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Review paper

Patenting and Technology Entrepreneurship in Nigeria: Issues, Challenges and Strategic Options

Abstract

Patentingis a useful indicator of scientific outputs andtechno-economic activities of countries. It provides opportunity for linkages between research organisations and industry within National Innovation Systems (NIS);but it has not been adequately utilised by several developing countries including Nigeria. Technological entrepreneurship has to do with the commercialisation of research results throughdiverse means such as incubators and spin-off firms. However, Nigeria with several universities and research institutes develops many inventions without deriving much benefit from them. This is due to low quality of the research outputs and the non-patenting of such inventions. Also, the commercialisation process is impeded by lack of venture capital and poor entrepreneurial culture among researchers. This paper proposesbetter funding for education and research, the inclusion of business experimentation in Nigerian institutionsto create a pool of technological entrepreneurswithin Nigeria's NIS. The paper also advocates for full implementation of the new Science, Technology and Innovation Policy to address the issues of patenting and commercialisation of inventions in Nigeria.

Keywords:**Patenting, technopreneurship, STI, Nigeria and commercialisation**

1.0 Introduction

It is pertinent to note that development of any nation does not hinge only on the natural resources possessed but rather on the stock of knowledge available and how such knowledge is applied to solve practical developmental problems. Consequently, countries' competitiveness depends more than ever on their abilities to access, adapt, utilise, and create new knowledge. It has also been established that the contribution of knowledge to economic competitiveness and social welfare cannot be overemphasised. Therefore, knowledge is a crucial tool for overcoming underdevelopment. This is because the application of knowledge in research and development (R&D) activities can lead to the development of inventions, which entrepreneurs can turn into innovations. Furthermore, people's education and skill levels are recognised as one of the key sources of growth and competitiveness in the global economy (Dahlman and Utz, 2005). Relying simply on rich endowments of natural resources and cheap labour, without any contribution of 'intellectual added value', has been and continues to be a dead end for development (Judith S, 2005).Hence, knowledge economy cannot be separated from Science, Technology and Innovation (STI) management.

2. Position of Science Technology and Innovation in Economic Development

Science, technology and innovation (STI) constitute a very important factor in the economic growth and development of any economy. The need for STI in bridging the gap

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between resource ownership and resource development for accelerated growth cannot be overemphasized. Prusak (1996) identified the disparity in the development of STI as one of the major factors responsible for the gap between the industrialised nations and the developing economies of the world. While resource endowment is good for a nation, the potential to exploit and transform such resources into valuable and exportable products can only be achieved through the deployment of appropriate technology.

All developed economies like United States of America, United Kingdom, Germany, France and Japan were able to achieve global competitiveness and rapid industrial development by harnessing science and technology (S&T) in their developmental efforts (Bayh, 2006). Recent accelerated development of the Asian Tigers like South Korea, Malaysia and Taiwan also reflects the application of modern S&T in their economies. Based on these experiences, many developing countries are becoming increasingly aware of the need to dedicate their efforts to acquiring the requisite S&T knowledge and the development of indigenous capability, which fast-track the economic growth and developments in their nations.

For the underdeveloped economies to move up the development ladder, they need to pursue a rigorous acquisition and application of S&T knowledge that could transform the different sectors of their economies, especially the industrial sector. In addition, a realization of the importance of innovation in bringing the improved products and services to the market is also required for rapid economic growth. This view was strongly supported by Sharma (2006) assertion that innovation and technology are indispensable for the transformation of countries from mere reliance on the exploitation of natural resources to technological innovation as the basis for development. Oyelaran-Oyeyinka (2006) also recommended that to achieve increased efficiency, growth and sustainability, there should be continuous improvement in all the sectors of the economy.

2. Technological Entrepreneurship: Definition, Concept and Benefits

Technological Entrepreneurship (TE) is synonymous to the commercialisation of technological discoveries or the establishment of new business ventures on new technological discoveries. Oyewale et al (2008) opined that TE is the training of the mind for the urge to commercialise inventions that are based on technological R&D. According to Bailetti (2012), TE is involves an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in S&T knowledge for the purpose of creating and capturing value for a firm.Therefore, TE must involve the use of S&T knowledge to create value; in fact, this differentiates TE from mere trading activities or ordinary entrepreneurship.The emergence of knowledge economy has also contributed significantly to the necessity of utilisingTE as an avenue for industrial development. Critical to generating commercialisable research outputs is the huge R&D funding which must be properly directed, focused and managed. In addition, a robust system of innovation is essential for technology commercialisation to occur and in most Developing Countries, especially in Nigeria, the system is weak.A detail of how the TE is accommodated within the national innovation system is discussed in the next section of this paper.

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4. NIS and Technological Entrepreneurship

Technological Entrepreneurship could be adequately explained by its position in the National Innovation System (NIS). The NIS of any country consists of distinct institutions, which individually and jointly contribute to the development, and diffusion of new technologies (OECD, 1999a). The System, through its activities and interactions, initiate, import, modify and diffuse new technologies (Freeman, 1987). The NIS as a concept is used to evaluate innovativeness of a country, and it provides the framework on which governments form and implement policies to influence the innovation process (Metcalfe, 1995). Four key elements are identified within the NIS; they are Education and Research, Industrial Production, Finance, and Public Policy and Regulation. Each of the elements has some organisations or institutions that perform specific activities towards the actualisation of the overall objectives of the system.

The Education and Research Element of the NIS include universities and specialised research institutes, whose functions are Teaching/Manpower Development, conducting of research and transferring technology to industry for exploitation. Universities are traditionally involved in the first two activities, but the third mission was added to their mandates since after the Second World War, in recognition of their contributions to the prosecution of the war. This new mission involves service to the community through technology transfer to business sector is in pursuit of national economic advantage (OECD, 1998). The fulfillment of the third mission of universities necessitates the creation of conducive environment for university researchers to establish spin-offs and to stimulate entrepreneurial interest among the students and the academe. This further provides the necessary justification for huge amount spent on R&D while also fostering requisite human capital development.

The Industrial Production Element of the NIS includes the public and private sector firms that produce and sell goods and provide services that contain science and technology (S&T). The Element comprise of the Multinationals or Trans-National Corporations, Large-, Small-Medium-, and Cottage-Sized Enterprises. In recent years, new generations of New Technology-Based SMEs, which are ~~called~~ spin-offs or start-ups have been established to commercialise research findings and technologies that originate in universities, government research institutes or private laboratories, called their parent organisations. The companies are usually formed by former employees of the parent organisations that were involved in the development of the core technologies; hence, they usually have single product focus and niche market character (Hoffman et al, 1998). In addition to their production facilities, the firms, since the 20th Century, the firms have been establishing in-house laboratories where they conduct research to support their products, processes and services. Webstar (1991) noted that before 1900, the idea of industrial research laboratory did not exist.

The Finance Element provides innovation funding in the form of venture capital, which is an investment in new, unlisted, high-risk, high-tech spin-off firms, in the form of equity, quasi-equity and/or a conditional loan. Venture capital is crucial to the innovation process. As large companies are reluctant to undertake high-risk innovative projects, such projects are usually undertaken by small technology-based firms, in which venture capitalists invest (OECD, 1996). The fund is usually provided at the early stage when an idea is not fully developed and research is being conducted. If sufficient fund cannot be found at this early stage, an innovating project may fail. Guild and Bachher (1996) identified Private Venture Capitalists, Public Venture

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Capital Funds and Business Angels as three classes of Venture Capitalists. The high returns from their investments attract the venture capitalists to sponsor the high-risk projects. However, the assurance of protection of the technology that is being developed from illegal exploitation through patenting encourages the Venture Capitalists to invest their resources in the young companies.

Public Policy and Regulation Element of the NIS include government ministries, agencies and other bodies at various levels that are involved in regulating S&T researches and their industrial exploitation. The government uses financial and non-financial policy instruments to promote innovation. For the NIS to work effectively, governments take steps to strengthen their innovation systems by reinforcing the basic framework conditions for innovation; promote the development of highly skilled labour force and a dynamic research base; provide the right climate for business innovation by implementing stable macroeconomic policies; protect intellectual property rights; and maintain a regulatory framework that promotes innovative behavior (OECD, 1999b).

5. Patenting and Exploitation of New Technologies

Patent is the legal protection placed on technological activities embodied in an invention to prevent its unauthorised ~~usage~~ or exploitation, and granted to firms, individuals or other entities by national and regional patent offices. The exclusive legal rights of industrial exploitation that patent confers its owner(s) allows them to exploit the invention for a period of time, generally for about 20 years (Kamil, 2003). Invention refers to the generation of an idea, or the creation of a new technology for the first time, or the improvement of an existing technology. Such invention could be a product or a process, which may be brand new, but more often, it could be a combination of existing technologies (Hauser, 1998). Thus, an invention can be a completely new product, which is based on new technologies and/or designs, or an existing product whose functions have been greatly improved by structural, material or process changes (White and Liu, 1997). As soon as research activity results in the development of an invention, it is important to apply for patent. While the first person or organisation to invent is recognised in the United State of America (USA), the first to file application is recognised in other countries. However, in order to qualify for patenting, an invention should satisfy three key conditions: it should be novel, non-obvious and be industrially applicable (Arnold, 1996). As an indicator of inventiveness on a country, patent is also used as a determinant of economic activities (Kamil, 2003).

~~The~~ patent can be commercialised through different routes including joint venture, licensing, outright sale of the patent right, or the establishment of spin-off firms to exploit the invention. The best route to use will depend on the status of the new technology and the maturity of the industry in which it is to be used. Lowe (1993) suggested that consultancy might be used if an invention is low-tech, but when it is progressing and not radical, licensing can be used. For both radical and less radical process innovations, the use of joint venture or licensing was suggested. However, when an invention is radical, i.e. the product and/or process is entirely new, establishing a spin-off company to exploit is expected to maximise returns.

6. Establishing Spin-Off Firms

Spin-off firms ~~are~~ usually have some stakeholders, the researchers, university or

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laboratory where the technology to be exploited is developed and the venture investor. Existing enterprises may also be involved in the formation of the spin-off firms in order to reposition themselves with the spin-off firms. Researchers who developed inventions could establish spin-off firms solely or in partnership with their institutions/institutes of employment and/or other investor(s). However, the spin-offs may be lacking in capital and other complementary assets needed for successful operations, venture capitalists come to their rescue by providing funds and management support.

Venture capitalists investments in the high-technology firms generally last about three to eight years (Guild and Bachher, 1996), during which spin-off firms are groomed into large companies. As the businesses become well established, their shares are offered for sale at the Stock Exchange to several shareholders. This ensures the survival and sustainability of the company beyond the lifetime of the initial founder(s) and owner(s), so that the knowledge, expertise, and assets of the company do not go to the graves with the founders. The valuation and sales of shares of the companies depend on an efficient and reliable financial system (Wellons, 1985) and it involves the operations of Stock Exchange and Securities Commissions, brokerage companies, experts in legal, financial, tax, regulatory and accounting issues.

7. Research Output, Patent Generation and TE in Nigeria

Several authors including Oyewale (2005, 2006, 2010), Oyewale et al (2007, 2008) and Bamiro et al (2008) reported that Nigerian universities and research institutes develop commercialisable inventions from time to time. The Raw Materials Research and Development Council (RMRDC) and National Office for Technology Acquisition and Promotion (NOTAP), which are agencies of the Federal Ministry of Science and Technology, have published compendia of commercilsable research results from Nigerian research endeavours (NOTAP, 2005).

In order to showcase the inventions of the universities, the National Universities Commission, the umbrella organisation that oversees the administration of university education in Nigeria instituted the Nigerian Universities Research and Development Fair starting with the maiden edition in 2004. Oyewale et al (2008) reportedthat over 70% of inventions on display at the 2004 and 2005 Fairs were not patented. Non-patenting of inventions was also revealed by respondents to the study conducted by Oyewale (2007); where about 13% of these respondents with claims of inventions also claimed to have filed applications for patents. The main reason advanced for not applying for patents for the inventions was lack of awareness of the procedure for patenting. Despite the development of inventions from the research activities in the country, it is pertinent to ask for the reasons for not patenting the inventions. This analysis indicates that the researchers did not know much about patenting, which was a reflection of poor patent education in Nigeria.

One of the challenges of not bothering to patent research results by Nigerian researchers is the equality of their researches. The quality of the nation's research and higher institutions as well as of its science, engineering, and technical know-how is far below the international benchmark as the available laboratory equipment for the conduct of research in this system are obsolete, though they are only being gradually replaced and new ones in recent years (Bamiro et

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al, 2008). Consequently, cutting-edge research that could generate high-tech inventions, which could be patented, is not conducted in the country.

In confirmation of low patent registration from Nigerian research efforts, Okongwu (2006) reported that 74 (29%) local patents were registered out of the 259 that were submitted to the Nigerian Patent and Trademarks Office, between 2000 and 2005. Within the same period, out of the 1,775 foreign patent applications, 122 (7%) were registered. More recent data from the World Intellectual Property Organisation (WIPO, 2011, 2012) indicated that 37 and 17equivalentpatent applications were filed from Nigeria in 2010 and 2011 respectively, while 3 and 2 equivalent grants were made in the two years. These figures were too low compared with those of other countries. For instance, Egypt recorded 61 and 89 grants out of 684 727 applications in 2010 and 2011 respectively; South Africa 1,347 and 1,119 out of 5,562 and 6,140; while Korea had 75,593 and 97,714 grants out of 177,795 and 187,454 applications. It is therefore necessary to promote the culture of patenting of inventions among Nigerian researchers.

The studies earlier cited reported the non-patenting of inventions by Nigerian researchers and suggest that they have inadequate information and poor understanding on patent matters. In addition to poor patent education in Nigerian institutions, other factors identified as preventing patenting of the inventions include poor technological entrepreneurial culture, lack of institutional infrastructure and inadequate funding of research. These challenges have been addressed over the years, though their impacts are yet to be seen. For instance, in order to promote entrepreneurial culture among Nigerian University students, Entrepreneurial Studies had been incorporated into the Curriculum of Nigerian Universities (NUC, 2007). Furthermore, the establishment of Intellectual Property Technology Transfer Offices (IPTTO) in Nigerian institutions is expected to address the problems of poor patent education and technological entrepreneurship, as the offices assist the institutions torefocus their R&D activities/projects, facilitate patenting of inventions emanating from their research activities, establish business linkages between the institutions and industry and create spin-offs from their research results (Orji, 2009). Starting with 15 in 2006, 33 IPTTOs have been established in Nigeria by the end of 2012 (NOTAP, 2013).

A study on Entrepreneurial Attitudinal Status in the Nigerian Tertiary Institutions that involved 42,800 student 249lecturers was conducted in 2010 (NACETEM, 2012). The study revealed that Nigerian students have high interest in personal businesses, with high propensity for technology-based enterprises (WBSB–NACETEM, 2012). However, no matter theinterest of students in personal businesses; they may not be able to engage in Technological Entrepreneurship. This is because of their low level of training, due to several factors including obsolete laboratory equipment for training and conduct of research and brain drain, which was responsible for the departure of 5.13% of the academic staff Nigerian universitiesduring 2001/2002 to 2005/2006 period (Bamiro *et al,* 2008). Nevertheless, with establishment of the Tertiary Education Trust Fund (TETFUND) in 2011(TETFUND, 2012),funding of tertiary education and research is expected to improve. An additional source of funding for research is the National Research and Innovation Fund that is proposed to be established by the STI Policy of Nigeria (FMST, 2012).

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The low level of training of Nigerian students notwithstanding, it is possible for them to adopt the already completed projects that are available for commercialisation from Nigerian research endeavous. Beside the Universities R&D Fair that was earlier mentioned, the RMRDC organises Techno-Exposition programme biennially. In order to facilitate investing in the technologies on display, the Council publishes Investment Profiles on them. The Investment Profiles provides information that could guide potential investors on the requirements for the projects. The impact of the Techno-Exposition in respect of TE is yet to be ascertained. Oyewale (2005) reported the absence of Venture Capital organisations in the Nigeria's NIS and noted that this was a serious omission.

Nigerian S&T Policy was recently reviewed and designated Science, Technology and Innovation (STI) Policy. Having formulated its first S&T Policy in 1986, the Policy had been reviewed twice, in 1998 and 2004 before the recent review. The STI Policy devoted Section 3.4 to Intellectual Property Rights. In addition, the Policy is proposing the establishment ofa National Research and Innovation Fund with a minimum of 1% of GDP, to ensure adequate funding of STI activities, while the National Research and Innovation Council, with Mr. President as the chairman, is to be instituted to among others coordinate STI activities and facilitate fund raising activities to support innovation activities in Nigeria. If adequately implemented, the new STI policy should address the non-patenting and exploitation of Nigerian research efforts, especially as spin-off companies, thereby strengthening Research-Industry interactions in Nigeria.

8. Summary and Recommendations

The study considered the issues of science and technology in development, and the position of patents in the commercialisation of inventions, especially through the establishment of spin-off firms. The paper further described the importance of technological entrepreneurs in the commercialization process. In addition, the paper discussed the essentials of National Innovation Systems and the position of technological entrepreneurship in the system, as a crucial element of the system. While discussing the position of patents and technological entrepreneurship in Nigeria, the low output level of research was discussed and the causes identified. We also delved into various infrastructures that can support the system to operate efficiently and bring together all the elements of the national innovation system.

To address the issues raised, the following recommendations were made: firstly, to address the problems of poor funding of education and research activities in Nigeria. To this end it is essential for Nigerian government to implement the establishment of the National Research and Innovation Fund recommended by the newly reviewed Science, Technology and Innovation Policy. The low awareness of patenting in Nigeriashould be addressed through patent education to be mounted in Nigerian institutions. The industrial sector is also encouraged toconsider exploiting the commercialisable research outputs of the institutions. As Technology Transfer Offices have been established in some institutions in Nigeria, there is the need to empower them to function effectively so as to address the challenges of patenting of inventions. The teaching of entrepreneurship in Nigerian universities should be made more practical to create rooms for business experimentation before graduation. The need for the governments at all levels in Nigeria to promote the creation of venture capital organisations and encourage the emergence of business angels to finance technological innovation is also advocated.

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