of nations and organisations. In that sense competing successfully in the long run means innovating and innovating entails building new competencies, new capabilities and new knowledge. Competing for the future, therefore, is not necessarily based on products and services but on the underlying capabilities that make the products and services possible [4].

2. SCIENCE, TECHNOLOGY AND INNOVATION (S, T & I) CONCEPTS

Science and technology (S&T) have nowadays become symbiotic and interrelated. In fact, they have become so closely related that the one now depends on the other for its development [5]. Science is widely accepted as organised or systematic knowledge of empirical phenomena in nature, art and society. Its main goal is to direct or forecast these phenomena using the understanding acquired through systematic inquiry. Technology explicitly denotes the whole or an organic part of scientific and empirical knowledge relating to industrial activities, material and energy resources, modes of transportation and communication, and other similar fields that are directly applicable to the production and improvement of goods and services. The concept of "Science and Technology" means, nowadays, the totality of activities in a nation that lead to innovation. These include [5]: *Scientific and technology research, Experimental development, Scientific and technological services, Innovation* and *Diffusion.*

The benefits derivable from S&T are not actually realised in an economy until innovation and diffusion occur. It is innovation that transforms R&D results into useful products or processes which are then diffused through to the end-user. On its own, innovation is a process which comprises several stages and usually takes a considerable amount of time, conscious efforts and money. The phases in the innovation process include [6]: Idea Generation, Screening of Ideas, Research and Development, Business Analysis, Prototype Development, Test Marketing, and Commercialisation. The existence of the capability to execute and manage these activities cannot be taken for granted. This capability generally referred to in the literature as technological capability [7], has to be acquired through deliberate efforts aimed at assimilating, adapting and modifying existing technologies and/or developing new technologies. We place our emphasis here on a specific kind of technological capability – the innovation capability which specifically refers to the ability to make major

improvements and modifications to existing technologies, and to create new technologies [8].

3. RESEARCH AND DEVELOPMENT (R&D) AND THE NATIONAL INNOVATION SYSTEM (NIS)

Innovation feeds on knowledge that results from cumulative R&D experience and it also contributes to this stock of knowledge. Therefore, an economy's productivity level depends on its cumulative R&D effort and on its effective stock of knowledge, with the two being inter-related [9]. Indigenous R&D produces traded and non-traded goods and services that bring about more effective use of existing resources and thereby raises a country's productivity level [10]. Additionally, domestic R&D enhances a country's benefits from foreign technical advances, and the better a country takes advantage of technological advances from the rest of the world the more productive it becomes [11]. The cumulative R&D effort is therefore intimately related to national innovative capacity of a country to produce and commercialise a flow of innovative technology over the long term [12]. However, the success achieved by any nation in exploiting R&D outputs for growth and development depends on the effectiveness of the nation's National Innovation System (NIS). The NIS therefore provides a framework for evaluating holistically a nation's attempt at generating and applying knowledge for meeting the needs of her society.

The National Innovation System (NIS) has been described as the network of economic agents whose activities and interactions initiate, import, modify and diffuse new technologies. Four key elements of the NIS - Education and Research, Industrial Production, Finance, and Public Policy and Regulation, have been identified [13]. These elements have some organisations or institutions that perform specific functions such as teaching and talent filtering, research and development, industrial production, brokerage, policy, financial and legal support, among others [14]. Thus, innovation is the result of a complex interaction between various individuals and institutions that make up the system [15].

4. THE NIGERIAN SITUATION

The Nigerian economy remains largely dependent on natural resources, primary processing and manufacturing, and for the most part, on imported technologies in spite of the visible S&T infrastructural network and the R&D activities in a broad range of fields. There exists a severe information gap within Nigeria's NIS, and interactions among the elements are too weak to bring about innovations and knowledge-based industrial development in the country [15]. Thus, the effect of R&D in Nigeria on industrial growth and productivity has been minimal.

In Nigeria, R&D is carried out by 66 research organizations controlled by various Ministries such as Science and Technology; Education; Agriculture and Rural Development; and Industry. There are 80 Universities, 48 Polytechnics and 16 Colleges of Agriculture for manpower training and research. Altogether these institutions produce much less than 100, 000 S&T personnel each year. Some level of applied R&D also takes place in the private sector. However, the industrial sector does not make adequate use of the R&D results for the generation of innovation that can create wealth for both sectors. The main factors militating against commercialisation of research results in Nigeria as identified by researchers are [16-18]:

a) Inadequate research orientations whereby more than 75% of research projects executed in the educational institutions/research institutes are not demand-driven.
b) Non-availability of information on commercialisable inventions and R&D results to the intended user industries.
c) Poor technological entrepreneurial culture.
d) Inadequate infrastructure.
e) Inadequate motivation for the commercialisation of inventions/research results.
f) Lack of funding and efficient funding structure for innovation.
g) Inadequate patent education.
h) Absence of effective linkage between research organisations and industries, and
i) Preference for foreign technology

The low level of industry-academic relations in terms of research observed in Nigeria has also been attributed to a number of factors such as communication gap, bureaucracy, inadequacy of research personnel, research facilities and infrastructure, politics and security, and the differences between industry and university culture as regards R&D activities [16]. As a result of this poor linkage, the industrial sector does not make adequate use of the academics for the generation of innovation that can create wealth for both sectors. This is in contrast to what obtains in the advanced countries where industry-academic relations are mostly on an R&D basis [16].

The Federal Government of Nigeria is currently taking concrete steps to address this problem through a number of initiatives. For instance the Federal Ministry of Science and Technology (FMST) through one of its agencies, the Raw Materials Research and Development Council (RMRDC) has profiled selected commercialisable research and development (R&D) results; and also embarked on efforts at developing local materials, products and technologies. NOTAP has also embarked on an awareness-creation program whereby technology information in patent documents is used to sensitize entrepreneurs to the usefulness of patent information as an innovative instrument for supporting SME creation, development and growth. A Presidential Committee on Invention and Innovation was also set up in 2006 to galvanize all these efforts and transform the outputs into concrete developmental indices. These are all steps in the right direction, but all agencies involved must be strengthened enough to ensure that the efforts pull through.

Most Nigerian firms are weak in terms of in-house R&D; and as a result do not have an efficient knowledge generation mechanism. In a 1999 study of 50 Nigerian food companies [17], it was found that most of the firms were not active enough in R&D as is reflected in their low funding and inadequate staffing for research. About 40% of these firms devote less than 0.5% of their annual turnover to R&D while only 20% devote between 1.5% and 2.4% of their annual turnover to R&D. This is in sharp contrast to the situation in Japan where close to 50% of companies spend at least 5% of their turnover; and in Australia where almost 30% of companies spend more than 5% of their turnover on R&D [19, 20].

In Nigeria, S&T fund has increased by about ten folds, from ₦1.5 billion in year 2000 to ₦16.0 billion in 2006. However, the question is – what percentage of that is spent on R&D? Most research institutes still complain that funds provided by government are inadequate for their operations. Staff emoluments and other charges still take up a high proportion of those funds, leaving only a small percentage for R&D efforts, which are sometimes duplication of projects already executed by other research institutes/institutions. This has now informed the intended establishment of the National Research and Development Coordination Council (NRDCC). The council will coordinate the application of R&D funds until the commercialization stage. The National Science Foundation being proposed will also institute $5.0 billion endowment for Nigerian researchers in Nigeria and in the Diasporas.

It has been shown [21] that the characteristics of innovative firms are strongly influenced by economic development and the management culture in the region. The findings from studies on the innovativeness of Nigerian firms [22-23] further confirm this. An examination of firms in the engineering and agro-allied sectors revealed that the firms innovate largely in response to materials constraints and scale bottlenecks (adaptive and incremental kinds of innovation). A particular constraint category shaping the rate of innovative activities is poor physical and engineering infrastructure [22]. Thus, the currently poor economic situation in Nigeria also constitutes a significant barrier to the development of the capability of indigenous firms to innovate at a level which could make for international competitiveness. Furthermore, most of the innovation expenditure in these firms is on improving and/or modifying existing products and processes. Linkages with local actors were found to be low while cooperation with foreign technical partners was rather on the high side. In other words, most of the enterprises, though fully Nigerian, depended on foreign firms for their growth [23].

5. LESSONS FROM EAST ASIA

A sound scientific and technological base, from which wealth-creating technological innovations and applications can develop, is essential to economic growth in a competitive international environment. This knowledge base should address the full spectrum of economic accumulation covering resource mobilization, effective production, knowledge-based marketing, sales, services and distribution of manufactured products. The efforts of the Newly Industrialising Countries (NICs) of East Asia, and their resultant economic growth in record time, are quite illustrative of this. The Asian NICs adopted the explicit technology policy approach. Thus, technological development in these countries took place over a much shorter period when compared to the European countries.

5.1. The Indian Example

The lessons from India offer us a good understanding of the place of virile institutions and functional infrastructure in developing indigenous innovation capability for national development. S&T infrastructure in India today is under the Central Government, State Government as well as public and private sectors. The Ministry of Science and Technology, which is the apex ministry responsible for S&T in India was formed through a Presidential Notification dated January 4, 1985. The departments under this ministry include the Department of Science and Technology (DST), the Department of Scientific and Industrial Research (DSIR), and the Department of Biotechnology (DBT), each of which has clearly defined, specific and closely monitored responsibilities. There are about 200 national laboratories and an equal number of R&D institutes in the Central Sector, while about 1300 R&D units exist in the industrial sector of India. The number of persons employed in the R&D establishments is estimated to be around 300,000 [24].

The country's university system (which comprises 162 universities, 32 institutions deemed to be universities, and 10 institutes of national importance), apart from being active in R&D, produces around 200,000 S&T personnel every year. The total stock of the S&T manpower in the country at the end of 1990 was estimated to be around 4.0 million [24]. The transfer of technologies developed through R&D in India is largely in the hands of India's National Research Development Corporation (NRDC), which has been described as a vital link in the innovation chain, and a prime vehicle for technology transfer. It issues licences for the commercial exploitation of technologies developed by research organizations [24].

5.2. The South Korean Example

The lessons from Korea offer us a good understanding of the place of education in national development. The achievement of rapid industrialisation of Korea was dependent on an educated workforce. From an illiterate workforce in the 1950s (22.0% in 1953), literacy rate increased to nearly 90% within two decades [25]. Interestingly, the private sector invests more than the government in education [25]. All levels of education are concurrently focused, creating a uniquely balanced system complemented with aggressive training of high calibre scientists and engineers in the West.

In addition, technological capabilities are key facilitators of the development process in Korea. In the

past two decades, the Korean government has shifted its stance from having a leading hand in R&D activities from the 1960s and 1970s to the encouragement of private firms to perform R&D. In 1980, 62% of R&D was performed by public institutes, along with 9.2% by Universities and only 28.8% by private firms. By 2005, this had dramatically shifted to over 76% of research performed by private firms (an increase of over 48%) whilst the public sector only performed 13.8% (a drop of almost 48%) [24]. The type of R&D performed in Korea has shifted towards technology development rather than basic. Basic research declined from 22.9% in 1970 to 13.2% in 1996. In addition, the Korean state founded companies had reached the technological frontier from reverse engineering and efforts were poured into R&D to gain international competitiveness.

6. RECOMMENDATIONS

Having identified the factors militating against the translation of scientific R&D outputs into innovations in Nigeria; and having reviewed the examples of two East Asian countries, we propose the following specific measures.

6.1. Research Re-orientation

A situation where 75% or more of research projects arise from within the R&D institution is definitely not demand-driven and therefore may affect the adoption of the research outputs and consequently the development of innovation capability in the industrial sector. There is, therefore, a need for institutions to embrace interdisciplinary research, always looking to solve specific problems emanating from the industrial sector rather than basic or curiosity-oriented projects. This will guarantee attention and funding from the private sector. It will also facilitate effective research-industry linkage. The establishments of linkages organizations such as brokerage firms, academies of science and engineering, and business development companies, as suggested by Oyewale [15], should also be encouraged.

6.2. Technological Entrepreneurial Culture

Conscious effort must be made to improve the quantity and quality of S&T manpower in the country by introducing courses in technical entrepreneurship in the curricula of tertiary institutions in order to promote the interest to start-up technology-based micro, small and medium (MSM) enterprises.

6.3. Improved infrastructure

Presently, most Nigerian institutions lack basic infrastructure/modern research facilities needed to execute inventive projects. Therefore, it is advisable for institutions to use whatever meagre fund is available to provide facilities in areas where they have comparative advantage. These facilities can then be shared by other institutions.

6.4. Motivation for Commercializing Inventions and Research Results

The tacit nature of inventions may require the inventors to work closely with the industrial firms that are exploiting the inventions in some instances. The current conditions of public service do not allow the researchers to take up such appointments. Therefore policies to encourage researchers to nurture spin-off companies within or outside their institutions should be implemented. The institutions should also map out guidelines for disbursement and sharing of royalties that emanate from such activities.

6.5. Promotion of Indigenous Technology

The development of local technology solutions for industrial problems is a very promising option. Costs of procurement and maintenance will be lower while the choice of appropriate technologies will be less of a problem.

7. CONCLUSION

The 21st century is anchored on developments in science and technology, particularly, the new technologies, biotechnology, genetic engineering, new materials and indeed information and communication technologies. Nations are acquiring greatness and sustainable competitive advantage through the mastery and harnessing of technology; and consequent innovativeness and food security. To remain active players in the new world, Nigeria must be pro-active in the development of its driving technologies, and the school is where to begin. It is clear from the experiences of Korea that education, and in particular, technological education is the power of wise nations. It is also a known fact that the rapidly industrialising countries that are poorly endowed with natural resources have become successful economies through the development of sound innovation capabilities through the appropriate application of S&T. It is thus apparent that for Nigeria to progress in transforming R&D outputs to tangible products and services, decided steps must be taken in the areas of institutional framework, support structure, knowledge generation, innovation, education and technological entrepreneurship.

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