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Involvement of Stakeholders in the R&D and Innovation Process: an Analysis of Nigeria's Innovation System

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Abstract

The study was designed to evaluate the business development and transfer of technologies to small manufacturing companies by research institutes in South Western Nigeria. The study covered all the industrial research institutions with headquarters in South Western Nigeria.

The study showed that the involvement of scientists in innovation process was rated highest in the idea generation (4.14) and idea screening (4.29) phases; high in R&D (3.86) and fairly high in pilot plant development (2.71) and commercialization (2.43) phase. Their involvement was rated low in business analysis and development (2.14), and test marketing (2.29) phase. The involvement of engineers was rated highest in idea generation (3.28), fairly high in R&D (2.71), pilot plant development (2.57), and idea screening (2.40) phases. However, their involvement was rated low in business analysis and development (2.0), test marketing (2.0), and commercialization (1.28) phases. The involvement of technology marketers in innovation process was generally rated fairly high in R&D (2.7) and business analysis and development (2.6), and low in all the other phases of innovation. However, their involvement at IAR&T, FIIRO, and NIOMR in all the phases was rated very high (3.0-5.0). The involvement of entrepreneurs was generally rated from fairly high to low (2.7-2.3) in all the phases of innovation. The involvement of financial institutions in all the phases of innovation was generally rated low (1.28-1.71).

In conclusion, the study showed that the involvement of stakeholders like entrepreneurs and financial institutions in technology packaging for commercialization is very low.

Key words: Research Institutes, National Innovation System, Nigeria, Entrepreneurs, Financial Institution.

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INTRODUCTION

The NIS approach by Lundvall (1992) represents an improvement over the Freeman 1987 edition by introducing cultural, historical and social aspect of the National Innovation System (Golden *et al.*, 2003). Studies on the concept of NIS even though is relatively old in developed countries, is very new in the context of developing countries. Its relevance to development cannot be overemphasized.

The strength of the NIS of a country determines the speed and direction of innovation and learning within the boundaries of a Nation (Golden *et al.*, 2003). The NIS has also been defined by Ilori (2006) as being constituted by elements and relationships, located within or rooted inside the borders of a nation state, which interact in the production, diffusion and use of new and economically useful knowledge. Often, the interactions of the elements of the system are mutually reinforced in promoting learning to bring forth technical advances that nurture economic and social progress of a nation (Kwanjai, 2000).

Lalkaka (1999) identified the various sub-systems that interact within a NIS as:

(i) S&T policy and policy instruments;
(ii) Technical human resources development;
(iii) Scientific research and its commercialisation;
(iv) Technology transactions in the international market;
(v) Technical support and business development services;
(vi) Financing S&T; and
(vii) International cooperation.

Mechanism of the National Innovation System

The National Innovation System (NIS) operates with actors performing certain functions and interacting with other actors performing a totally different function, all operating in synergy. The result of these interactions leads to production of new knowledge which is usually incorporated in production activities within the economy of a nation. The most important actor

within the innovation system is the firms in the industries. These firms interact with all other actors in the system. Other actors includes: universities, research institutes, government ministries and regulatory agencies, trade associations, financial institutions and the market. All these actors operate in the context of a social, political, cultural, and economic environment according to Lundvall (1992).

The Firm

The firms are critical to the NIS as technological changes take place within firms (Adeboye, 2000). The firm's primary duty is to introduce new products into the make to meet consumer's needs. This is usually done through corporate strategies. Corporate strategies include diversification, new product development, and market penetration amongst others. New product development is usually done through 7 stages: idea generation, idea screening, research and development, business analysis, pilot plant development, market testing and commercialisation. For a product to thrive in the market, these 7 stages must be observed. This is because the market is the determinant for innovation. However, developing countries, especially African countries, the market is yet to be fully incorporated in the innovation systems and also the innovation process. The severance of R&D from the market may be responsible poor innovation prevalence in developing countries. This was further stressed by Bell and Pavitt (1992) that "failing to recognize the firm as the fundamental actor in the accumulation of technology has been the major short - coming of technology policy of most countries, especially African countries".

Adeboye (1997) posited that technological innovation follows at least three principal models. The first model is characterised by strong S&T institutions and large R&D. His was observed by the frontiers of technology like Japan, United States. The second model emphasizes broad tacit skills, versatility and agility in learning new skills, information sharing, and intense interaction among the entrepreneur, the customer and the producers. Many transition countries are in this category, they include the BRICS (Brazil, Russia, India, China and South Africa). The third model is a diffusion model, which is based largely on the transfer, adoption, adaptation and diffusion of

existing knowledge. Examples are these countries are the Northern African countries and the Asian countries.

While the first model is characteristic of technologically advanced nations, the third is characteristic of late comer economies; which are based on the ability to learn and adapt new knowledge without necessarily contributing to it. For the third category, the major activities include reverse engineering, here R&D is carried out to learn, adapt the technologies form the first category.

Research and Development (R&D) Institutions

Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the knowledge stock, including knowledge of man, culture and society, and the use of this knowledge stock to devise new applications (OECD, 2002). The research and development institutions make vital contribution to technological transformation, mostly indirectly contributions. The universities conduct basic research, while research institutions conducted applied research. However, developmental research contributes to innovation process mostly. R&D Institutions develop the nation's knowledge capability to absorb, adapt, and deploy technology. A recent survey of in Nigeria showed that these indicators are very weak (African Innovation Outlook (AIO), 2010), while in some cases, they are absent (AIO, 2010).

The Educational Institutions

The primary role of the universities is to produce graduates who will use their knowledge to produce goods and services. Educational activities are supposed to be channelled towards developing and adapting modern technologies, without this, the economy of the nation cannot grow.

Industrial Institutions

Lall (1992) defines these industrial institutions as "those that provide inter-firm linkages in production, technology or training, or provide support to smaller enterprises, or help firms to restructure and upgrade". Some of the

industrial institutions are not within the firms. Those that are outside of the firms include government technical centre, or privately own training organisations. The duties of the industrial institutions are to augment the knowledge produced from the universities and research institutes. The activities of the industrial centres are using the basic research from universities and applied research from research institutes as input and their output is usually developmental research which can be directly utilised in the firms in productive activities. The presence of these institutions is great inputs into the national innovation system of a country.

The Market Structure

The market organisation of any country is an important part of the NIS. The market structure shapes technological changes in a country. The market determines if an innovation will be diffused within the borders of a nation or not. This is because market structure determines both opportunities for innovation and the profits from innovation. Bell and Pavitt (1992) opined that the presence of many large firms or many small gives the market different orientations

Financial Institutions

Another critical part of the NIS is the financial institutions. They include commercial banks, development banks, micro finance banks, multilateral organisations, funding organisations and venture capitalist. The way financial institutions are legally and organizationally structured determines their impact on the innovation system of a country. For example, the commercial bank gives out funds at an interest rate while venture capitalist gives out funds on contract (not necessarily at interest. Other the other hand, the funding agencies gives out funds for research or for the commercialisation of an invention at no cost. The presence of these financial actors also shapes the market structure within the innovation system.

Information Networks

The role of information networks for technological transformation is very essential. They determine the rate of diffusion of new knowledge. They

make available the details of new technologies and new knowledge mainly through informal means. In other words they serve as intermediaries between the R&D institutes and the market. Information networks are primarily run by government. They establish standards for products and by enforcing adherence to the standards (Adeboye 2000). Example of this are: Standard Organisation of Nigeria, National Agency for Food and Drug Administration and Control, National Environmental standards and Regulatory Agency, etc.

Government Element

The duty of government in NIS is beyond correction of market failures (Lall, 1996). The role of government is mainly in providing policies, programmes and support. Also, government has agencies that provide regulations and enforce conformance to standards and policies. Another important role government play is in correction of market failure (Kim, 1999).

Other Elements within the NIS

There are other important components of the NIS, this include the social and cultural environment of the economy. Political stability has also been seen as an important determinant of the rate and structure of technological transformation (Lundvall 1992). One of the core duties of government regulatory framework has been identified to be to enforce intellectual property. Although it is popularly believed that the enforcement of intellectual property right encourages technology transfer and economic growth, on the other hand Ilori, (2006) found little connection between the enforcement of intellectual property rights and technology/knowledge transfer.

Other actors within the Lundvall NIS include: the financial system, technology brokers, industry and professional associations, the legal base, non- governmental organisations, press, public opinion and international cooperation structures (Plonski, 2000; Oyelaran-Oyeyinka, 2002; Oyelaran-Oyeyinka and Barclay, 2003). The innovative performance of an economy depends on how the individual institutions and actors (e.g. firms, research institutes, universities) perform in isolation and how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (OECD, 1999). Without adequate

development of these actors and institutions in the domestic and regional settings the innovation system remains underdeveloped and weak (Jinma *et al.*, 2005).

Partnerships within the National Innovation System

The continuous search for knowledge within the NIS result in the development of partnerships between the system's major actors and these partnerships cut across the public and private sectors (Ilori, 2006). They are often facilitated and stimulated by the government and are defined by a joint contribution of financial, research, human and infrastructural resources either directly or in kind. The partnerships within the national innovation system (NIS) according to the types and characteristics of actors are presented (Cervantes, 1999):

- University-industry partnerships;
- Government-industry partnerships;
- Research institute-industry partnerships; and
- Any combination of the above.

The university-industry partnerships are spurred largely by the need for universities to look for additional sources of funds and industry's need to access a broader science base for coping with the challenges of competition. Government's inability to sustain previous growth rates in expenditure on research has made these institutions more adventurous in seeking stronger linkages with industry (Senker and Senker, 1997). The firm's willingness to take advantage of institutional innovations which are favourable to the introduction and diffusion of new technologies also stimulates the university-industry partnerships.

According to Ilori (2006), governments go into partnerships with industry generally to reduce the technical risks associated with industrial research projects. They also induce the firms to bear the remaining commercial risks that can be managed with their market strategies. According to Cervantes (1999), industry partnerships with research institutes are more common than those with universities in developed countries and have served as ve-

hicles for meeting specific industry needs. Most of them started as collaboration with large firms, but the increasing prominence of small and medium-sized enterprises (SMEs) in their national economies has shifted focus to linkages involving groups of small firms and research providers.

The Nigerian Innovation System

The Nigerian innovation system consists of three major elements which perform diverse but inter-related functions within public policy, legal and financial framework of the economy (Ilori, 2006). These entities include: (i) educational institutions; (ii) research institutions; (iii) industrial production by firms.

Educational institutions

Education, in Nigeria, is based on a 9-3-4 system with some emphasis on science and introductory technology education at the primary and secondary levels. The enrolment targets for science-based courses and non-science courses are in the ratio of 70:30 for universities and 80:20 for polytechnics. However, actual enrolment figures have consistently skewed in favour of non-science courses (Okebukola, 2002).

Nigeria's higher education sector currently has about 36 federal universities, 37 state universities and 50 private universities. These institutions, mostly owned by the federal and state government train students in diverse disciplines to meet the nation's human resources needs. The National Policy on Education explicitly emphasises that universities must develop the physical and intellectual capabilities of individuals and serve as an instrument of change by bringing the fruits of the nation's cultural heritage and modern technology to as many Nigerians as possible. In addition to these functions, lecturers in these institutions, particularly in the universities, conduct basic or applied researches which are funded largely by the government through supervisory agencies such as the National Universities Commission (NUC). The results of such research efforts are expected to be commercialised by industry.

The relative number of S&T personnel in Nigeria is very low compared with other countries. Within the Nigerian Innovation System, the univer-

sities have the highest concentration of high quality research personnel (80.7%). Among polytechnics, only 2.2% of research /teaching personnel have doctorate degrees as against the 27.3% found in the public research institutes (Oke, 2005).

Research institutes

Presently, there are about 65 R&D institutes and research agencies widely located across the country and operating under the supervision of their respective ministries. Some of the research institutes and their mandates are presented. Generally, the R&D facilities in educational institutions and public research institutes are in poor states but facilities in the industries are much better (Oduola *et al*., 2005; Oke, 2005). Virtually all these research institutes, universities and other higher institutions operate outside industrial structures and conduct basic research which is not needed in the manufacturing sector in Nigeria. The producer-user relationship, as determined by the proportion of spin offs/spin outs and commercializable research outputs actually commercialised, is very weak (Oyewale, 2003; Oke, 2005).

Industrial production

The Nigerian manufacturing industrial sector is made up of ten sub-sectors. These are: food, beverages and tobacco, chemical and pharmaceuticals, textile, wearing apparels and leather, wood and wood products, plastic and rubber products, pulp and paper products, printing and publishing, basic metal, iron and steel, electrical and electronics, non-metallic mineral products, and motor vehicle and miscellaneous assembly (Ilori, 2006).

According to Ilori (2006), firms operating in these sub-sectors vary in size, number of employees, turnover and ownership with most of them operating on a small scale. These firms are located across the six industrial groupings but their activities are concentrated in major urban centres (Nigeria Institute for Socio-Economic Research [NISER], 1998). For instance, the firms along the Lagos-Ota-Ibadan axis alone account for about 44% of the total registered number of firms and roughly 52% of the employment in the manufacturing sector (World Bank, 2002).

As a major employer in the Nigerian economy, the manufacturing sector had over the years, intensified training as a way of upgrading the technological capabilities of their employees. These efforts had largely resulted in the decline of expatriate staff in the country (NISER, 1996). However, Oke (2005) found that the technological skill intensity (0.07%) of employees which measures the ability of firms to generate and/or adopt new products and process technologies is generally low. It was also found that the Nigerian economy in the 1990-2000 periods ranked fifth behind South Africa, Egypt, Algeria and Morocco. The average GDP growth rate of 2.4% was considered to be low (Ilori, 2006). Though the industrial value-added was fairly high (1.7%), the growth rate was also very low in same period (Oke, 2005).

METHODOLOGY

The framework used in this work was a slight modification of the Innovation Model of Knowledge Transfer by EC Expert Group Report (2004). The study covered all the industrial research institutions with headquarters in Southwestern Nigeria. The study also covered the agricultural research institutes with crop utilization departments in Southwestern Nigeria. It included Federal Institute of Industrial Research, Oshodi (FIIRO), Lagos; Nigeria Institute of Oceanography and Marine Research (NIOMR), Lagos; Nigerian Building and Road Research Institute (NBRRI),Ota; Cocoa Research Institute of Nigeria (CRIN), Ibadan; National Institute for Horticultural Research (NIHORT), Ibadan; Institute of Agricultural Research and Training (IAR&T), Ibadan; Engineering and Material Development Institute (EMDI), Akure; Nigerian Natural Medicine Development Agency (NNMDA), Lagos and Forestry Research Institute of Nigeria (FRIN), Jericho, Ibadan.

All Heads of Departments that are responsible for technology generation and transfer were selected as respondents for the study. The Chief Executive Officers and Directors of Accounts in each institution were also involved in the study. A list of entrepreneurs who have benefitted from R&D results of one of the institutes was compiled.

The Research instruments for the study were structured questionnaire technique, interview schedule as well as secondary data collection. The

Chief Executive Officers and Heads of Departments responsible for technology development, packaging and transfer in the research institutes and entrepreneurs who have commercialized R&D results of one of the research institutes were interviewed to obtain data that complimented those obtained through the questionnaires. The type and level of involvement of the entrepreneurs during the developmental stages of the invention/innovation were determined. The type of their involvement was indicated as financial or contract research agreement. The level of involvement of the entrepreneurs was measured on a 5-point liker scale with 5 being the highest contribution and 1 being no contribution. The process of innovation usually occurs through seven (7) phases or stages. These are idea generation; idea screening; R&D; pilot plant development; business analysis; test marketing; and commercialisation. The extent to which R&D institutions follow these seven (7) stages was measured on a five-point liker scale with 5 being highest and 1 being the lowest. Moving from laboratory prototype to pilot plant requires scaling up. This requires the development of optimum process for semi commercial production of the product. At this stage, process engineers, scientists, technology marketers within the organization, entrepreneurs and financial institutions are usually involved. Their level of involvement at this stage and the other stages in the innovation process was measured on a 5- point liker scale. The number of such scale-up activities was indicated. Secondary data were collected from publications of the research institutions such as annual reports, research reports, journals, newsletters, magazines, publications of the organized private sectors such as National Association of Small Scale Industrialist (NASSI), and National Association of Small and Medium scale Enterprises (NASME).

The data collected from the properly filled questionnaires were analysed using the descriptive and inferential statistics. These included frequency counts, percentages, cross tabulations, correlation, regression analysis and analyses of variance (ANOVA).

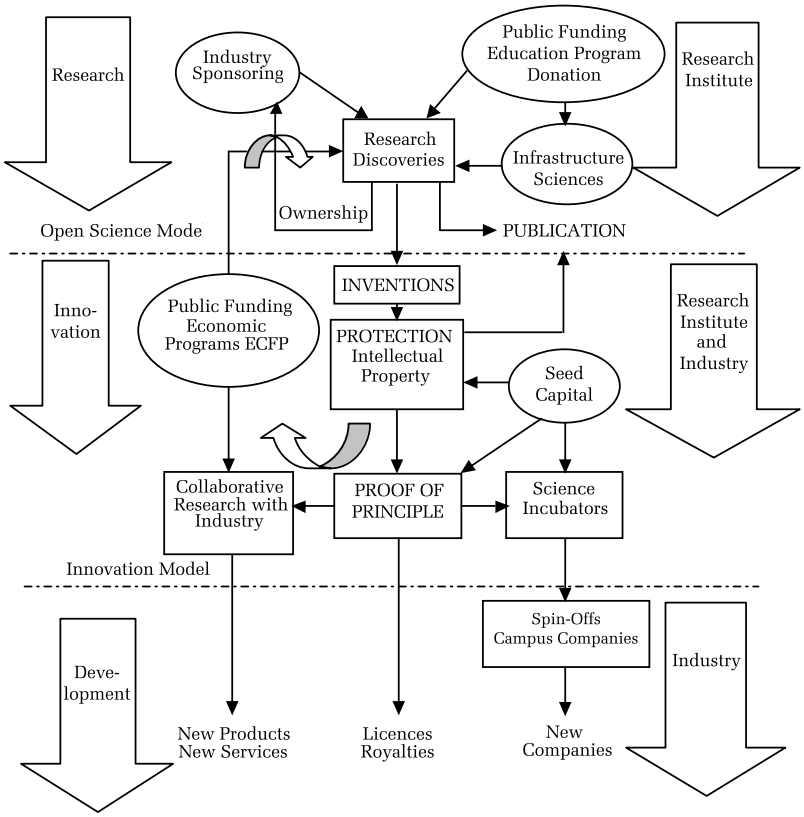

Figure 1: The Innovation Model of Knowledge Transfer (Adopted)

Source: EC Expert Group Report (2004)

RESULTS

The seven phases of innovation process include idea generation, idea screening, R&D, pilot plant development, business analysis and development, test marketing and commercialization (Stanton *et al.*, 1994). For the generation of commercializable research result, the involvement of various stakeholders within and outside the research institutes in the innovation process is very important. These stakeholders include the R&D scientists, technologists/engineers, and technology marketers within each research institute and entrepreneurs outside the organization.

Involvement of R&D scientists in the innovation process

The R&D scientists were fully involved in all the phases of innovation at Federal Institute of Industrial Research, Oshodi (FIIRO) and Nigeria Institute of Oceanography and Marine Research (NIOMR) (Table 1). The involvement in each of the innovation phases was rated high (3.0-5.0) except at FIIRO where their involvement in test-marketing of the R&D products was rated low (2.0). At National Institute for Horticultural Research (NIHORT) and Cocoa Research Institute of Nigeria (CRIN), the involvement of R&D scientists in pilot plant development and business analysis and development was rated low (2.0). Their involvements in the remaining phases were rated high (3.0-5.0). The scientists were not involved in business analysis of the R&D results in Institute of Agricultural Research and Training (IAR&T). Their involvement in test-marketing and commercialization is low. However, their involvements in the idea generation and screening as well as R&D phases were rated high. At Nigerian Natural Medicine Development Agency (NNMDA), pilot plant development, business analysis and test-marketing were not done. Forestry Research Institute of Nigeria (FRIN) was highly involved in idea generation, idea screening, R&D and pilot plant production or development. However, they were not involved in business development, test-marketing and commercialization.

Involvement of engineers in the innovation process

The involvement of engineers in all the innovation phases was very high at NIOMR except at the commercialization stage (Table 2). Similarly, at FIIRO, their involvement was rated high from idea generation up to business analysis of the R&D results. Their involvement in test-marketing and commercialization was rated low. The involvement of engineers in generating R&D ideas at NIHORT was rated low. However, their involvement in idea screening, R&D, pilot plant development, business analysis and test-marketing was rated high. At NNMDA, CRIN, IAR&T and FRIN, the involvement of engineers in the innovation was either not existing or low. However, at FRIN the involvement of engineers in the pilot plant development was rated high.

Involvement of technology marketers in the innovation process

After the development of the technology, the technology marketers are supposed to be responsible for transferring the technologies to entrepreneurs. Technology marketers interact with the end users of industrial technologies, so as to know their R&D needs. From the interview conducted, technology marketers or agricultural extension officers usually relate with entrepreneurs or farmers through visits, seminars and workshops. Technology marketers also conduct need assessment studies in order to unfold the areas where technologies are required to solve problems.

At IAR&T, the involvement of technology marketers whom they describe as extension officers was very high (4.0-5.0) in all the phases of the innovation process (Table 3). Their involvement at FIIRO and NIOMR in all the phases of innovation was rated high (3.0-5.0). At NIHORT and CRIN, their involvement was high in test-marketing and commercialization of R&D results. At FRIN and NNMDA, technology marketers were not involved in any of the innovation phases.

Involvement of entrepreneurs in the innovation process at the research institutes

Table 4 shows the involvement of the entrepreneurs in the innovation process in the research institutes. At NNMDA, the entrepreneurs who were traditional medicine practitioners were highly involved in idea generation (4.0), idea screening (4.0) and pilot plant production (5.0) phases of the innovation process. This is probably because natural or traditional medicines involve traditional knowledge. However, the traditional medicine dealers were not involved in the business analysis, test-marketing and commercialization of the R&D results. This may be due to their low level of Western education. These set of entrepreneurs (traditional medicine dealers may not have the prerequisite for carrying out business analysis and test-marketing of products. At FIIRO, the involvement of the entrepreneurs was rated high except in the R&D and pilot plant production where their involvement was rated low (2.0). The involvement of the entrepreneurs in the innovation process was rated high in all the phases at NIOMR (3.0-5.0), while at NIHORT it was rated high in the idea generation (3.0), idea screening (3.0), busi-

ness analysis (3.0) and low in all other phases of the innovation process. At IAR&T, entrepreneurs were highly involved in pilot plant production (4.0), business analysis (5.0), test-marketing (4.0) and commercialization (5.0) of the R&D results. Their involvement in idea generation and other phases of the innovation process was rated very low. At FRIN, the entrepreneurs were highly involved in pilot plant development, business analysis and commercialization. At CRIN, the involvement of entrepreneurs was rated generally low (1.0-2.0).

Involvement of financial institutions in the phases of innovation process

Table 5 shows the ratings of the involvement of financial institutions in the phases of innovation process in the research institutes. These ratings ranged between 1.0 and 2.0 indicating that either the financial institutions were not involved in the innovation process or their involvement was very low (2.0). It was only at NIHORT that their involvement was rated high (3.0) in the R&D, pilot plant production, business analysis, test-marketing and commercialization of their R&D results.

DISCUSSION AND RECOMMENDATION

One of the ways scientist and engineers get involved in innovation process in firms is through research. Research can either be in form of basic research, applied research or developmental research. The most important effect of basic research on innovation is most likely through the training that the scientist receive, and they then move on to find solutions in the firms and increase their absorptive capacity (Pavitt 1991). Basic research is an excellent means of learning both specific knowledge and methodical ways of working, and it helps import and filter knowledge produced in other countries. Basic research is mainly done by scientist while applied research is largely done by engineers but developmental research is usually done by the combination of scientists, engineers and social scientists. The involvement of scientists in innovation process was rated highest in the idea generation (4.14) and idea screening (4.29) phases; high in R&D (3.86) and fairly high

in pilot plant development (2.71) and commercialization (2.43) phase. Their involvement was rated low in business analysis and development (2.14), and test-marketing (2.29) phase. The involvement of engineers was rated highest in idea generation (3.28), fairly high in R&D (2.71), pilot plant development (2.57), and idea screening (2.40) phases. However, their involvement was rated low in business analysis and development (2.0), test-marketing (2.0), and commercialization (1.28) phases. The involvement of technology marketers in innovation process was generally rated fairly high in R&D (2.7) and business analysis and development (2.6), and low in all the other phases of innovation. However, their involvement at IAR&T, FIIRO, and NIOMR in all the phases was rated very high (3.0-5.0).

Some innovation activities are mainly market-oriented, involving entrepreneurs and innovators trying out new goods and services in the market and experimenting with new processes and business models to find the most efficient or profitable outcomes. The early work of Schumpeter (1911) established conceptually the ''entrepreneur as innovator'' as a key figure in driving economic development. The innovative activity of entrepreneurs feeds a creative ''destruction process'' (Schumpeter, 1942) by causing constant disturbances to an economic system in equilibrium, creating opportunities for economic rent. In adjusting to equilibrium, other innovations are spun-off and more entrepreneurs enter the economic system. In this way, Schumpeter's theory predicts that an increase in the number of entrepreneurs leads to an increase in innovation thereby leading to economic growth and finally development (Wong *et al.,* 2005). The involvement of entrepreneurs was generally rated from fairly high to low (2.7-2.3) in all the phases of innovation. The involvement of financial institutions in all the phases of innovation was generally rated low (1.28-1.71). The involvement of stakeholders like entrepreneurs and financial institutions in technology packaging for commercialization is very low. This could be responsible for low commercialization of research outputs from these institutes. It could even be responsible for the failure of those that were commercialized. This result is in line with findings of Ilori (2006) which stated that financial institutions especially banks do not finance R&D and innovation stages, but wait till the phase of production before they provide supports in form of debt financing and that commercialization of R&D requires a special type of funds called

venture capital. Debt financing is defined to include both traditional bank lending (be it short term to cover working capital needs or medium-long term for investment financing). Venture capital investments are usually in the form of equity financing and quasi-equity financing. Equity financing includes private equity and public equity. Private equity financing is produced by two main types of agents namely: venture capitalist and "Angel Investors" or "Business Angels" who are wealthy individuals, often entrepreneurs, with an inclination for investment in ventures promoted by others (Infodev, 2006). Public equity is raised through the offering of shares to the public, which in turn, typically involves the listing of the company in a stock exchange, through an initial public offering (IPO); quasi-equity financing is a heterogeneous category of financing instrument such as convertible loans. Seed financing relates to the research, assessment and initial development of a product (www.infodev.org/innovation,2006). A study of small businesses that were established based on technologies acquired from FIIRO was carried out. The types of financial supports employed by the respondents (entrepreneurs) are presented in Table 5 showed that personal savings was used by 85.7% of the respondents; government assistance was used by remaining 14.3% while other forms of financing namely commercial bank loans, venture capital funds, cooperative loan, industrial bank financing, agricultural loan and microfinance bank loan were not employed by the entrepreneurs to commercialize their products (Table 5). From the study, it was revealed that Nigeria lacks the financing mechanism that had successfully incubated venture businesses in Silicon Valley, USA and other entrepreneurial habitats in the world and raised them in stages to maturity. Also, early stage venture financing is particularly difficult to come by, and there are no angel investors in Nigeria. Entrepreneurs in Nigeria have limited access to debt financing from banks, which insist on collaterals. This is in variance to what obtains in other parts of the world. For instance, by 1998, 82 percent of total investments in Japan were from venture capital equity financing and since 1995, equity investments outstanding hovered around 820 billion yen (about US $7 billion) (Nakagawa, 1999). Also, U.S. venture capitalist equity investment outstanding reached US $43.5 billion in 1996 (Nakagawa, 1999).

Five of the research institutes namely NIHORT, FIIRO, NIOMR, IAR&T and FRIN indicated the existence of technology transfer policy for their orga-

nizations. In conclusion, the significant factors that contributed to the R&D outputs were level of involvement of entrepreneurs; ideas of R&D from scientists; functional equipment; ratio of scientists to non-scientists; and presence of product champion.

Recommendations

From the study, the following are recommended to improve the involvement of stakeholders in the R&D process in Nigeria

1. The research institutes (RIs) should provide support services to the new companies formed out from their R&D results. The services may include management, coaching and entrepreneurial training support among others. The RIs should also link them with TICs for the purpose of further nurturing of the R&D results to innovation proper.
2. There is also the need for close interaction among all the key actors within the innovation system in order to create and maintain the necessary enabling environment for new entrants.
3. A robust between the research institutes and the industry will produce a knowledge economy. Government should be interested in fostering more collaboration between the research institutes and the industry so have to achieve the status of knowledge economy for Nigeria.
4. Researchers should seek out problems confronting particular industries through needs assessment studies and make their research relevant to these problems to avoid wasting time and resources. There is also the need to make R&D results Demand-driven by obtaining R&D ideas from entrepreneurs through interactions as market force is the prime determinant of technical progress.

Table 1: Ratings of involvement of scientists in innovation process in the research institutes

Phases of involvement	NIHORT	FIIRO	NIOMR	NNMDA	CRIN	IAR&T	FRIN	Average Rating
Idea generation	3	5	5	4	4	4	4	4.14
Idea screening	3	5	5	4	5	4	4	4.29
R&D	3	5	5	3	4	3	4	3.86
Pilot plant development	2	4	4	1	2	3	3	2.71
Business analysis and development	2	4	4	1	2	1	1	2.14
Test marketing	3	2	4	1	3	2	1	2.29
Commercialization	3	4	3	1	3	2	1	2.43
Average ratings	3	4	4	4	3	3	4	

Source: Field Survey (2010).

Table 2: Ratings of involvement of engineers in innovation process in the research institutes

Phases of Involvement	NIHORT	FIIRO	NIOMR	NNMDA	CRIN	IAR&T	FRIN	Average rating
Idea generation	2	3	5	1	2	1	2	3.28
Idea screening	3	4	5	1	1	1	2	2.40
R&D	3	5	5	1	1	3	1	2.71
Pilot plant development	3	5	4	1	1	1	3	2.57
Business analysis and development	3	3	4	1	1	1	1	2.0
Test marketing	3	2	4	1	2	1	1	2.0
Commercialization	1	2	2	1	1	1	1	1.28
Average Rating	3	3	4	1	1	1	2	

Source: Field Survey (2010). Key: Very high - 5
High - 4
Fairly high - 3
Low - 2
Lowest - 1

Table 3: Ratings of involvement of technology marketers in innovation process in the research institutes

Phases of Involvement	NIHORT	FIIRO	NIOMR	NNMDA	CRIN	IAR&T	FRIN	Average rating
Idea Generation	2	3	3	1	1	5	1	2.3
Idea Screening	2	2	3	1	1	5	1	2.0
R&D	2	3	3	1	1	5	4	2.7
Pilot Plant Development	2	4	3	1	1	4	1	2.3
Business Analysis and Development	2	5	3	1	1	4	2	2.6
Test-Marketing	3	3	3	1	1	3	3	2.4
Commercialization	3	5	4	1	1	5	1	2.4
Average Rating	3	3	4	1	1	4	1	

Source: Field Survey (2010)

Table 4: Ratings of involvement of entrepreneurs in innovation process in the research institutes

Phases of Involvement	NIHORT	FIIRO	NIOMR	NNMDA	CRIN	IAR&T	FRIN	Average rating
Idea generation	3	3	3	4	2	2	1	2.6
Idea screening	3	3	3	4	1	2	1	2.4
R&D	2	2	3	4	2	2	1	2.3
Pilot plant development	2	2	4	5	1	4	4	
Business analysis and development	3	4	4	1	1	5	3	2.7
Test-marketing	2	3	3	1	2	4	4	2.4
Commercialization	2	5	4	1	1	5	3	2.7
Average rating	2	3	3	1	1	3	2	

Source: Field Survey (2010).

Very high - 5
High - 4
Fairly High - 3
Low - 2
Lowest - 1

Table 5: Ratings of the involvement of financial institutions in the innovation process in the research institutes

Phases of involvement	NIHORT	FIIRO	NIOMR	NNMDA	CRIN	IAR&T	FRIN	Average rating
Idea generation	2	1	1	1	2	1	1	1.28
Idea screening	2	1	1	1	2	1	1	1.28
R&D	3	1	1	1	2	1	2	1.57
Pilot plant development	3	1	1	1	3	1	2	1.71
Business analysis and development	3	2	1	1	2	1	1	1.57
Test-marketing	3	1	1	1	2	1	2	1.57
Commercialization	3	1	1	1	3	1	1	1.42
Average rating	2	1	1	1	2	1	1.4	

Source: Field Survey (2010). Key: Very high - 5
High - 4
Fairly high - 3
Low - 2
Lowest - 1

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