

Diffusion of innovation and technology from research centers into the industries in Nigeria

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ABSTRACT

It is not an overstatement to say that technology dictates the rule in the world. Almost every diversity of human life depends on technology. In fact, the quality of global life and the standard of local living have come to be defined by the diffusion of technology.

Technology is almost the primary determinant of the quality of life of many people. The more adapted and relevant a technology is to the need of its targeted people, the better it enhances their quality of life.

Over the years, the Nigeria government has made deliberate effort toward achieving technological advancement by establishing research and development centres across the country but there has been no remarkable improvement.

This research work aims to address the challenges that affect the diffusion of technologies from research centers into the industries in Nigeria, using the Federal Institute for Industrial research, Oshodi (FIIRO) and the Project Development Agency (PRODA), Enugu, as case studies. FIIRO and PRODA are among the foremost research centers in Nigeria.

The research institutes were visited to establish the research so far carried out and an analysis was carried out to determine the level of diffusion of these inventions.

This research takes a brief look into the level of technological advancement of some other countries other than Nigeria.

It is concluded that the diffusion of technology from Nigeria's research centers to industry is indeed poor. A framework is presented in chapter 6 to improve the situation.

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Finally, to all, I say thank you!

Dedication

This dissertation is dedicated to:

The faithful

The Gracious

The Almighty God

Abbreviations

EU	European Union
FIRRO	Federal Institute of Industrial Research, Oshodi
FRN	Federal Republic of Nigeria
GDP	Gross Domestic Product
MIT	Ministry of International Trade and I Industry
NASENI	National Agency for Science, Engineering and Infrastructure
NOTAP	National Office for Technological Acquisition and Promotion
OECD	Organization for Economic Co-operation and Development
PRODA	Project Research Development Agency
R&D	Research and Development
RMRDC	Raw Materials and Research Development Center
SMEs	Small and Medium-Scale Enterprises
SMEA	Small and Medium Enterprise Agency
TEC	Training and Enterprise Council
UNIDO	United Nations Industrial Development Organization
UK	United Kingdom
WAITRO	World Association of Industrial and Technological research

Key words

- ✓ Diffusion
- ✓ Gross Domestic Product
- ✓ Invention
- ✓ Innovation
- ✓ National Innovation System
- ✓ Research and Development
- ✓ Vision 2020
- ✓ Policies Reforms
- ✓ Technology

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CHAPTER ONE

Introduction

1.1 Overview of Nigeria

Nigeria is one of the largest countries in Africa with a land area of about 923,768 km². According to the 2006 census, Nigeria has a population of over 140 million (Census, 2006) and this made her the largest black nation in the world.

Nigeria operates a democratic system with three tiers of government which is made up of the federal, state and local government. The Federal Republic of Nigeria comprises of 36 states and 765 Local government areas with three seats of government located in the central city Abuja.

Nigeria has one of the most productive lands in the African continent. It is rich in different mineral resources. The land is good for farming and also rich in minerals like coal and oil.

Nigeria has companies and industries which comprise of oil and gas companies, mining companies, power generation companies, finance companies, building and construction industry, equipment industry, engineering industry, food and beverage industry, leather industry and so on.



Figure 1: Federal Republic of Nigeria (www.mapsofworld.com 2007)

Before independence in 1960, agriculture played a dominant role in the overall economy of Nigeria- contributing significantly to both the Gross Domestic Product and Total Value of Export. The bulk of revenue accruing to the government at the time was derived from the agricultural sector, which contributed 45% of total export. During the decade 1960 – 1970, the growth rate of agriculture was comparable to that of population of about 3%. By 1965, agriculture accounted for 50% of the GDP and 45% of export. During the decade of the 70s agriculture’s contribution to the GDP has gone down to about 30% while contribution to export was under 10%. Petroleum exports assumed a dominant role as an export commodity. It comprised 58%

of all export in 1970, 96%, 97% and 95% in 1980, 1990, and 1999 respectively (Vanguard, 2008)

However, the oil glut and the consequent drop in the price of petro-products in the early 1980s (1982 to 1986) reduced foreign exchange earnings and necessitated efforts towards the revival and revitalization of the other sectors of the economy.

1.2 Background to the study

In 1996 the government of Nigeria set up a committee of a wide spectrum of men and women into the vision 2010 committee. Their singular mandate is to bring out an achievable plan to make Nigeria achieve technological advancement by the year 2010.

National Office for Technological Acquisition and Promotion (NOTAP), Raw Materials and Research Development Center (RMRDC), National Agency for Science, Engineering and Infrastructure (NASENI), Project Research Development Agency (PRODA), Federal Institute of Industrial Research, Oshodi, (FIIRO) and many other agencies were established by the Nigeria Government for technological growth and transfer.

The Vision 2010 committee was set up by the Military regime of General Sani Abacha and suffered set back after his death and the enthronement of democracy in Nigeria. From 1998 to 2007 (time of President Olusegun Obasanjo), the vision was not being pursued. The administration in Nigeria led by President Umaru Musa Yar-Adua from 2007, realizing the need for technological advancement in Nigeria, decided to set a new target called the VISION 2020 on assumption of office in 2007.

This decision of Vision 2020 by the Nigeria Government has come at the niche of time given the poor state of industries in Nigeria, which has made the country to practically depend on imported products. At the moment, manufacturing contributes less than 5 percent of GDP (*Business Day, 2008*).

Hence, it is argued that for Nigeria to make any significant impact in the areas of employment generation, wealth creation and poverty alleviation, something drastic must be done to boost activities in the manufacturing sector.

Above all, given the challenging targets that Nigeria has set for itself:

- To meet the Millennium Development Goals by 2015 (agreed by world leaders in September 2000 at the United Nations Millennium Summit);
- Realize President Umaru Yar-Adua's Vision 2020, which will make it one of the top 20 economies by 2020.

Nigeria does not have a more viable alternative than to massively create jobs and wealth in the country. One way to do this on a sustainable basis is to encourage value addition in Nigeria's production processes through innovation and technology.

1.3 The State of Science, Technology and Innovation Policies in Nigeria

The ministry of Science and Technology was scrapped and recreated several times during the period of military rule in Nigeria. However, from the late 1990s till date the Federal Ministry of Science and Technology has witnessed more stability. Since then many technology and innovation policies have been put in place.

According to Okonkwo, (2008), the recent emergence of more science and technology draft policies is based on the premise that there is the dire need for appropriate technologies that will propel Nigeria through the 21st century. The policies are designed to underpin the nation's socio-economic progress taking into account domestic productions in agriculture and rural development, industrial and health sectors.

The policies prescribe the use of science in integrating indigenous knowledge into development initiatives and popularizing of science and technology for growth and development.

At the time of writing this dissertation, there were twelve policy documents on Science and Technology in Federal Ministry of Science and Technology. These policies have received the approval of the Federal Executive Council.

The policies are:

1. Policy on Linkage of the Federal Ministry of Science and Technology Universities, National and International research Institutes.

2. Policy on Human Capacity Building of Nigerians in, and Transfer of Technology by Multinational Companies
3. Policy on Cooperation of Federal Government Ministries and Federal Ministry of Science and Technology based Capital Projects at Federal, State and Local Government levels.
4. Policy on Appropriate Technologies for Empowering Small and Medium-Scale Enterprises (SMEs).
5. Policy on Engineering Materials Development
6. Policy on Science and Technology Data Bank
7. Policy on Intellectual Property Rights
8. Policy on Energy Research and Development
9. Policy on Biotechnology
10. Policy on Space Research
11. Policy on Information technology
12. Presidential Council on Science and Technology (PCST)

Despite the existing Science and Technology policies, in Nigeria, there is still the lack of strong diffusion and innovation component in the country.

1.4 Problem statement

Notwithstanding the fact that Nigeria has put in place at least twelve technology policies, there is limited evidence that these policies yield any benefits. This apparent lack of positive impact is believed to be a consequence of lack of diffusion of developed technology into the industry and society. **Research is therefore required to determine the factors inhibiting the diffusion of technology and subsequently design a framework for the diffusion.** It is hoped that this diffusion framework, if implemented, will bring social, economic and industrial growth to the nation.

1.5 Research objectives

The purpose of this study is to:

- i) Assess the level of innovation and technology development in two research centres and the extent of diffusion of resulting technologies into the industries.
- ii) Investigate the factors that inhibit the diffusion of technology from these research centres.
- iii) Create a framework for the diffusion of innovation and technology in Nigeria.

1.6 Outlines of Chapters

The following chapters present the concept, research findings, analyses, results, as well as the recommendations and conclusions of this research work.

Chapter two reviews the relevant literatures and existing information on the topic. It also reviews the diffusion of technology policies in Germany, United Kingdom, Japan, United States and Nigeria

Chapter three presents the methodology used to execute the experimental investigation. Data was collected during a visit to the Federal Institute for Industrial Research and the Project Development Agency. In addition, interviews were conducted for staff of FIIRO and PRODA.

In chapter four, detailed information of FIIRO and PRODA, their activities, inventions, diffusion gathered during visits were presented. It also presents the research centers collaboration with other international agencies.

Chapter five analyzes the data collected from the research centers and during the interview carried out. It identifies the weaknesses in technology transfer in Nigeria.

Chapter six presents a framework for the diffusion of technology in Nigeria. It proceeds to validate this framework against Organization for Economic Co-operation and Development Report (OECD)

Finally, chapter seven concludes the research with recommendations and conclusions.

CHAPTER TWO

LITERATURE REVIEW

Technology and innovation have been with man since the Stone Age when man first increased productivity by some innovation of using stone as a tool. Over the millenniums, information has been generated about the topic, especially with respect to modern day industry where knowledge ranging from economics to psychology has been applied to it.

In this chapter, already existing information on the topic and those related to it are concisely reviewed. Consequently, this chapter tends to give comparisons of diffusion of technology policies in Germany, United Kingdom, Japan and United States.

2.1 Definitions of terms

For the purposes of this study, the following definitions and assumptions are used:

a) Technology:

Technology is the application of knowledge of Science (pure and social), and Engineering to produce or enhance the production of tools and techniques for achieving desired objectives (Obiazi, 1994). The desired objectives may be a product or improved productivity, but all may result in higher profit either for user or producer.

b) Innovation and Invention.

Experts have described innovations in so many ways and these different definitions bring out an additional facet to it that increases the understanding of innovation.

An innovation is an idea, practice, or object that is perceived to be new to a person or adopting entity. When an innovation emerges, diffusion unfolds which entails communicating or spreading of the news of the innovation to the group for which it is intended (Rogers, 1995).

The United States of America Department of Commerce defines inventions and Innovation as:

Invention – TO CONCEIVE the idea

Innovation – TO USE the idea. The process by which invention is transferred into the economy.

Twiss, (1992) conclusively said, "For an invention to be an innovation it must succeed in the market place."

Irrespective of how outstanding an invention may be, until it is translated into a way that it has to contribute to economic value, it is not termed an innovation. Thus invention diffused into the economy yields innovation. An invention attains an innovation status if it begins or goes into a form that it yields economic results.

c) Innovation and Research and Development

Another needful distinction is between technological innovation and research and development. Twiss (1992) hypercritically described research as ... aimed at acquiring new knowledge for its own sake. Price (1984) emphasized research as a provider of the knowledge that business exploits, especially in high technology industries.

While Twiss and Price did not so much differentiate between Research and Development, Ezekwe (1981) distinguished Development from Research as that additional research which may be unavoidable in adapting laboratory procedures to large-scale operation. The researcher notes here that these adaptations in the form to make product to suit customers' needs, have been classified as level of relevance factor to innovation in the hypothesis.

Hence according to Twiss, research and development is a description of activities of one department while technological innovation implies a company wide approach to the profitable application of technology. It goes through from just application or adaptation to the commercial exploitation.

Research and Development are funded so that they yield innovation not to end at invention. The innovation will then bring increased profit and sustenance to the company or investor in the most economical way.

Taking a more business perspective, Drucker (1985) described innovation as the means to explore change as opportunity for a different business or service.

Research and Development brings out a resource while innovation changes it either by enhancement or any other form to be a wealth producer. Hence Twiss (1992) classified technology as “a corporate resource”, which means that with innovation, it can become a “profit-yielder” to the corporation. It may involve minor or major changes. But the result is economic growth.

2.2 Concept of Innovation System

According to Speilman (2005), Innovation system approach emerged in the mid 1980s as a Schumpeterian perspective that drew significantly from the literature on evolutionary economics and system theory. The concept of an innovation system was first mentioned in the industrial literature in the late 1980s. In recent times the concept is gradually spilling into policy making circles in developing countries (Roseboom, 2004).

An innovation system is an interactive learning process in which enterprises/agents in interactions with each other, supported by organizations and institutions play key roles in bringing new products, new processes and new forms of organizations into social and economic use (Francis, 2006).

The above definition by Francis, points to the three essential elements of innovation system namely:

1. Input - Organization and individuals involved in generating, diffusing, adapting and using knowledge.
2. Output - The interactive learning that occurs when organizations engage in generating, diffusing, adapting and using new knowledge and their translation into innovation (new products, processes or services) and economic success.
3. Framework - The institutions (rules, norms, conventions, regulations, traditions) that govern how these interactions and processes occur.

According to Agwu (2008), the concept of innovation system is established on several assumptions and integrates current trends in development in the analytical framework. They include the following:

- a. Innovation takes place everywhere in the society and therefore bringing the diffuse element of a knowledge system and connecting them around common goals should promote economic development.
- b. Innovation is an interactive process and is embedded in the prevailing economic structure and this determines what is to be learnt and where innovation is going to take place.
- c. Innovation includes development, adaptation, imitation and the subsequent adoption of technology or application of new knowledge.
- d. Innovation takes place where there is continuous learning and opportunity to learn is a function of the intensity of interactions among agents.
- e. Heterogeneous agents are involved in innovation process, and formal research is a part of the whole innovation processes.
- f. Linkages and/or interaction among components of the system (knowledge generating, transfer and using agents) are as important as direct investment in research and development.

g. Institutional context rather than technological change drives socio-economic development.

h. In addition to technical change and novelty, innovation includes institutional, organizational and managerial knowledge.”

The analysis of innovation may focus on the study of the system at different levels (local, regional, national) or sectors. The analytical dimension at national level is called national innovation system and this is that set of institution which jointly and individually contributes to the development and diffusion of technologies.

2.2.1 Characteristics of a national innovation system

According to Agwu (2008), general characteristics of most national innovation systems are:

“(1) They try to break out of the traditional linear and supply-driven thinking of research, technology transfer and application and place emphasis on interdependence and non- linearity in innovation processes and on demand as a determinant of innovation.

(2) They are strongly influenced by evolutionary thinking. Innovation processes and systems are context specific and strongly influenced by each country’s economic and sociological experiences.

(3) They place great emphasis on the role of institutions, in terms of norms, rules, laws and organizations.

(4) National innovation system emphasis on the patterns and intensity of interaction between the different actors within the national innovation system.

(5) It is seen as an analytical tool that can be used for planning and policymaking. It is not a blue print of how innovations should be organized (Roseboom 2004)".

2.3 Factors favouring innovation

According to Twiss(1992), the most critical factors favouring innovation are

1. A market orientation. This is how much the innovation was made with respect to customers' requirements.
2. A production orientation. This is the profitability of the innovation to customers or users.
3. Relevance to organisation's corporate objectives
4. An effective project selection and evaluation system
5. An organisation receptiveness to innovation
6. Commitment by one or a few individuals.
7. Effective project management and control.
8. A source of creative ideas.

Market orientation and production orientation are indicators of the level of relevance of the innovation. These factors are critical when the aim of the innovation is to make profit.

2.4 Diffusion of technological innovation

Once a technological innovation has been made, the next step will be its diffusion in the market.

Diffusion of technology in relation to innovation in an industry talks about the performance of a technological innovation either a product, process or in any form, in the market – its popularity among target customers.

“Diffusion of innovations theory postulate that diffusion of innovation occur as potential users become aware of the innovation, judge its relative value and make a decision based on their judgment, implement or reject the innovation, and seek confirmation of the adoption or rejection decision” (Roger, 1995). This theory provides explanation for when and how a new idea is adopted or rejected over time in a given society.

According to Rogers (1995), diffusion of an innovation gradually occurs over a time frame, which is categorized into two periods. The first period covers the availability of the technology and its acquisition by the potential users (diffusion delay) and the second period covers the period between acquisition and installation to the application and realization of potential benefits of technology (realization delay) (see figure 2 below).

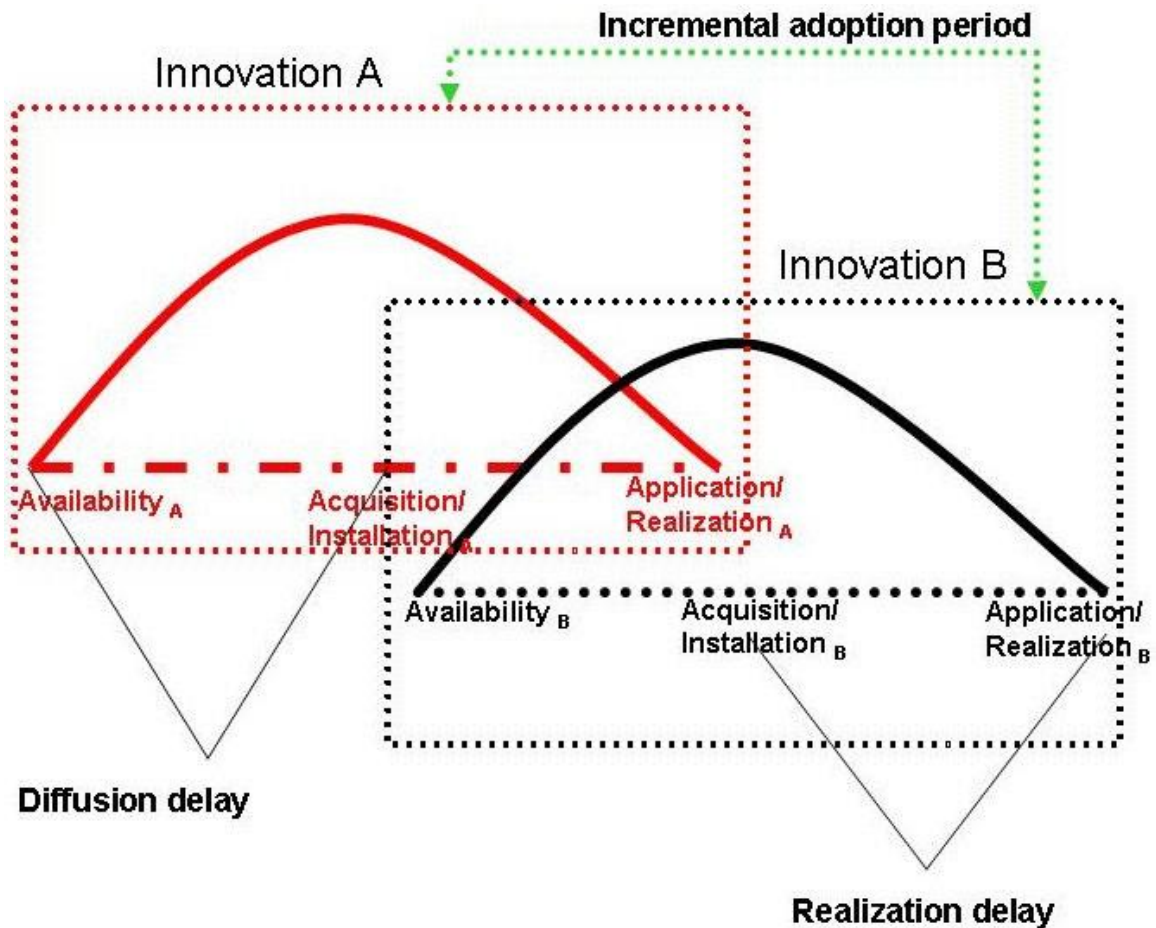


Figure 2. Diffusion/Realization Delays and the Incremental Adoption Period (Okunoye, 2007)

These processes take place through a channel over a period of time among people (users) within a social system. Diffusion of innovation recognizes that individual as well as social factors can influence the decision to adopt or reject a given innovation. Rogers concludes that diffusion of innovation could be affected by psychological and behavioral as well as external and environmental factors. He identifies factors like perceived characteristics of the innovation and the type of

individual decision involved in the adoption process, size of the organization and socio economic status of the users of the innovation.

Although authors on this issue are disagreeing on the indicator of technology diffusion, as either the amount of turnover or profit, patronage will always be reflected in the number of total sales and to most extent profit.

Understanding the concept of technology diffusion and using it for informed decision-making, needs an understanding of some other related-concepts.

2.5 Strategy for diffusion of technology

i) Marketing drive (advertisement)

This involves deliberate and decisive efforts to get technology to take over dominion of the market. It involves the activities of sales engineers to get technology or knowledge translated into products to the users or market. It will involve orientation of people to the technology – the how to use it and how beneficial. Most technology-intensive products which are mostly relatively new innovations have found sales engineers better than general marketing personnel in this area.

A sort of advertising may be necessary. Drucker (1985) commented that the Silicon Valley high technology enterprises in United States of America failed because they still operate in 1800 mould. They still held to Benjamin Franklin's dictum: "if you invent a better mousetrap the

world will beat a path to your door". This may be done through exhibitions trade fairs, publication etc.

Cost may also be reduced to the producer. Some economic expert postulates that for a new innovation, you may need to run at a loss initially till you acquire a market.

The sales engineer brings these responses to the innovators for market oriented innovation.

ii) Market oriented design

An innovation can be successful but still have little market orientation lapses. For example the innovation for an out board engine on a wooden canoe might be successful in a primitive market. But if the people have a cultural belief that canoes must have a horn shape rear end because of their religious beliefs, then a market oriented design will not take cognisance of requirement which makes the invention technically irrelevant.

This will enhance the difference that the diffusion of the technology will cause among the primitive people.

iii) Diffusion system

From literature there is tendency of authors towards postulating a strategy involving development and application of engineering technology.

These strategies postulated were done based on the research carried out by the author and is a function of the peculiarity of the environment.

2.6 Country Comparisons

This section of the research work considers how selected countries approach technology diffusion, focusing particularly initiatives to assist technology diffusion for SMEs. The countries examined are Germany, the United Kingdom, the United States, and Japan. This project would considered the significance of the technology diffusion policy and programs of these countries and not all facets of their technology diffusion.

a) Germany

Germany employs a dense array of technology diffusion instruments. Most policy measures have been established, and are supported to varying degrees, by the state.

Although the German Ministry of Research and Technology supports research and technology transfer, technology diffusion policy is largely implemented by the state. Some states in Germany like Baden-Württemberg have a Ministry of Economic Affairs and Technology that sees its prime task as playing an active role in articulating the needs for cooperation and technology and providing organizational and expert support for companies concerned about approaching the various institutions.

The building blocks of Germany's technology diffusion infrastructure are the Fraunhofer Gesellschaft (Society), or "FhG," the Chambers of Commerce, state, regional, or institutional technology transfer programs, and research centers. These are supported by applied educational institutions - vocational schools, polytechnics and technical institutes.

The FhG's forms of assistance include joint pre-competitive research, bilateral applied research agreements with single firms, subcontract manufacturing for local firms, testing and pre-production, and cooperative technology transfer arrangements with companies (Fraunhofer Society, 1995).

Research and technology transfer in Germany are funded by the government (which includes the federal government and state) and industries. In addition, federal and state governments have various matching grant programs to stimulate private sector investment in R&D and technology acquisition. These grants provide opportunity for small and medium enterprises (SMEs) to purchase services from regional programs at lower cost.

In recent years, there have been some lapses in R&D in Germany especially in the area of SMEs adopting new innovation and this has led the government in January 2004, to release its "Weimar Innovation Guidelines" which is meant to cater for areas relevant for improving innovation performance in the country. The Weimar Innovation Guidelines are vital but it fails to propose tangible measures to achieve innovation success (Deutsche Bank Research, 2004).

b) United Kingdom

"Harnessing innovation in Britain is the key to improving the country's future wealth creation prospects... (Britain) must invest more strongly than the past in its knowledge base, and translate this knowledge more effectively into business and public service innovation. Securing the growth and continued excellence of the UK's public science and research base will provide the platform for successful innovation by business and public services". HM Treasury et al (2004).

The United Kingdom (U.K.) has tried a number of successive schemes for supporting technological modernization in the country. The government has set up diffusion programs to encourage industry to partner with organizations in the scientific and technology community.

There have long been well-developed institutions, mechanisms, and traditions for the promotion of scientific research and advanced technology development. Ministries, national research bodies, national laboratories, universities, non-profit organizations and private companies are among the key elements in scientific and technology development. In recent decades, there has been an increased focus on technology diffusion.

The central government has a Small Firms Service combining counseling with information and also technology is being diffused through local Training and Enterprise Councils (TECs), Nickell, 2001.

The TECs was established in 1990 and served as a major vehicle for Small and Medium Enterprise (SME) competitiveness and technology diffusion programs. It helped employers diagnose training needs as well as invest to meet them.

The U.K. has a number of other local centers created to expose SMEs to new technologies and these centers are funded by the government. According to Hughes, 2006, the government has also created Business Links to provide a system of Innovation and Technology Counselors. Business Links are intended to achieve accelerated technology diffusion by empowering SMEs to learn from other firms. Also, trained brokers work through Business Links to encourage joint ventures and strategic alliances such as sharing the costs of new equipment. The Business Links Innovation and Technology Counselors are backed by an on-line data base of specialized technology expertise residing in universities, trade associations, businesses, and consultants.

It is hoped that improved technology diffusion measures will increase the commercialized outputs of the U.K. science base, as well as enhance industrial competitiveness.

The UK government has established a framework for investment in science and technology for the period of 2004-2014 which is to raise the total UK R&D from 1.9% GDP to 2.5% GDP by 2014. See table 1

Table 1.

R&D INVESTMENT AS PERCENTAGE OF GDP		
	2004	2014
Science base	0.4	0.5
Other Government R&D	0.3	0.3
Private sector	1.2	1.7
UK TOTAL	1.9	2.5

Science and innovation investment framework 2004/2014. HM Treasury, DTI, DES, July 2005

For UK to meet this target there must be matching investments from private sector that must raise its R&D from 1.2% to 1.7%. The private sector in UK has only a handful of large firms in a few sectors with intense R&D expenditure. (DTI2005). This has led to increasing focus on the potential role that newer technological based UK small and medium size enterprises can play to fill the void.

It is evident that the government is focusing on meeting the GDP target while not paying much attention to other aspect of the framework like how effective the R&D is converted into output. The conversion R&D input to output requires complementary investment in marketing and human capital investment.

c) Japan

The small firm sector occupies more than three-quarter of the country's over 14 million manufacturing workers. SMEs typically find it difficult to attract good scientists and engineers, who generally prefer

to work in the more stable and better resourced environment of large Japanese companies. Consequently, most Japanese SMEs absorb technology from larger customers and other external sources (many SMEs then make subsequent incremental improvements in acquired technologies). Long-term relationships between smaller and bigger firms have given the smaller units the confidence to invest in new equipment, workforce training, and ongoing product and process improvement.

Technological institutions have been established which provides technological assistance and conduct research aimed at assisting local SMEs. These public research and testing centers numbering over 180 at present, makes new manufacturing equipment and computer facilities available to SMEs for evaluation, training, and trial production. The technology centers supplement these facilities with seminars, cooperative research projects, industrial exhibitions, and individual technical assistance to area companies. The centers also organize technology exchange and fusion groups, consisting of collaborative of small and medium companies who meet to exchange technical information and cooperatively develop new products and technologies. National guidance and coordination of these centers are provided through the Ministry of International Trade and Industry (MITI), by its Small and Medium Enterprise Agency (SMEA) and the Agency of Industrial Science and Technology (which oversees Japan's national laboratories).

Local governments in Japan also sponsor trade centers and other local small enterprise assistance centers. These centers provide facilities for

equipment testing and prototyping and organize trade exhibitions where new products and process technologies can be viewed.

In addition, under national guidance, a wide range of public financial incentives, loans, and tax concessions are made available to SMEs to help them in the process of technological upgrading and absorption.

Three national public financial institutions target fund to SME; there are systems to support equipment leasing; and prefectural and local governments offer subsidized loans and matching project funds for SME technology projects (P. Shapira et al).

Research Core program has been established to build special facilities for promoting small firm technology transfer, business incubation, and training. Sponsored by MITI, although funded mainly by local government and the private sector, about a dozen Research Core locations have been chosen to date. A research core is a grouping of four facilities: an open research and technological development facility, an education/training facility, a technological information exchange facility, and a venture business incubator (D.W. Edgington, 1994).

d) United States

The United States has a very extensive science and technology base. It combines federal level research funding and performing institutions, federal laboratories, universities, non-profit research organizations, and private laboratories and companies. The system is decentralized, with multiple organizations at national, state, and sector levels involved in policy-making, research, and development. While there have been numerous ways in which technology is diffused through this

system and into industry, concerns during the last decade about the links between the U.S technology development base and industrial performance have resulted in new policy measures to promote technology diffusion. American policymakers have been particularly worried about the slowness of the country's over 400,000 SMEs in adopting and fully using new manufacturing technologies and techniques and the resulting adverse effects on industrial competitiveness, domestic supply chains, regional economies, and the stability of high-wage manufacturing jobs.

To assist U.S. SMEs, a series of technological infrastructural initiatives and programs have been put into place by federal and state governments, academic and industry organizations, and other groups. These efforts include legislation and policies to promote industrial technology transfer, the expansion of industry assistance centers and the stimulation of industrial networking.

Manufacturers, of course, obtain information and guidance about new technologies from a variety of sources, including private ones such as customers, vendors, trade associations, and other firms and business associates. In general, private sources are more significant to SMEs than public ones, although the role of the public sector is increasing with the expansion of federal and state manufacturing modernization and extension measures. In many instances, diffusion policies are implemented through non-governmental or private agencies (for example, through private consultants and "third-sector" technology centers).

U.S has research parks which act as path through which innovation flows from research centers into the market place. These parks provide training to new companies in other areas like intellectual property and business planning.

According to Proton (2007), one of the factors contributing to the success of U.S economy is the transformation of the U.S economy toward a more entrepreneurial form of capitalism and philanthropy has played a vital role in this.

Proton(2007) reported that there are more than 68,000 foundations in the U.S and some of the biggest ones include in their mission statement "the promotion of research and policies that initiate and grow innovative, sustainable enterprises".

Philanthropic foundations are also active in supporting initiatives in education sector so as to address the difficulties in finding and attracting talents for research purposes.

According to the AUTM Survey (2005), industries in the United States provides only 7% of the total funding of research in the country although this figure do not include philanthropic donations by industry. 2.5% of the federal research funding is reserved to finance research for small enterprises through the Small Business Innovation Research contracts.

Federal funds have been provided to groups of firms and local institutions to help them demonstrate improved ways of organizing work and improving productivity. State and local manufacturing

technology and extension centers, colleges, and other programs in many locations are also sponsoring various continuous improvement groups, learning networks and industry consortia to demonstrate and disseminate best manufacturing and workforce practices.

2.7 RESEARCH AND TECHNOLOGY DIFFUSION IN NIGERIA

According to the ministry of science and technology, there are 65 research establishments in Nigeria (FMST, 2004). Some of these research institute include the Project development agency, (PRODA) Enugu, Federal Institute for Industrial Research, (FIRRO) Oshodi, Nigeria institute for oil Palm Research, (NIFOR) Benin, Cocoa research Institute of Nigeria, Ibadan, etc.

The federal ministry of science and technology is mandated to coordinate, publicize and promote research and development activities in Nigeria research institutes and tertiary institutions.

In spite of the number of research institute in Nigeria, research and technology diffusion is regarded as low. Uwaifo V.O, 2009 stated that the research institute has made a good number of innovations but most of the technology failed to be commercialized in Nigeria.

As part of the reforms by the government to promote diffusion of innovations and technology, the Federal ministry of science and technology in 2004, published the profiles of 78 selected commercialisable research and development results that have been achieved by the research institute in Nigeria (FMST, 2004). From the 78 research results released, only 2 of these results were attributed to

have originated solely from PRODA, 6 were attributed to have originated solely from FIRRO while 30 were attributed to 2 or more research institutes.

Between 1993 and 2010, Nigeria have established 25 technology incubation centers, TIC, in different states in Nigeria. To coordinate and supervise this incubation centers, the federal government of Nigeria, in 2005, instituted the National Board for Technology Incubation (NBTI). NBTI have as its stakeholders, the federal government, the states and local governments, private sectors, entrepreneurs, research and tertiary institutions, any of which can establish a TIC (NBTI, 2010). The development of these TIC's have been hampered by inconsistent funding, structural problems in organisation relationships and poorly construed linkages with relevant institutions (UNIDO, 2006).

In the United Nations Industrial Development Organisation, UNIDO, report on 'Business incubators in economic development-Nigeria (2006)' identified the following as problems facing technological schemes in Nigeria as:

1. Financing and loan schemes are usually difficult to access and face problems with delivery, technical assistance components and realistic repayment schedules.
2. Training programmes are not fully linked with financing and other technical services.
3. SME development centers are not properly funded.
4. Lack of extension services.

According to UNIDO, 95% of funding of TIC's in Nigeria is from the federal and state government.

The Nigeria government offer tax incentives to investors. To qualify for this incentive, a company must invest a minimum of \$9,000, and \$170,000 to reach the maximum level of tax relief. Small enterprises are at a disadvantage to this policy as most of them could not afford to do business of this range.

Three major challenges have been identified by Adeoti, 2010, to be affecting research and technology diffusion in Nigeria. They include poor infrastructure, poor policy on research and development, and poor attitude. According to him, most research institute has obsolete or non-functional equipment and laboratories and that the decay is not only in the physical infrastructure but also human infrastructure as the best engineers and scientist are abroad.

Summary

This chapter explains the meaning of innovation and technology and also reviews relevant information on the research topic. It gives an overview of national innovation system, technology diffusion and also reviews how selected countries approach technology diffusion.

The next chapter explains the various ways through which data was collected for this study, the case studies used and the method used in the interview process.

CHAPTER THREE

EMPIRICAL INVESTIGATION

This chapter presents the methodology used in this study to execute the experimental investigation. It motivates how the data was collected in order to carryout the investigation. This research involves two types of data collections: case studies and interviews. First, empirical data were collected on the visits to the two case studies (Federal Institute for Industrial Research, FIIRO, and the Project Development Agency, PRODA). Secondly, qualitative information was collected by conducting interviews with some personnel of FIIRO and PRODA.

Once the data has been collected, data analysis was carried out to compare the results obtained from the research and to identify the problems associated with the diffusion of innovation and technology in Nigeria. The outcome of the data analysis was used to recommend a framework for the diffusion of technology in Nigeria.

3.1 Case Study

According to Soy (1997), "Case study research excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through research". Over the years, case study research has been used across various disciplines. Robert K. Yin defines the case study method as an empirical inquiry that investigates a contemporary phenomenon within its real life context; when boundaries between phenomenon and

context are not clearly evident; and in which multiple sources of evidence are used.

A case study may consist of a single case or multiple cases. Multiple case studies involve the collection and analysis of data from several case studies unlike single case study that deals with one case. A single case often contains data and interviews from multiple sources and this data may be incompatible or contradictory.

Yin said that the most important element in a case study is the researcher's ability to recognize and handle a variety of evidence derived from diverse data collection techniques and to use each type to the best of the current state of the art. He stresses the need for interviews, documentation, direct observation, and archival records which will be treated by applying the concept of triangulation to establish the facts of the case.

The context of this research is to use two case studies to investigate the lack of diffusion of innovation and technology in Nigeria. Federal Institute of Industrial Research, Oshodi (FIIRO), and the Project Development Institute, PRODA, were used as the case studies because of their positions as one of the fore-most research centers in Nigeria.

The location of the case studies, that is, Lagos (southern Nigeria) and Enugu (eastern Nigeria) for FIIRO and PRODA respectively are major commercial cities in Nigeria with access to major industries. This will also aid in getting data as it relates to research and technology diffusion in different part of Nigeria. The data from FIIRO and PRODA

were collected and multiple interviews conducted and treated to establish the fact of the case.

3.2 Interviews

According to Coolican (1994), there are various kinds of interview and these kinds vary in terms of the amount of structure they contain. The types of interviews include non-direct interviews, informal interviews, guided interviews, clinical interviews and fully structured interviews.

Non-direct interview gives the person being interviewed the opportunity to discuss almost anything he or she wants. It has the least structure and little relevance to research.

In informal interviews, the interviewer focuses on encouraging the interviewee to discuss issues in more detail.

For guided and clinical interviews, those to be interviewed are asked the same questions while the questions asked the interviewees are in the same order for guided interview, it is not so for clinical interviews. In clinical interviews, the choice of follow-up question depends on the answers that are given.

In this study, guided interviews were used as it is a structured but open ended interview. The interviewees were asked the same set of questions that allows for various kinds of answer. Employees of FIIRO and PRODA were interviewed.

3.3 Data Analysis

Data analysis involves using many interpretations in order to find linkages between the research object and the outcomes with reference to the original research question.

Gall (1996) identifies three methods of analyzing data which are interpretational, structural and reflective analysis. Reflective analysis was adopted in this research as it describes data based on the researcher's intuition and judgment. This approach would enable the readers to understand the researcher's view and determine how it compares to their own views.

Comparisons were made with the empirical data collected to determine the right balance of the reports. In a bid to find answers to the diffusion of innovations from research centers to industries in Nigeria, the weaknesses or problems associated with the diffusion of innovations were identified from the analysis.

3.4 Framework and strategies for diffusion

Based on the analysis of the findings and the practices identified through literature survey, a framework was designed which recommended solutions to the problems with the diffusion of innovation in Nigeria and also for the successful diffusion of innovation in Nigeria. The framework design was based on the peculiar situation in Nigeria.

Summary

This chapter briefly explains the various ways through which data was collected for this study. It motivates the choice of the case studies, the method used in the interview process and explanation on the choice of people used in the study. Finally, it explains the approach adopted for the analysis of the data collected.

The next chapter presents the data collected and interviews conducted at FIIRO and PRODA.

CHAPTER FOUR

DATA PRESENTATION

4.0 In this chapter the data collected for the case studies and from the interviews were presented. First, the data for Case A was presented followed by Case B. This was immediately be followed by the presentation of the interviews for employees of both FIRRO and PRODA.

4.1 Case A: FIIRO- LAGOS {Source of material; FIIRO, (2009) www.fiiro.com}

4.1.1 Overview of FIIRO



Figure 3: Federal Institute for Industrial Research, Oshodi (Adapted from www.fiiro.com)

The concept of FIIRO came about in 1953 when the World Bank economic mission sent to Nigeria to understudy the country, observed that the industrial research in Nigeria was diffused, uncoordinated and without definite direction and for this reason FIIRO was recommended. Consequently in 1956 FIIRO was instituted and given the mandate of assisting in accelerating the industrialization of Nigerian economy through finding industrial utilization for the country's raw materials and upgrading the indigenous production techniques.

FIIRO is located in Oshodi, Lagos and is overseen by The Federal Ministry of Science and Technology.

The institute activities include carrying out research on their own as well as when commissioned by other bodies and agencies. It is also recorded that FIIRO have carried out consultancy services for indigenous companies as well as international organizations like the United Nations Industrial Development Organization (UNIDO) and the European Union (EU).

4.1.2 Objectives of FIIRO

The objectives of FIIRO are listed below:

- To assist in accelerating the industrialization of the Nigerian economy through finding industrial utilization for the country's raw materials and upgrading indigenous production techniques.
- To conserve the foreign exchange earnings of Nigeria by reducing the dependence on foreign goods, through the

development of local substitutes from the available local materials.

- Improve the nutritional qualities of Nigeria foods.
- To improve the traditional techniques of production which are labor intensive, time consuming and unable to cope with the modern market demand.
- Engage in technology transfer activities to the public through training courses and dissemination of pre-feasibility reports, and also provide consultancy services to individuals and other institution in Nigeria.
- Publication and dissemination of useful technical information to industries and researchers.
- Design and fabrication of machinery and equipment and analysis of metallurgical materials.
- To provide chemical raw materials for industries and to screen local woods for suitability for pulp and paper production.
- FIIRO shall engage in research and development in areas of food science and engineering research.

4.1.3 Services and activities of FIIRO

Apart from its in-house research and development activities, data collected shows that FIIRO renders services to the public, small and medium enterprises and corporate organizations by assisting them to solve their problems concerning raw materials, process know-how, machinery and equipments etc. Services rendered are briefly explained below as gotten from the information received from the visit to FIIRO.

4.1.3.1 Sponsored Research

Government agencies and international organizations sometimes commission the institution to carry out research on their behalf. These researches are aimed at benefiting the public and are sponsored by these agencies or organizations. The results of such research are made available to the sponsors and interested persons. Examples of research conducted by FIIRO in the past include the low cost weaning food project sponsored by the World Bank.

4.1.3.2 Contract Research

Contract research are carried out for private companies who commission FIIRO to carry out research for them on contract basis and the results of such are confidential to the clients.

4.1.3.3 Analytic Research

FIIRO has a highly qualified, well trained and experienced team of analyst which comprises of microbiologists, biochemists, food technologists and toxicologist. It also has fully equipped laboratory services that offer analytic services for their clients.

Their laboratory has served various sector of the nation's economy. It offers the client both routine and investigational types of analyses. Typical among the products that they analyze are: food, feed, water, industrial effluent, fine chemicals and cosmetics. FIIRO in alliance with government agency also conduct routine quality control and safety evaluation checks.

4.1.3.4 Technology transfer services

FIIRO is obliged to ensure that the results of its research and development gets to the public to bring about better living and economic benefits. Process technologies and production know how of FIIRO are transferred to the public through training workshops, technical assistance services, acquisition of machinery and equipment and licensing.

4.1.3.5 Engineering services

FIIRO has an engineering department that renders various services to meet the research and development needs of industries and the general public. It offers technical services to industries and small and medium enterprises and also carries out designs and fabrication of machinery and equipments.

4.1.3.6 Industrial extension services

For the small and medium enterprises, SMEs, FIIRO offers industrial extension services with the aim of seeking to know and offer solutions to their technology problems. FIIRO pays visit to these SMEs and this services is now been extended to the industries.

4.1.4 Case Studies of FIIRO Inventions

It was gathered that FIIRO has at least 25 notable inventions from which 21 are product inventions while 4 are process inventions. The list of inventions can be seen in the table below.

Table 2. FIRRO inventions

PRODUCT INVENTIONS	PROCESS INVENTIONS
Cassava flour	Detoxified cassava
Cassava starch	Cassava peeling and grating
Gums, glues, adhesives from cassava starch	Garri(cassava flakes) -making machinery
Garri and garri flour	Gluco
Composite flour	
Fufu	
Maize flour	
Soy-ogi baby food	
Sorghum flour	
Sparkling wine	
Portable alcohol	
Table vinegar	
Bottle palm wine	
Pitto (local beer)	
Tomato puree, ketchup, powder	
Peanut butter	
Salad cream and mayonnaise	
Full-fat soy grits and oil	
Nico skin cream	

Cassava pellet	
Laundry soap and bath soap	
Smoked fish	

4.1.5 Measure of Diffusion.

In determining the diffusion of these inventions, the number of users of each invention was estimated. Diffusion can be in the form of an outright purchase of the R&D institute's invention as a final product, or the starting of production facilities on the basis of the institute's invention.

From the 25 inventions from FIIRO, only 7 have been diffused to the outside manufacturers and, therefore qualify as innovation. These include mechanized garri-making, portable alcohol, Nico cream, bottled palm wine, sparkling wine, smoked curing of fish, and soap making.

Table 3: FIIRO diffused inventions

INVENTION	NUMBER OF USERS
Mechanized garri-making	6
Portable alcohol production	4
Nico cream production	2
Bottled palm wine	40
Sparkling wine production	1
Smoked curing of fish using FIRRO kiln	1

Soap making	60
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Palm wine bottling and soap making are the two most widely diffused inventions from FIIRO with 40 and 60 commercial clients respectively. FIIRO record shows that their technology users have the entire bottled palm wine market in Nigeria.

Three products have been commercialized by FIIRO itself and effort is being made to commercialize the fourth which is composite flour. Soyogi, garri flour, and fufu are currently being produced by FIIRO, itself, in pilot plants in the country.

However, despite the extent of diffusion in FIIRO most of their inventions remain unused or have not attained satisfactory diffusion and some of these are of great importance to the nation. Composite flour is an example and is considered below.

4.1.6 Composite Flour

Composite flour is the name given to wheat flour that is diluted with other types of flour, such as cassava, sorghum or maize flour that is readily available in the country.

Bread, a staple food in Nigeria and confectionery are produced from wheat flour as a major component as wheat contains gluten, a good source of protein. Wheat is not produced in Nigeria, therefore the country depends on importation to meet the demand. The challenge in replacing wheat is to find a suitable substitute for the gluten.

Research evidence at FIIRO has shown that cassava flour can be incorporated into wheat flour for bread making at different level of substitution; 10-15% being most acceptable for bread making, while 15-20% is acceptable for confectioneries and other baked products.

Benefits of composite flour are;

1. The use of cassava flour in composite flour will help to reduce post-harvest loses normally experienced by cassava farmers.
2. Increase in cassava output due to ready market, thereby enhancing farmer's income.
3. Creation of jobs
4. Save foreign exchange

Policy

The federal government of Nigeria brought out a policy to compel flour mills to include cassava flour in all flour produced in Nigeria in the ratio of 90% wheat flour and 10% cassava flour as against the existing 100% whole wheat bread conventionally consumed. The policy was institutionalized in 2004 while its implementation was to commence in January, 2005. A. D Dada

The director general of FIIRO, Oluwole Olatunji was quoted as saying in "Businessday, Feb 16th 2009, "through this policy, Nigeria has found an effective utilization for its cassava as Nigeria is currently the highest producer of cassava in the world with an estimated current annual production of about 49 million tons".

Challenges

Despite the policy put in place by the federal government of Nigeria, the diffusion of composite flour has met various constraints. As at the time of writing this dissertation, no flour millers have incorporated this invention into their products.

1. Bakers have resisted the composite flour because it involves a major change in their baking practices. Most Nigeria bakers do not use the mechanized dough process. Composite flour, being weaker than wheat flour is more susceptible to gluten damage with the process that most Nigerian bakers use.

2. The flour millers in Nigeria still produces pure wheat flours, and as long as this is available, this invention is unlikely to be diffused, as there is no price advantage accompanying the use of composite flour.

4.1.7 External Relations

FIIRO have carried out research consultancy services for international bodies over the years. Below is a table showing the research carried out or services rendered to notable bodies and their outcomes.

Table 4 FIIRO external relations

COLLABORATION WITH INTERNATIONAL AGENCIES			
Project Title	Sponsor Organization	Duration	Achievements
1. Textile testing and quality control	UNIDO	1976-1981	Equipment installed has been successfully used for evaluating fibres, yarns, fabrics, carpets and allied products from

			various organizations.
1. Mechanized garri processing plant	UNIDO	1989-1994	Garri processing plants were produced and installed in the Republic of Cameroun, Togo, Ghana, Sierra Leone and Zaire.
2. Wheatless bread development and extension	FAO/EU/FIIRO	1991-1994	Flour formulation of 70-75% of sorghum with 25-30% of cassava was developed.
3. Local raw materials processing and test centre	EEC	1991-1996	Kaolin processing plant was successfully set up for small scale entrepreneurs
4. Foundry project	EU	1993-1999	1. Provision of vital machine components 2. Development of foundry crucible for melting ferrous and non-ferrous materials
5. Bread making using composite flours	FAO/FIIRO	1994-1997	Flour formulation of 45/30/20/5 of cassava/wheat/sorghum/Soya was developed
6. Low-cost weaning food	NARP/World Bank	1994-1999	A simple food processing technology was developed for the production of a low-cost, high protein weaning food from Nigerian staple crops (corn and millet) blended with soybean and groundnuts/crayfish.
7. Biological degradation of aflatoxin in maize and sorghum products	EU / WAITRO	1999-2003	Isolation and identification of two new aflatoxin degrading microorganisms
8. Developing biochemical and molecular markers for quality assurance of cocoa in west Africa	EU / WAITRO	2002-	On-going studies on cocoa processing in West Africa

4.1.8 Funding of FIIRO

FIIRO is primarily funded by the federal government of Nigeria through the ministry of Science and Technology. The institute also raises funds

from the sales of technology and products. Below is the breakdown of the 2009 allocation to FIIRO by the Federal Government of Nigeria.

Table 5. 2010 budget allocation to FIIRO (Budget office, 2010. www.budgetoffice.gov.ng)

Expenditure Items	Naira =N=	USD \$
Total personnel cost	557,645,157	3,717,634
Salary & wages – General	401,867,309	2,679,115
Consolidated salary	401,867,309	2,679,115
Benefit and allowance - General	106,928,650	712,857
Non-regular allowance	18,615,680	124,104
Rent subsidy	88,312,970	588,753
Social contribution	48,849,198	325,661
NHIS	19,539,679	130,264
Pension	29,309,519	195,396
Total goods and non-personal services- general	172,020,208	1,146,801
Total capital project		
Ongoing projects(others)	260,000,000	1,733,333
Acquisition of laboratory facilities for research R & D into food processing/agro-allied products.	65,000,000	433,333

Rehabilitation of engineering complex/HMT tools	60,000,000	400,000
Procurement of equipment /materials for development of pulp & paper technology/packaging & product from local raw materials.	100,000,000	666,666
Prototype development of FIIRO completed technology	35,000,000	233,333
TOTAL ALLOCATION	989,665,364	6,597,769

4.2 Case B: PRODA ENUGU {Source of material; PRODA, (2010) www.proda-ng.org}

4.2.1 Overview of PRODA



Figure 4: Project development Agency, Enugu (Adapted from www.proda-ng.org)

PRODA located in Enugu, which is a commercial city, was established in 1970. It is wholly owned by the Federal Government of Nigeria and is under the Ministry of Science and Technology which serve as the supervising ministry. It was established with the aim of catalyzing industrialization by carrying out research from laboratory to pilot plants.

The research institute functions through a governing board and a management committee.

4.2.2 Objectives of PRODA

PRODA was established with the aim of playing a leading role towards national self reliance through the production of capital goods that will enable small and medium enterprises process available local materials and produce needed by the consumer with emphasis on power equipment and industrial sector. The research institute is expected to continually transfer the research results to the industry sector.

It is to undertake research work into:

1. The design, development and pilot production of:
 - Primary power equipment employing solid and liquid fuels, gas, steam etc as working fluids
 - Electrical machines, motor transformer, generators etc
 - Mechanical power transmission elements, speed converts etc
 - Steam raising equipment and accessories.

2. Establish and operate a mechanical/electrical training school.
3. Establish and operate a power equipment test laboratory
4. Transfer power equipment production technologies to private sector industries and render extension and consultancy services to industries.
5. Collaborate with higher institutions, government agencies, international organization and corporate bodies in the execution of its projects and programs.

4.2.3 Services and activities of PRODA

PRODA is involved in a number of technological services which include:

1. Industrial promotion/extension services

PRODA carries out extension services to ensure that their research information is disseminated to SME's.

They also carry out other services like:

- Organize workshops for the transfer of technology and to enhance industrial growth.
- Publicizing research results.
- Technology transfer through trade fairs and exhibitions.
- Technology transfer through printing of journals.

2. Technical consultancy

The technical services they offer are aimed at assisting industrialists to maximize the use of their machines and equipments through local fabrication.

They offer:

- Industrial investigations into research needs.
- Fabrication of equipment and mechanical appliances etc.

3. Chemical/physical laboratory analysis consultancy

PRODA carries out laboratory services analysis for its research work and also for companies and other organizations. Such laboratory analyses carried out include:

- Analysis of industrial raw materials.
- Analysis of samples of food products for end users.
- Analysis of drug and chemicals.

4. Training and skills Programs

PRODA offers training programs as part of their manpower development efforts and covers such areas as vocational training/skills acquisition, practical work experience for students, seminar and workshops.

The training areas cover such areas like:

- Machine fabrication.
- Bricks and pottery production.
- Laboratory technology.
- Mould making.
- Ceramics.
- Adhesive technology.
- Foundry technology.
- Glass blowing technology.

- Engineering draughtmanship.
- Auto electrical/mechanical maintenance.

Training methodology: The lectures conducted by PRODA involve both a class based lectures and practical hands-on machine exercises based on moulds.

Depending on the type of training being conducted, the duration of the training is between 2 months and two years. Examinations are usually conducted and successfully candidates issued with certificates of completion.

5. Research and development

The institute undertakes numerous researches for the development of new products and utilization of raw materials. Some research and development carried out in the past include:

- Development and production of activated carbon from coal.
- Development of bio-fuel.
- Coal liquefaction.
- Development of smokeless solid fuels.
- Production of bio-ethanol form cellulosic biomass such as palm truck and raffia palm truck.

4.2.4 Case Studies of PRODA Inventions

PRODA has over 40 research projects on its slate which covers agricultural produce processing equipment, institutional and industrial

thermal process equipment, electrical power product, pottery product and materials etc.

Some of the notable products and inventions of PRODA are found below.

Table 6: PRODA diffused inventions

INVENTIONS	NO OF USERS
PRODA all-purpose grinder	29
PRODA cassava pellet for animal feed	
Cassava grater	13
Cassava peeling machine	35
PRODA communal fryer	2
Garri rotary sieve	22
Palm kernel cracker	1
Industrial cassava peeling machine	2
Palm kernel oil extractor	1
Palm kernel shell extractor	2
Mellon sheller	4
Soya-bean dehuller separator	1
Smokeless fuel sawdust admixture	6
Kerosene heater dryer	
Mosquito coil	5

The number of users indicates the commercial clients that have adopted the technology. PRODA all purpose grinders, cassava peeling

machine and garri rotary sieve are the technologies are most widely diffused and being reproduced by the commercial client.

4.2.5 Cassava pellet for livestock feed

Cassava pellet is derived from the processing cassava using cassava pellet machine to extrude the pellet. Pellets are the common form of cassava that is traded internationally and used for feeding animals. However because of its deficiency in proteins and vitamins, they are combined with other nutrients-bearing food stuffs in the formulation of livestock feed such as fish feed, poultry feeds, layers etc.

Product derivable:

- Cassava pellets
- Livestock feeds
- Fish feeds
- Cassava starch

The processing of cassava into pellets reduces the volume by about 20-25% and therefore reduces transportation cost (Henk K, 2007). The raw materials for this project are readily available since Nigeria is one of the largest producers of cassava in the world.

PRODA produced the cassava pellet machine to serve the small and medium scale enterprises.



Figure 5: PRODA cassava pellet machine

There is no patent for this as it is meant to encourage other industries to fabricate the machine.

Government initiative

In 2003, the federal government of Nigeria announced an initiative to use cassava as an export commodity to generate five billion naira annually in export revenues. This initiative has increased the knowledge of the use of cassava as an industrial raw material.

The current production level of cassava in Nigeria is about 45 million metric tons per annum (www.nigeriaembassy.cn). Though Nigeria is the leading cassava producer in the world, 90% of its produce is targeted for domestic food market.

Successes and challenges

Presently the vast majority of cassava is processed at the village level using small scale methods. Smallholders who only deal on small surpluses produce over 80% of the cassava (Henk K, 2007). Consequently large scale assemblies that will be able to process cassava are not feasible.

The cassava pellet machine designed by PRODA is aimed at the small and medium farmers so as to discourage them from their old local way of processing cassava.

PRODA has made some successes from the cassava pellet machine having seen some local farmers adopting the machines in the cassava production and some local fabricators already producing the pellet machine. As at the time of this report, there was no record of the exact number of local fabricators that are producing the machine.

Nevertheless some small scale cassava farmers still stick to their traditional way of making pellets.

According to Henk, K (2007), the cost of the cassava pellet machine that will be suitable for small mechanized cassava milling is in the range of 141,000 naira (\$940). He also explained that for farms with high cassava production it is economical to buy the machine and use in their process but the local farmers seeing this as an expensive venture instead stick to their hand peeling methods and this is a major factor affecting the diffusion of the pellet machine.

4.2.6 Funding of PRODA

PRODA is under the ministry of Science and Technology and primarily funded by the federal government of Nigeria. The institute also raises funds from the sales of technology and products. Below is the breakdown of the 2010 allocation to PRODA by the Federal Government of Nigeria.

Table 7: 2010 budget allocation to PRODA (Budget office, 2010. www.budgetoffice.gov.ng)

Expenditure Items	Naira =N=	USD \$
Total personnel cost	408,462,937	2,723,086
Salary & wages- general	303,062,601	2,020,417
Consolidated salary	303,062,601	2,020,417
Benefit and allowances- general	67,517,511	450,116
Non-regular allowances	1,592,000	10,613
Rent subsidy	65,925,511	439,503
Social contribution	37,882,825	252,552
NHIS	15,153,130	101,020
Pension	22,729,695	151,531
Total goods and non-personal services- general	81,974,915	546,499
Total capital project		
Ongoing project(others)	177,000,000	1,180,000

Development and production of smokeless solid fuel and activated carbon from Nigeria coal	45,000,000	300,000
School pencil production	30,000,000	200,000
Electrification and refurbishing of the engineering workshop complex	2,000,000	13,333
Re-tooling of PRODA	100,000,000	666,666
TOTAL ALLOCATION	667,437,851	4,449,585

4.3 Personal Interview

In investigating the diffusion of research and technology from research centers into the industries, selected persons from both FIRRO and PRODA were interviewed. These interviews were conducted to get the view of the research centers with regards to the successes and challenges facing the research centers.

Questions adopted for the interview were designed to address the following issues:

- What is the level of diffusion of technologies and do FIIRO get enough patronage for their products and services?
- What are the factors and problems affecting diffusion of technology from the research centers into the industries?
- What are the extension and technological services offered by the institutions?
- What are the modes of transfer of innovation to the industries?
- What is the level of funding in the institutions?

- Are there enough human resources and equipments to carry out research?

Summary

In this chapter, an overview of FIIRO and PRODA, their activities and services, inventions and their diffusion were presented. It also presented case studies of FIIRO and PRODA inventions and the challenges facing their diffusion. It also captured the questions area that the interview covered.

The next chapter will discuss the results of the research investigation and analysis of the results.

CHAPTER FIVE

DATA ANALYSIS

This chapter presents the results of the research investigation and the analysis. It begins by analyzing the data collected from the research centers. It also analyzes the results received during the interview sections. From the analysis, the weaknesses identified in the technology transfer in Nigeria were identified.

5.1 FIIRO DATA ANALYSIS

The data recorded in chapter four shows the activities and technology program of FIIRO. It shows the extent to which they carry out their research programs.

Generally, the data collected reveals that;

- FIIRO was established to assist in finding industrial utilization of Nigeria's raw materials and also in upgrading local production techniques.
- When commissioned, FIIRO carries out research for international organizations which is aimed at benefiting the public
- It has a competent team of analyst and fully equipped laboratory.
- FIIRO transfers its technologies to the public through training workshop and technical assistance services.
- It offers industrial extension services with the aim of seeking to know and offer solutions to problems experienced by industrialists.

The data collected from FIIRO shows that it was established to assist in accelerating the industrialization of Nigeria economy. It was given a mandate to by the federal government of Nigeria, in 1958, to find industrial utilization of Nigeria's raw material and also to help in upgrading indigenous production techniques. R&D programs are normally based on mandate tied to a legal instruments used to established the research institutes. According to Adeoti, (2010) there seems a complete absence of government R&D contracts for the research institute. Without a clear contract, the institutes will tend to act according to what it perceived was needed. There is a high chance that if the research institutes in Nigeria have a clear mandate and budgets bonded on legal document, better results will be obtained. Research reveals that FIIRO carries out research for private companies and non-governmental organizations and the public.

Extension workers and technological centers

The data also shows FIIRO research and technology infrastructures for technology transfer which include extension services and training programs. It organizes training programs for SMEs who have to pay a token for these trainings. Its extension workers visit SMEs and industries seeking to know and meet their needs. However, the data was silent about if FIIRO has an interface like transfer centers between it and the public. In Japan there are 180 technological centers compare to the 25 currently being operated in Nigeria. These centers and their effectiveness are vital for technology diffusion in any nation. Not having the 36 states in Nigeria covered by the technological

centers can be identified as one of the factors affecting diffusion of technology in Nigeria.

Innovations and technologies

Section 4.1.4, table 2 shows the list of inventions developed by FIIRO. 26 inventions were listed among which 7 attained satisfactory diffusion, 3 though have diffused but is currently being adopted only by FIIRO and a fourth which has being accepted by only a small fraction of the industries. This brings the number to 11, of the inventions that have either attained satisfactory or partial diffusion in the market. That means 15 inventions released have failed to diffuse into the Nigeria market.

In section 2.7, only 6 inventions were listed to have been released solely by FIIRO by the federal ministry of science and technology, 2004. That means 20 of the other FIIRO inventions are also being done by other research institutes. This shows lack of harmonization by the research centers as there is duplication of effort whereas they should have been geared their resources towards researching in other relevant areas.

There is a lack of new technological ideas in the research centers. Most of the technologies that the institute is commercializing now are ideas or inventions discovered some years back. Example, the composite flour that FIIRO are working hard to commercialize was introduced over 20 years ago. This shows that the rate at which new ideas are coming out of the research institute is poor and also, the fact that

after 20 years, not one flour millers in Nigeria have fully adopted this technology shows that the rate of diffusion is slow.

5.2 PRODA data analysis

PRODA is a research institute with the mandate to produce technologies that will enable small and medium enterprises to process local materials.

In general, the analysis of PRODA data revealed that:

- ✓ PRODA is a research center in Nigeria established by the federal government and is oversee by the ministry of science and technology.
- ✓ PRODA is funded primarily by the federal government of Nigeria.
- ✓ PRODA carries out research work for other industries and corporate bodies.
- ✓ The institute offer training and manpower development programs.
- ✓ PRODA has over 40 research project on its slate.

The innovations and technologies of PRODA does not have patent and this was done to encourage small and large industries to reproduce the technologies for commercialization.

Innovations and technologies

The analysis of the data of PRODA showed that the research institute has over 40 research projects on its slate in areas like agricultural processing equipment and industrial equipments.

From the list of 15 technologies of PRODA that has achieved one or more commercial clients, the most diffused are PRODA all purpose grinders, cassava peeling machine 25, garri rotary sieve and cassava which got 29, 35, 22 and 13 commercial clients respectively.

Section 2.7 of the literature review reveals that only 2 inventions were recorded solely to PRODA and their other inventions are also being carried out by other institute. This shows a lack of fresh ideas coming from PRODA as an institute.

Funding

In the 2010 budget shown table 7, the sum of 177,000,000 naira (\$1,180,000) was allocated to PRODA for capital project. Uwaifo U (2009) stated that Nigeria highest allocation figures for research from its budget was in 1983 with 0.43% of its GDP. And this went as low as 0.05% in 1992 and 0.23% in 2003. This trend shows poor funding of the research institutes in Nigeria. From the literature review, the United Kingdom in 2004 allocated 1.9% of its GDP to research and also aimed that it will increase to 2.5% of it GDP by 2014.

UNIDO report of 2006 identified funding as one the problems facing diffusion of technology in Nigeria. According to the report, SME development centers are not properly funded.

The case study of cassava pellet for livestock feed that was considered showed that the raw materials for the production of the pellets are readily available in Nigeria. There is a market of cassava in Nigeria as the government has identified it as a means to generate money annually for the nation. The exact number of fabricators of this machine is not known at the time of this research but PRODA is identified as one of them. The research shows that the cost of the machine is a major factor affecting the diffusion of the machine as small SME's sees it as expensive to their process.

5.3 FIIRO AND PRODA INTERVIEW ANALYSIS

For a guide to analysis, the research questions are summarized as follows:

1. What is the level of diffusion of technologies and do FIIRO and PRODA get enough patronage for their products and services?
2. What are the factors and problems affecting diffusion of technology from the research centers into the industries?
3. What are the extension and technological services offered by the institutions?
4. What are the modes of transfer of innovation to the industries?
5. What is the level of funding in the institutions?
6. Are there sufficient policies backing research and technology in Nigeria?
7. Are there enough human resources and equipments to carry out research?

Research Question 1

What is the level of diffusion of technologies and do FIIRO get enough patronage for their products and services?

Question 5, 6 and 7 of the interview section were designed to address this. According to the result of the interview question, the technologies and the activities are targeted at the local communities, SME's and other industries.

Both persons interviewed for FIIRO and PRODA reported that the level of technology diffusion in the institutions is poor. The respondent of FIIRO said that despite the fact that some of their technologies have diffused, a lot more have not been diffused. The respondent of PRODA gave garri rotary sieve as an example of their technologies that has successfully diffused into the market.

Research Question 2

What are the factors and problems affecting diffusion of technology from the research centers into the industries?

The common factors affecting diffusion of technology that was given by those interviewed in FIIRO and PRODA are:

- ✓ Inadequate funding
- ✓ Lack of policies implementation
- ✓ Shortage of human resources
- ✓ Relevance of technology
- ✓ Poor standard of laboratories and technological centers

✓ Advertisement of technologies

Similar challenges were given by the two respondents on the problems facing diffusion except the respondent in PRODA also gave relevance of technology as one of the problems affecting diffusion.

1. Lack of Funds

This entails the non-availability of funds for carrying out research and development of projects. It also includes the non-availability of funds for advertisement and running cost.

These funds could have come from the government grants, from patronage or maybe donations. Therefore, this problem could have been due to insufficient grant from government, insufficient turnover from patronage and maybe lack of donations.

Every opinion sourced on the factors affecting diffusion of technology, gave this as one of their reasons.

Research institutes may not be profit-oriented establishments, but they must be success-oriented. As funds cannot adequately come from Government, they can come from patronage.

Inherently, there is a need to get more patronage, although government funding should not be neglected or stopped.

2. Lack of Relevance

This is the problem of innovation not meeting or satisfying the needs of clients either in terms of cost, performance or other criteria.

This may be as a result of the innovations too expensive for small scale entrepreneur and not knowing the specific needs of the clients. From the respondent, it can be deduced that a shortage of field officers to bring back feedback on innovation performance and without the feedback, there will not be able to know, from the user point of view which area needs improvement.

3. Lack of policies implementation.

Commitment of the government could include making goal oriented policies, implementation of policies like banning importation of innovation that research institute have produced creation of a favorable environment and funding.

The interview conducted revealed that government commitment is not only view from the point of just the provision of fund but also to involve setting the right polices for areas like importation regulations, credit facilities etc and ensuring they are implemented.

4. Lack of Advertisement

This problem extends to cover every inability to get clients to know of innovations and persuade them to purchase research institute innovations. Hence it can be traced to;

- a) Lack of information on needs of companies/industries
- b) Lack of adequate information on your institute by companies
- c) Difficulty in finding partner for joint venture
- d) Geographical proximity

It was deduced from the oral interview that the respondents see lack of funds as the reason for low advertisement also to be affecting the extension services.

5. Shortage of Human Resources

This entails lack of business-oriented technical expertise.

The interview shows that there is shortage of adequate personnel which contradict the information gotten from FIIRO record which says they have competent personnel. Investigations revealed that some of their competent staff leaves the job for better paying and more challenging jobs.

This shortage is as a result of a decline in the standard of education in the Nigeria University. it has been noticed that practical knowledge gained in the universities in Nigeria is declining that is why the Nigeria University Commission instituted a compulsory industrial training program for all engineering courses in the country's universities. This has led to the employment of people without the required practical knowledge and drive for innovation.

Research Question 3

What are the extension and technological services offered by the institutions?

Question 11, 12 and 13 of the interview questions were design to address this issue. According to the FIIRO respondent, FIIRO sends it extension workers to the SME's and communities as this helps them in understanding the research needs of the people. FIIRO organizes training but this is not regular and often upon request. They also carry out research for corporate bodies to interact with the people solicit for the factors from the interviewee.

The result for PRODA is the same as that of FIIRO as their extension workers have contact with the SME's. The respondent of PRODA earlier identified relevance of technology as one of the problems facing the diffusion of technology and this shows that their extension service is not effective. Except on request, PRODA organizes training workshops at their training centers in Enugu and this is not convenient for local farmers and SME's in the villages that will need to travel down.

Research Question 4

What are the modes of transfer of innovation to the industries?

FIIRO and PRODA use extension, exhibitions and marketers to carry their technology to the SME's and industries. Trade fairs and exhibition is an avenue to showcase one technologies and product, however it has also been identified not to be effective in reaching local farmers and SME as trade fair in Nigeria are usually hosted in big cities.

According to the data obtained from the interview, there are no technology transfer or contact centers in the country. Technology transfer centers acts a good avenues for transfer of technology in most

countries, since it takes the technology to the people and also offer technological support to the people. Transfer centers can also be a good medium of getting feedback about technologies from the people. The data gotten from the institute did not identify the institute involvement in any technological transfer centers around the country. Hence it is concluded that the institute does not operate transfer centers.

Research question 5

What is the level of funding in the institutions?

Question 17, 18 and 19 addresses the issues of funding. According to those interviewed, the institutes are primarily funded by the government of Nigeria through its ministry of science and technology. Other means through which the research institute get funds including carrying out consultancy services for corporate bodies and training programs. They rated the level of funding to be poor.

Research question 6

Are there sufficient policies backing research and technology in Nigeria?

It was gathered from the interview conducted that there is the need for more policies to encourage research and development. Apart from the shortage of policies, another problem identified was the implementation of existing policies. Nigeria need policies with

particular focus on promoting R&D in selected sectors that is considered strategic to national development.

Research question 7

Are there enough human resources and equipments to carry out research?

FIIRO and PRODA have laboratories and workshops that need to be upgraded according to results from the interviews. The interview carried out showed that the equipment and laboratories are outdated and this confirms Adeoti, 2010, of the literature review which says that the equipments in research institutes in Nigeria are obsolete and most are non-functional. To meet up with the modern research, laboratories need to be equipped with equipments for analysis and for the workshop. This is a need identified in the institutes and also this may be traced to lack of government and private support of the institute. The interview conducted also reveals that there is a shortage of human resources. The best scientist and engineers are either abroad or working for companies with better incentives (Adeoti, 2010).

Summary

Chapter five presented the analysis of the data collected from FIRRO and PRODA and also the results gotten from the interview sections conducted. It also identified the challenges facing technology transfer in Nigeria.

The next chapter will present a framework that is designed based on the challenges discovered in the research analysis to be facing technology transfer in Nigeria.

CHAPTER SIX

FRAMEWORK FOR DIFFUSION

In the diffusion of innovation in Nigeria, many factors play different roles. Therefore it is recommended that Nigeria adopt a national innovation system. This innovation system will place more emphasis on the roles of research centers, private organizations, market and users in the innovation system and how their various roles affects the diffusion of innovation in the country.

Funding and investing in innovation and technology was identified as one of the factors in the diffusion of innovation but it can be argued that increased funding of research and development may increase knowledge but may not spur an innovation culture in the nation. This makes it necessary to also address other actors like policy and legislative, physical infrastructure, human capital, investment climate, and systems for enhancing the flow of knowledge.

Section 2.2 of the literature review point to the three essential elements (input, output and framework) needed in an innovation system. Adopting an innovation system will make diffusion of technology not to be seen as the sole duty of research centers but also bringing in other actors like training and educational institute, policy makers, private organizations, credit institutions and the users of technology. It will also make us not just to consider the availability of technology but also what is preventing other factors from playing their own role.

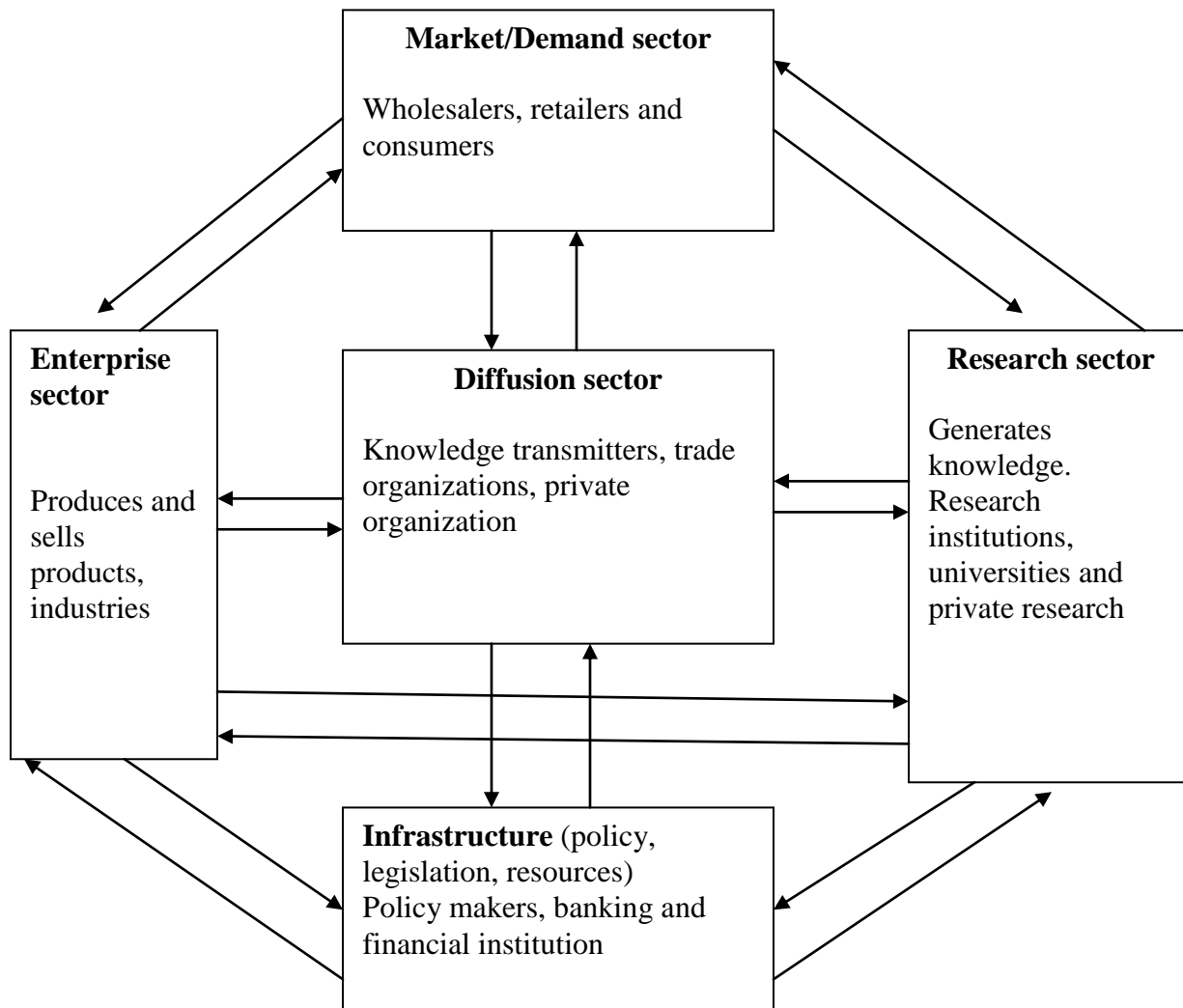


Figure 6: Framework for diffusion in Nigeria

6.1 Policies Reforms

Innovation and productivity outcome can be strengthened through policies reforms. Policy reforms will help improve the business environment for innovation in Nigeria. The research carried out identifies the need for strong and definite policy for Nigeria innovation system.

Policies need to be introduced to encourage adoption and application of new ideas in Nigeria. Innovation system presents major policy implication:

1. For efficiency in the R&D in Nigeria there is a need to improve the climate for the commercialization of inventions. The following steps should be adopted;

- Policies that deter self-reliance should be scrapped so as to bring about the commercialization of useful inventions. These include the liberalization of imports; indiscriminate withdrawal of subsidies for agricultural inputs, which may badly affect local raw materials.
- They should create the need to commercialize inventions on the nation. Not only that the need should be created or forced on the nation, it should also be sustained for a long time for it to be worthwhile for investors to commit resources.

2. The R & D institutes should stop commercializing their inventions in-house. Setting for themselves manufacturing centers or pilot plants dissipates their meager resources. The R & D institutes should instead focus on:

- Running training programs for entrepreneurs who wish to commercialize the institute's inventions.
- Providing consultancy services to entrepreneurs by providing detailed designs and other technical services.
- Solving developmental problems encountered in commercialization.

3. Government should fund R & D activities after it has identified specific social, economic, technical, and other kinds of problems that need R & D solution. This is to ensure that inventions are vital to the society.

4. Research programs at the institute need to be evaluated so that only programs that are of economy and national importance are carried out.

5. The research institute need to be challenged in developing fresh ideas in their research and the R&D personnel be rewarded on the basis of ultimate utility of the solution they devise.

Just bringing out policies is not enough but the government needs to bring out workable implementation strategy for these policies. It is always difficult to change behavioral patterns as this may require the establishment of appropriate incentives. Well managed Innovative friendly regulations will foster the flow of technology in Nigeria.

6.2 Human resources

The government and private sector should work in unison with the higher institution in the country in ensuring that necessary funding and support is given. The scheme for industrial training attachment program for science and technology students should be reviewed to make it more effective and to get the private sector to support it.

Government and industries should invest meaningfully in the programs of the university and also provide funds for the furnishing of the

laboratory. These are essential in raising a well trained engineers, scientist and technologist.

Research institute should constantly engage its staff in training programs as this will improve their quality of work.

6.3 Private involvement in research and development

In Nigeria, few industries especially the mega industries own their own laboratory. These laboratories are to serve mainly their research need of the industry that owns it.

Findings in the America shows that privately funded research is more efficient than government funded research.

The government should set up program to encourage private involvement in research and development. Private companies should be made to carry out research on the needs and for the benefit of the people of the nation not only for their companies. This can be achieved by fiscal incentive for private sector.

Two kinds of fiscal incentives namely tax incentives and direct grants should be introduced.

1. Tax incentives.

Tax incentives can be created to stimulate private sector research in the country. Tax deduction or full write-off can be given to firms that engage in research programs.

2. Direct grants.

Government should offer direct support to firms in the form of competitive grants and subsidized loan. This support is important to foster innovation and technology. However its effectiveness depends on its design and implementation.

6.4 Funds

Fully equipped laboratory for research, improved advertisement of technologies, running of a research institute etc can only be achieved when there are enough funds.

The research funding in most developed countries is between 1.5% and 3% of their GDP but Nigeria is far behind in this. In 2009 budget allocation, research and development is 0.69% of the nation's GDP. Nigeria though a developing country will need to increase funding of research and development so as to bring development to vital areas of the economy.

Despite the fact that funding is one of the main factors identified in this research to be affecting the diffusion of invention and technology in Nigeria, effort should be made to effectively utilize the meager resources set aside for research. To achieve this, the research institute need to evaluate their programs to ensure that funds allocated to them are effectively used by venturing into vital projects.

The Nigeria government will need to increase funding of the research institute and also encourage private participation funding research centers. It is important to have;

1. Grants or loan scheme for SMEs. This will enable them in acquiring new innovations and technologies.

2. Technology and innovation funds. New and increased financing is required so as to aid the research centers in meeting with the present innovation demands. Extension services, research antennas etc needs funding to make it efficient.

6.5 Innovation and technology strategies

There is a need for new strategies for effective diffusion of innovation and also the research centers to provide support for the people. It is important for the government to support the research institute in;

1. Establishing antennas or contact centers at various locations round the nation. This research shows that there are currently 25 technological centers and this does not cover the entire states in Nigeria. These centers should well structured and funded for them to be effective. This will give the research institute the opportunities to reach out to the people it serves with their technologies, and also to provide technical support and advice to SMEs and industries. These centers will liaise with the main research centers in its activities.

2. Improve advertisement. There is a need to create awareness of the inventions made by the institution and its relevance to the people.

3. Improved extension services. Establishing antenna at various locations will support extension services like quality control,

information and training programs. The extension services should be provided with funds for its activities.

6.6 Validation

Innovation and Growth Organization for Economic Co-operation and Development Report (OECD), 2007

The OECD's Committee for Scientific and Technological Policy carried out an extensive research on innovation systems and developing indicators to map knowledge flows. The report was meant to identify best innovative practices for the knowledge-based economy.

The findings of the report say that innovation and technology development is a result of a complex set of relationships among actors in the system.

The OECD report said that the role of innovation for growth in a nation is strengthened by advances in new technologies, and a greater focus on knowledge creation.

Policies

According to the OECD report of 2007, policy reforms are needed to strengthen innovation and also OECD analysis shows that increase in research are driven by a wide range of factors which include;

- ✓ Availability of internal and external finance

- ✓ Stable macroeconomic conditions and low interest rates which encourage the growth of innovation activity by creating a stable and low cost environment for investment in innovations
- ✓ Fiscal incentives like tax relief for private researchers, which can be effective in raising research and development.

Human Resources

An effective education system facilitates the diffusion of innovation. OECD reports that human capital is a key factor in the diffusion of new technology and the introduction of innovative practices. Also creating, developing and diffusing new innovations require strong science and technology skills as well as entrepreneurial skills.

The OECD 2007 report 'Going for Growth' identifies education reform as a priority action for 18 out of 30 countries and as such there is increasing emphasis to move towards the school environment to make it more efficient.

Private involvement in research

According to OECD report, despite the facts that countries provide support to promote innovation activity in the private sector, improvement is required to make it more efficient. It pointed out that such improvement may be in the form of identifying an appropriate mix of direct and indirect instruments such as tax credits, direct support and well designed public-private partnership.

It listed direct support to be in the form of competitive grants or subsidized or guaranteed loans. The effectiveness of both instruments depends on their design and implementation.

Funds

Investments in science and research play an important role in innovation and technology. The report stresses the need for government to provide incentives that focuses on excellence and relevance of the research to the social and economic needs of the nation.

Summary

This chapter presented a framework for diffusion of innovation and technology based on the findings in chapter five of the dissertation. It dealt with policies, human resources, funding of researches, private involvement in research and innovation and technology strategies. The framework was also validated against the OECD recommendations.

The next chapter carries the concluding part of the research and it gives recommendations on the diffusion of innovation and technology and also for further study on the research area.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

In this concluding chapter, a brief conclusion of the research work is given and also recommendations are presented on the way forward for the diffusion of inventions in Nigeria as well the scope for further research work.

7.1 Conclusion

This research work set out to address the challenges facing the diffusion of innovations from research centers into the industries in Nigeria. The Federal Institute for Industrial Research, FIRRO and the Project Development Agency were chosen as case studies. The case studies were visited in the course of the work and data collected.

To determine the extent of diffusion of innovation and technology in Nigeria, the researcher assessed the inventions of FIIRO and PRODA and the rate at which they have diffused into the industries. Composite flour and cassava pellet being inventions of FIIRO and PRODA respectively were also used to investigate the factors affecting the diffusion of technology from the research centers.

From the study and investigations, the researcher concluded that:

1. There is a low level of diffusion of innovations from the research centers into the industries in Nigeria.

2. Factors inhibiting the diffusion of technology from the research centers to the industries in Nigeria are;

- Relevance of innovations either in terms of price or performance.
This conclusion follows from the findings reported in section 5.3, research question 2. The data showed that there is a problem of innovation not meeting the needs of the clients and it may be as a result of not knowing their specific needs.
- Inadequate manpower.
The findings in section 5.2, research question 3 and 7, showed that there is a shortage of well skilled/qualified manpower at the research centers.
- Inadequate Policies
Policies were identified in this research as one of the factors inhibiting diffusion of innovation.
- Policies implementation
This inhibiting factor was revealed from the findings reported in section 4.3.2. The data revealed that despite some existing policies put in place by the government, the rate of diffusion of innovation is still poor because of their lack of implementation.
- Lack of funding
This was revealed from the findings in section 5.3, question 2 and 5. The data identified the lack of adequate funding such as direct grants and incentives for research institutes, SME's and private bodies.

A framework for the diffusion of innovation in Nigeria was developed based on the discovery of the level of innovation and technology diffusion in the nation, the factors inhibiting diffusion of innovation and

best practices for the diffusion of innovation. The framework proposes the following:

1. Research centers should effectively devise strategies to tackle the factors affecting the diffusion of innovation.
2. There is a need for an innovation system where every stakeholder involved in the diffusion of innovation will be actively involved in playing their roles.
3. There is a lack of vital policies needed to create the right environment for diffusion. Also implementation of policies is a problem as can be seen in the case of the composite flour that is still awaiting implementation.

For this dissertation, the researcher gave data only on budget and plan allocations to FIIRO and PRODA which are not a true reflection of the amount of money spent annually on FIIRO and PRODA by the government. Regrettably, the researcher was unable to get data regarding the actual amount of money spent on FIIRO and PRODA during the duration of the research work.

7.2 Recommendations

Innovation and technology forms the foundation for the development of any nation, therefore much attention need to be given to it to ensure its success in any nation.

This research work has proven that the rate of diffusion of innovation from research centers into the industries in Nigeria is very poor. To mitigate this situation it is recommended that the government and research institutes should utilize the strategies presented in section 6.1 to 6.5.

7.3 Recommendations for further research

In this research work, emphasis and survey was focused on the research institute (FIRRO & PRODA) in determining the diffusion of innovations from research centers into the industries. There is a need to carryout this research from the industries point of view so as to get a balance particularly for the factors responsible for the non-diffusion of innovations.

This research made no attempt to investigate the actual cost of running a research institute like FIRRO and PRODA and therefore avoided assessing the direct or indirect benefits of the activities of the research institute. This should be an area for further research.

Appendices 1

INTERVIEW QUESTIONS

The means of technology transfer was addressed in this section of the interview. It also asks questions regarding the funding at FIIRO and PRODA. Private bodies' participation in the institutes was also investigated.

Part One

1. May I know your name sir?

My name is Ajayi Kayode

2. What is your role in FIIRO?

I work with the policy and management department.

3. Can you briefly tell me the objective of FIIRO, sir?

The core objective of FIIRO is to find industrial utilization of the country's raw material and upgrading indigenous production techniques.

4. Do you think the objective is effectively being achieved?

It is a very challenging task achieving this objective. You see my dear, success is easily achieved when all the resources needed are available but here we have some challenges. We cannot say we have fully achieved success here at FIIRO, but that is not to say that we have not achieved success in little way here.

5. What are the types of innovation produced by FIIRO?

Our innovations in FIIRO include products and services

6. Who are your targets for your inventions and technologies?

Our inventions are targeted at the local communities, small and medium enterprises, companies and everyone in general. Our engineering department focuses more on SMEs as these are the people who operate more with the indigenous production techniques in their production process.

7. How would you rate the level of adoption of technologies and frequency of patronage of FIIRO products and services?

We have some technologies that are ready for commercialization but the rate of diffusion of these technologies into the market is poor. Some of our technologies have gotten wide acceptance among the people but many are yet to be accepted by the as people as some SMEs still stick to their old techniques that they are used to.

8. What do you think are the problems associated with technology transfer in FIIRO?

The problems with technology transfer in this nation are many and may differ with institutions. For FIIRO are challenges are:

- Inadequate funding. Why I said this first is because fund will solve most of the other issues. To run an effective institution like this you need money.
- Human resources. We need fresh hands to bring new ideas to the FIIRO. We also need people with good knowledge in various research and technology discipline.
- Here in this country, people do not really know much about FIIRO and what we do. So we need to take the information to them about what we do and our technologies too. That means there is a need for advertisement.
- Lack of policies implementation. Not that there are no policies here but what we face is implementation of these policies.
- There is a need for a well equipped laboratory and fabrication workshop.

9. How would you rate the level of equipments with regard to your laboratory at FIIRO?

We have a laboratory and workshop for our research and design that was built years ago and equipped. With the present technological advancement in the world today there is a need to upgrade the laboratories for better research studies to be carried out. Much fund has not been put in this area recently.

10. Do you think FIIRO have enough specialized staff like sale engineers, extension service engineers etc to fulfill the objectives of the institution?

There is a need for specialized staff here at FIRRO. With the condition of the country most experienced staff prefers to look for blue collar job than to work under the ministry. Nevertheless there is experienced staff that has worked with us over the years but there is a need for fresh talents to come into the system.

11. How do you learn about the research need of your targets?

We sometimes send our extension workers to the markets, farmers etc to learn about their challenges as this will aid us in bringing out technologies that will be useful to them.

12. Do you offer training programs for the local communities and the SME's?

Yes, we offer training programs for SME's, corporate bodies upon request. Once in a while we also organize trainings for local farmers, traders and those that need our technology.

13. Does your institute offer technological support to the people or SMEs?

Yes we do provide technological support to SME's, corporate bodies upon request. We help them carryout research and also offer advice to them in different technological areas.

14. How do you get your inventions across to the companies and targeted people?

Here at FIRRO, we normally take our technologies to industries to showcase to them. We also use trade fair platforms that are organized by the ministry of commerce to bring our technologies to the industries. The challenge with this is that the village SME's cannot be reached during such trade fairs.

15. Do FIIRO have transfer agencies or centers at different regions around the country for technology transfer and support?

No. we do not have transfer center outside lagos.

16. How effective are the means used in your technology transfer?

While our approach may benefit some it may not be effective to others. For example, taking our technologies to trade fairs that I earlier mention will be effective in getting corporate and large investors that visit trade fair but local/village SME's hardly uses trade fair here in Nigeria. Generally I think we need to improve on our technology transfer strategies.

17. Let's talk about funds. How do you get funds for your institute?

This institution is under that ministry of Science and technology and funded by the government. We also get funds when we render consultancy services and trainings to corporate bodies.

18. Do you get adequate fund or support financially from the government?

Funding of research centers in Nigeria is very poor. This is one of the major problems we are facing here. The government needs to place much attention on science and technology in this nation because it is the bedrock of development of nay nation.

19. How would you rate the private bodies' participation in FIIRO?

Here, people leave research institute financing to the government. Over the years, we have received support from some organization. The government needs to encourage private body participation in research in this nation. Corporate bodies that do not own their own research centers can support the government owned research centers.

20. Do you think there are enough government policies backing innovations?

The problem we face is not the lack of policies but the implementation of existing one. We agree we need policies but the existing ones what are their results? I will say the existing

policies are not enough but most importantly we need implementation of the policies.

Part two

1. May I know your name sir?

My name is Ugo Mgbachi

2. What is your role in PRODA?

I work with the Administration and finance department

3. Can you briefly tell me the objective of PRODA, sir?

The objective of PRODA is to produce capital goods and technology that will enable SME's process available raw materials with emphasis on power equipment.

4. Do you think the objective is effectively being achieved?

PRODA has an institute has made effort to achieve this objectives through our technologies and products. We have not been effective in carrying out this objective as there are many problems with challenges with research institute in Nigeria.

5. What are the types of innovation produced by PRODA?

Here we produce innovations in the form of products as well as services.

6. Who are your targets for your inventions and technologies?

Our targets are small and medium enterprises.

7. How would you rate the level of diffusion of technologies and frequency of patronage of PRODA products and services?

The level of diffusion of some of PRODA technologies has been impressive. Like the garri rotary sieve is being used by a high number of garri processing farmers. The mosquito coil technology is being used by some small scale industries to produce mosquito for the Nigeria market. So some of our technologies have diffused well into the market but some still fall short.

8. What do you think are the problems associated with technology transfer in PRODA?

In PRODA today many factors are affecting the transfer of technology and also other institution may face similar problems.

These problems are;

- Shortage of human resources.
- Creating technologies that are relevant to the people and industries.

- Lack of good funding of research centers. The fund allocated to research in Nigeria is very small compare to other nations.
- Lack of awareness of our technologies.
- Infrastructures for technology transfer.
- On the government side, there is a lack of policies implementation.

9. How would you rate the level of equipments with regard to your laboratory at PRODA?

Well, the level of our equipment compare to what is found in modern research centers in other countries is poor. Our equipments need upgrade. Some of the equipments that we have here are not in good working conditions. Our extension services also are short of necessary equipments and vehicles for its services

10. Do you think PRODA have enough specialized staff like sale engineers, extension service engineers etc to fulfill the objectives of the institution?

We do have specialized staff but there are not much and for us to be more efficient we need more.

11. How do you learn about the research need of your targets?

Our extension workers play a big part in this as they have contact with the targets and SME's. We get feedback from our

extension workers on the challenges facing the SME's and how we can help out.

12. Do you offer training programs for the local communities and the SME's?

Yes. We offer training programs that involves both lectures and practical trainings. We train people on various technological areas. Sometimes too we will need to train the SME's on the best use of our technology. The only challenge we face with this is that most SME's in the villages cannot access our training meetings.

13. Does your institute offer technological support to the people or SMEs?

Yes we have, not only for SME's but also for industries and corporate bodies.

14. How do you get your inventions across to the companies and targeted people?

We use means like extension workers, marketers and exhibitions.

15. Do PRODA have transfer agencies or centers at different regions around the country for technology transfer and support?

No. We do not have.

16. How effective are the means used in your technology transfer?

The means used here in transfer of our technology would have been more effective if we actively apply them. For example, we do not organize seminars often, our extension workers have some constrain in reaching some of the SME's because of logistics problems and so on. Generally, I will say that the means are not effective.

17. Let's talk about funds. How do you get funds for your institute?

We are under the ministry of science and technology and we are being financed majorly by the government. I said majorly because we still get other fund from means like carrying out research for corporate bodies and also too we get donations from organizations but this does not come often.

18. Do you get adequate fund or support financially from the government?

Funding of research in Nigeria is poor. Check the Nigeria budget annually and it will shock you how much is being budgeted for research. This need to be looked into.

19. How would you rate the private bodies' participation in PRODA?

Here at PRODA there is no patent on our technologies because we want to encourage other industries to adopt them and helped diffuse them to the market.

We work together with some SME's during our research work. On some few occasions private organizations have sponsored researches here. Apart from undergoing researches for some of private bodies, we need more assistance and support from them like grants.

20. Do you think there are enough government policies backing innovations?

There are not enough policies. We need policies that will encourage private sector investment in research in this nation. We need more policies that will stop the importation of goods into this nation that we can produce locally.

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