EVALUATION OF TECHNOLOGICAL CAPABILITY AND INNOVATIONS IN THE NIGERIA CASSAVA PROCESSING INDUSTRY

A Ph.D. RESEARCH PROPOSAL

AT THE AFRICAN INSTITUTE FOR SCIENCE POLICY AND INNOVATIONS (AISPI), FACULTY OF TECHNOLOGY, OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

BY

DADA, ABOLAJI DAUDA

BACHELOR OF AGRICULTURE
FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA, NIGERIA

MASTERS OF SCIENCE, AGRICULTURAL ECONOMICS
UNIVERSITY OF IBADAN, IBADAN, NIGERIA

MASTERS OF SCIENCE, TECHNOLOGY MANAGEMENT
OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The global competitiveness of any economy depends on its science, technology and innovation (STI) capabilities (Adeoti *et al.,* 2008; Malerba and Nelson, 2010). STI are increasingly recognized as a major determinant of economic growth and sustainable development (Nobuo, 2005). Technological capability is the ability to create new technologies and to develop new products, processes or new industries in response to changing economic environment (Kim, 1997). Technological capability is a specific collection of equipment, skills, knowledge, aptitudes, and attitudes that confer the ability of a firm to operate, understand, change and create production processes and product (Marcelle, 2004). The advancement in the level of technical know-how and widespread application of technological innovations resulting in high productive capability and economic growth is not new in developed nations. For developing countries that are on the path to technological and economic catch-up, strengthening such technological capability and innovations are their pursuits (Adeoti and Adeoti, 2010). This is because acquiring advanced knowledge and technologies have no value if the acquiring nation doesn't possess the necessary technological capabilities that can allow such nations to seize such technological opportunities for promoting innovations (Morrison *et al.,* 2008; Hong, 2009). Building local technological capability therefore, is a necessary condition for any nation aspiring to develop technologically (Adeoti, 2002).

The totality of STI activities includes scientific and technological research, experimental development, scientific and technological services, innovation and diffusion (Ilori *et al.,* 2002). New capabilities (absorptive and innovation) is of central importance in almost all economic sectors as they are the key elements in the change of the key economic system (Malerba and Nelson, 2010). The capabilities are required in order to adopt, adapt and modify technologies

developed elsewhere, introduce modifications and incremental innovations and eventually generate totally new products and processes (Miller and Morris 1999). Research has shown that innovative technological capability building is a key to technological and economic progress of countries throughout history. Such capabilities are required in the Nigerian cassava processing industry to increase its shelf life, enhance its nutritional value, upgrade cassava traditional food technologies, as well as to develop value-added products with export potential which could contribute considerably to transforming the economies. The cassava processing industry involves cassava processors such as flour mill companies, starch companies; cassava equipment and machineries fabricators that are involved in medium-scale motorized cassava grater, hammer milling machine, cassava mash and gaari shifter, frying system; and food processors that are involved in bread making and other confectioneries.

Since the 1980s, Nigeria has remained the global leader in cassava *(Manihot Esculenta Crantz)* production with an annual production of 45 million metric tonnes (FAO, 2011). While Nigeria is regarded as the largest producer of cassava however, output per hectare remains one of the lowest in the world principally due to poor technological development (Odebode 2008; Dada *et al.*, 2009; Ogundari 2010). Cassava production like other crops in Nigeria is mostly driven by land area expansion rather than productivity associated with improved technology (Manyoung *et al.*, 2005; IFPRI, 2010). Dynamic and sustainable approach to cassava development has remained great concern to Nigerian government and policy makers (Agwu *et al.*, 2008). Moreover, the utilization of cassava has largely explored traditional technologies for processing of its roots into human food such as *gari*, *fufu*, and flour (FAO, 1998; Adebayo *et al.*, 2003a; 2003b; NEPAD, 2006; Dada *et al.*, 2010). There is more than 40 million tonnes of demand for other products of cassava - starches for the textile, pharmaceutical, pulp and paper, adhesives for packaging industries and flour for bakery and confectionery industries (RMRDC, 2004).

In order to identify gaps in technology, infrastructure or information that can facilitate the deployment and use of technologies that can enhance the cassava processing industry, there is the need for a comprehensive evaluation of the technological capability and innovations of the industry. Proper evaluation of the Nigerian cassava processing industry could lead to growth and development of the cassava industry and transformation of cassava from the traditional food crop to industrial raw material (Farinde, 2006). The study will propose policy framework that can improve the interactions among the key actors of the cassava sectoral system as well as enhance industrial competitiveness of cassava utilisation in Nigeria.

1.2 Statement of the Research Problem

The total world cassava utilization is projected to reach 275 million tonnes by 2020 (IFPRI in Westby, 2008) with some researchers estimating the number closer to 291 million tonnes (Scott *et al.,* 2000 in Westby, 2008). Africa is the largest producer of `cassava cultivating 62% of the total world production. Nigeria is the global leading `economy in cassava production with an annual crop of approximately 45 million metric tonnes (ECP, 2010; FAO, 2011); about 20% percent of global market share (Hillocks, 2002; IITA, 2007). However, in contrast to Thailand, where cassava processing is highly mechanized, and majority is exported to Europe and China as dried chips for animal feed, the larger proportion of the cassava produced in Nigeria is used for human consumption. About 80% of cassava produced in Nigeria is consumed in the form of human food - *Lafun, Fufu, Gari,* Starch, *Tapioca* (FAO, 1998; Dada *et al.,* 2010). This is in contrast to Latin America and Asia where less than half is utilized for food consumption. Nwokoro, *et al.,* (2007), reported that two third of the total cassava production in Nigeria is used as food for human consumption with less quantity being used for animal feed and industrial purposes. No supply chain structure exists for industrialization of secondary cassava products as a primary source for agro-industries (Ezedinma, *et al.,* 2002). Also, in China, there are more than 400 cassava processing factories. Ten of these have a production capacity of more than 10,000

tonnes of starch per year. Cassava starch is also used in the production of ethanol and acetone. In Brazil, leading agribusiness multinationals process cassava products, some of them directed to large markets, exporting these products to regional markets (Adeoti and Adeoti 2010). Nigeria imports more than 60,000 metric tonnes of starch for industrial purposes (equivalent of 300,000 metric tonnes of cassava roots) and more than 150,000 metric tonnes of starch derivatives (equivalent of 750,000 metric tonnes of cassava roots) such as sugar (high fructose syrup) for the soft drink industry.

However, there are a lot of cassava technology and innovations to increase the production outputs and income generation from cassava in Nigeria. There is also an appreciable level of demand for other products of cassava such as starches for the textile, pharmaceutical, pulp and paper, adhesives for packaging industries and flour for bakery and confectionery industries. It is estimated that more than 40 million tonnes of cassava would be needed to service industries that would produce the products to satisfy the needs (RMRDC, 2004). Furthermore, machineries and equipment such as Chipping machine, Rotary dryer, Packaging machine (stitching and sealing), Rapid moisture analyzer, and automated cyanide analyzer are also needed for effective cassava processing in the industry.

Research has shown that innovative technological capability is a key to technological and economic progress of countries throughout history. Failure to build STI capabilities has resulted in Nigeria's current economic lag behind newly industrialising countries of Southeast Asia which were at relatively similar levels of per capita income with Nigeria in the early 1960s (Oyelaran-Oyeyinka, 2006). However, several cassava processing researchers from universities, polytechnics, and research institutes (national and international), have developed some major interventions in cassava processing. For instance, research done at the International Institute of Tropical Agriculture (IITA) and Federal Institute of Industrial Research Oshodi (FIIRO) has lead to the production of nutritious bread and other baked products such as cakes and biscuits using

cassava and soybean flour, cassava starch, margarine and eggs. In the department of Agricultural Engineering, Obafemi Awolowo University, Ile-Ife, hammer milling machine, cassava grating machine, cassava mash and *gaari* shifter, frying system have been developed (Farinde, 2006). Cassava harvester and peeler, hammer miller have also been developed by the National Centre for Agricultural Mechanisation (NCAM), Ilorin (Agbetoye, 1999). There is however, the dearth of information on the appropriateness of such capabilities and innovations to the cassava processing industry, the extent of adoption of the innovations; and the impact on the cassava industrial performance. At the industrial sector, previous studies have established some major interventions in cassava processing such as medium-scale motorized cassava grater. Several equipment manufacturers including engineering firms, small-scale artisanal shops, blacksmiths and mechanics have developed and produce various types of cassava processing equipment. For instance, the Dutch Agricultural Trading and Development Company (DADTCO) has developed a state-of-the-art technology that has been piloted in Nigeria and proven for the cassava industry so that high quality cassava flour (HQCF) can be produced at a competitive price. Despite some impressive technological achievement through development of new machinery and equipment and new products, cassava processing still continue to present daunting challenges in Nigeria. The nature of the processing equipment, their appropriateness to the cassava processing industry, constraints to the adoption of the technologies, the extent of the impact on the industrial performance have not been systematically and adequately investigated. There is no doubt that technological capability and innovation studies (Adeoti, 2006; Adeoti and Adeoti, 2009; NACETEM, 2010; Aderemi, 2010; IFPRI, 2010; Oluwale, 2010) have received attention in Nigeria. Other studies (Ajibola, 1988; IITA, 2007; Davies, 2008; FIIRO, 2008; Dada, *et al.*, 2007; Dada, *et al.,* 2010) on cassava have limited scope with relative scarce information about the capabilities and innovations in the Nigerian cassava processing industry. There is therefore

the need for a study on technological capability and innovations in the Nigerian cassava processing industry in order to increase value added products for cassava.

The following research questions will be answered in this study:

i. Are there technology needs in the Nigerian cassava processing industry?
ii. To what extent is technological capability available in the industry?
iii. What is the nature of innovations in the industry?
iv. What are the factors influencing technological capability and innovations in the industry?
v. To what extent have the technological capability and innovations impacted on the performance of the industry?

1.3 Objectives of the study

Generally, the research aims to investigate the technological capability and innovations in the Nigerian cassava processing industry with a view to proposing policy recommendations that can enhance the performances of the industry. The specific objectives are to:

i. assess the technology needs in the Nigerian cassava processing industry;
ii. examine the technological capability of the industry;
iii. establish the nature of innovations in the industry;
iv. investigate factors influencing technological capability and innovations in the industry; and
v. evaluate the impacts of the technological capability and innovations on the performance of the industry.

1.4 Expected Outcome of the Study

Effective linkages among cassava farmers, processors, food industries and markets are essential for exploring benefits of improved technologies in the cassava processing industry (Dada *et al.*, 2010). The information on the process of technological capability and innovations in the cassava processing industry will be provided in this study. This will provide appropriate information that could enhance proper policy formulation of the industry.

This study will provide adequate information on effect of the technological capability and innovations and strategy that can enhance the operations and business performance of the Nigeria cassava processing industry. The study could also provide information to relevant government agencies, knowledge institutions and industrial support organisations on the need to provide necessary technical assistance to upgrade the technology of the cassava processing industry. This study will also provide adequate information on technological capability needs of the Nigerian cassava processing industry.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.0 Preamble

This chapter will provide a methodological framework to systematically assess the technological capability and innovations in the Nigeria cassava processing industry. It draws literature on the systems of innovation, adoption model, technological capabilities and technology needs assessment. The chapter will be divided into the following sections: theoretical and conceptual frameworks; study variables and their measurements; model specification and data analysis; the study area; sample population and sampling techniques; and research instruments.

3.1 Theoretical Framework for the Study

To study technological capabilities, the basic elements need to be identified: the components, their attributes or functions, and their relationships (Carlsson *et al.*, 2002). As illustrated in Figure 3.1, capabilities are generated by complex interactions within firms, technological collaboration arrangements between competing and complementary firms, and through linkages with innovation-oriented organizations such as universities and research organizations (Kline and Rosenberg, 1986; Bell and Pavitt, 1993). Collaboration can be formal or informal (Storper and Venables 2004, Asheim *et al.*, 2007). Third, firms tend to move along particular trajectories within which past learning contributes to particular directions of technical change and the experience derived from those paths of change reinforces the existing stock of knowledge and expertise (Bell and Pavitt, 1993). Assessing the technological capabilities of a region is a function of its components, its capabilities and its interactions, and these might differ significantly between developed and developing countries. Any method assessing the role of the innovation system supporting the acquisition and development of technological capabilities in firms has to bring together both the firm and the regional technological capabilities (Padilla *et al.*, 2009).

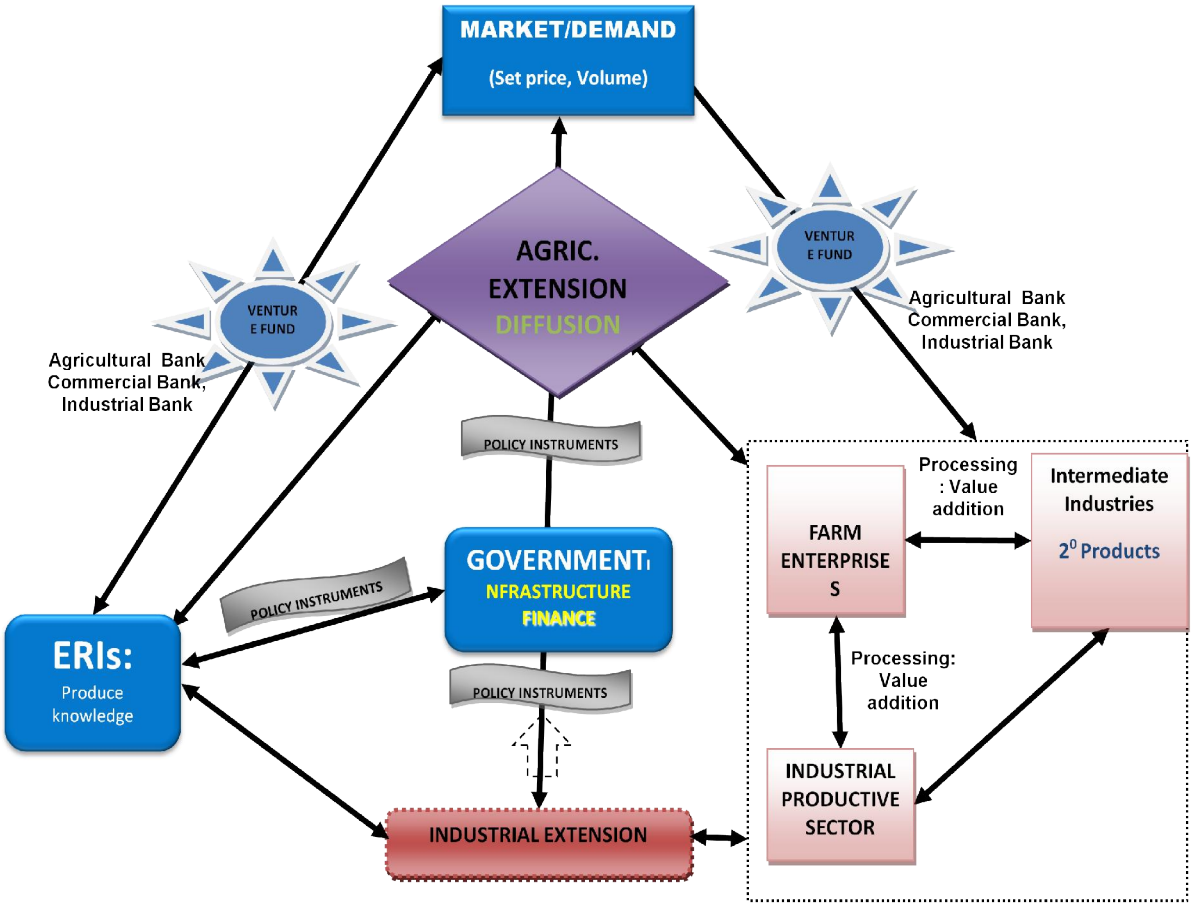

Figure 3.1: Structure of Interactions Among Actors of Agric. Systems of Innovation

Source: Tiffin (1997), Arnold & Bell (2001), Siyanbola (2010)

3.2 Conceptual Framework

In this study, the works of Tiffin (1997), Arnold and Bell (2001), Ragasa *et al.,* (2010), Siyanbola, (2010) will be adopted and modified for evaluation of the Nigeria cassava processing industry. Identifying all the actors who make up the cassava innovation system (CIS) and establishing their linkages is an important step in identifying who are involved and can contribute to continuous innovation of the system. Cassava system of innovation conceptual framework places great emphasis on understanding the nature of relationships between actors and the attitudes and practices that shape those relationships.

The framework (Figure 3.2) consisted of various actors who interact for the functional performance of the NCSI. For the purpose of this research, the following key actors shall be considered. These are Farm enterprise sub-sector, Government policy sub-sector, Knowledge institution sub-sector, Industrial production sub-sector and the finance sub-sector. The existence of technological capabilities and innovations will be measured by both internal and external factors. The effects of these innovations on the cassava industrial competition will then be analysed.

3.3 Study Variables and their Measurements

The actors of the NIS work together to develop, apply, fund and regulate science, technology and innovation (STI) with a view to solving industrial, environmental, economic and cultural needs (Tiffin, 1997). Continuous interactions among various users and producers

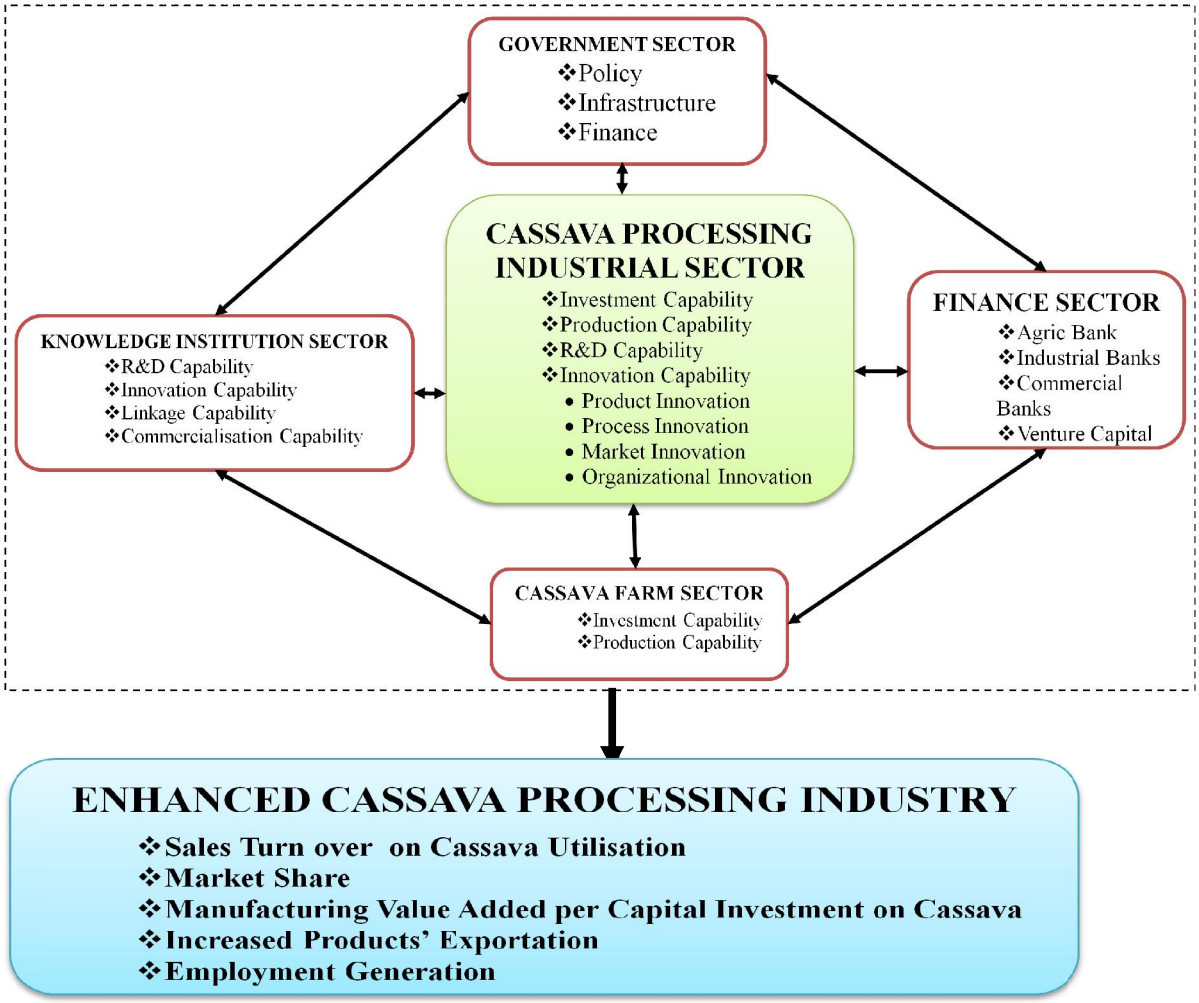

Figure 3.2: A Conceptual Framework for Enhanced Cassava Processing in Nigeria

Source: Adapted from Tiffin, (1997); Arnold and Bell, (2001); Ragasa *et al.*, 2010; Siyanbola, (2010)

Some of the parameters that will be evaluated in this study and how they will be measured are discussed as follows.

3.3.1 Interactive learning among the Actors of Cassava Innovation System (CIS)

The functioning of effective linkages especially amongst the main actors of innovation system, i.e., industry, research institute, and university is one of the key factors in enhancing innovation capacity of the cassava processing innovation systems. The extent of the linkages will be measured with variables such as: training and information dissemination services,

business development support services (business plan, market expansion), new product development, new process development, resolution of industrial problems, provision of information on utilization of cassava in the indusrial production, personal contact with the academic staff, Industrial fellowship, short term internship in the industry, personal contact with industrial staff, establishment of joint contract, personal contact with extension personnel.

3.3.2 Funding of Cassava R&D of Knowledge Institutions

In Nigeria, government is the major source of R&D funding. However, there are other funding sources from international funding agencies, commercial banks etc. Sources of funding to universities, research institutes and researchers will be elicited in this study. The number of companies that sponsor R&D of the KIs and researchers will be obtained. The role of the financial actor in the commercialisation process will also be investigated. The financial organisations who might have granted venture capital to the industry will also be ascertained.

3.3.3 Training and Retraining of Industrial staff

The existence and nature of training and retraining given by the knowledge institutions, extension agents; and the international organisations. This will reflect the extent of linkages among the actors of the CIS.

3.3.4 Industrial Utilisation of Cassava R&D outputs of the Knowledge Institutions

The study will examine the various methods by which the R&D outputs of the universities, research institutes and polytechnics are being made available and utilised by the industrial production sector in Nigeria. In the cases where the outputs had been utilised by the industry, the extent of commercialisation will be studied. The benefits to the knowledge institutions on the commercialisation of such outputs will also be investigated. The effects of the govenment policies on the exploitation and commercialisation by the industrial actors will be examined.

3.3.5 Extension Services and Farmers Training on New Technology

Effective communication and dissemination of research results as a mean of transferring technology to enable farmers to adopt the new technology will be studied. Training of farmers on the use of new technologies will also be studied.

3.3.6 Solving of problems in Cassava Processing Industry

The study will asses how the cassava processing industry will view the use of Nigeria universities and research instututes in solving problems been encountered during their operations. The study will investigate the type of indusrial comppanies that had approached the KIs for assistance in resolving their problems in the past.

3.3.7 Technological Innovation in the Cassava Processing Companies

For the purposes of this research, we shall deterrmine product innovation, process innovation, market innovation and organisational innovation of the companies.

3.3.8 Firms' Performance Factors

Another aspect that will be investigated in the research is the firms' competitiveness. Therefore, in accordance to Little (2004) we define competitiveness (from a company's perspective) as its ability to provide products and services more effectively and efficiently than relevant competitors.

3.3.9 The Influence of Technological Innovations on the Performance of Cassava Processing Firms

The influence of technological capability and innovations on performance of the cassava processing companies will also be considered in this study. This will be measured with the aid of regression analysis (r^2) and analysis of variance (F).

3.4.2 Impact of Technological Capability and Innovations on Firms' Performances.

Regression analysis will be employed for this purpose. The model will relate the dependent variable Sales Turnover on Cassava Utilisation (Y) to the independent variables. The Sales Turnover on Cassava Utilisation will be measure by means of a proxy variable which is quantity of cassava processed and utilised per annum measured in Naira. The independent variables include Install capacity of the firms (X_1), capacity-in-use in the firms (X_2), annual R&D expenditure of the firms(X_3), Linkages with R&D institutions(X_4), volume (kg) of exported processed cassava(X_5), new product development in the firms(X_6), new process development in the firms(X_7), type of business ownership(X_8), scale of business operations(X_9), in-service-training(X_{10}), government policy(X_{11}), trade association(X_{12}), respondent's highest level of education (X_{13}), years of work experience (X_{14}).

Mathematically, the models shall be specified as below with a view to achieving objective five of the study:

Objective 5: Evaluate the impacts of the Technological Capability and Innovations on the performance of the industry

Linear Function: $Y = \beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots + \beta_{14}X_{14} + \varepsilon$ …… (Equation 6)

Semi-Linear Function: $Y = \beta_o + \beta_1LnX_1 + \beta_2LnX_2 + \beta_3LnX_3 + \ldots + \beta_{14}LnX_{14} + \varepsilon$..(Equation 7)

Double Log Function: $LnY = \beta_o + \beta_1LnX_1 + \beta_2LnX_2 + \beta_3LnX_3 + \ldots + \beta_{14}LnX_{14} + \varepsilon$ (Equation 8)

Exponential Function: $Y = e^{\beta o + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots + \beta 14X14 + \varepsilon}$ ..... (Equation 9)

Where,

Y = Sales Turnover on Cassava Utilisation (Y),

X_i = vector of independent variables with *i* =1-14.

β_o = Constant

β_1 ... β_8 = regression co-efficient

ε = Stochastic term (error term)

The lead equation (least error term value) out of the four functional regression forms (equations 6-9) will be selected based on the best fit.

3.5 Data analysis

A multiple of analytical methods will be used to analyze the data in this study. These will include descriptive and inferential statistics. The descriptive data analysis will involve measures of central tendency. For the variables that will assess the respondents' perception on a likert scale, the degree of importance of each factor will be analyse using the Weighted Average Index (WAI). For the computation of WAI, 5 will be assigned to the highest level of perception on the likert scale while 1 will be assigned to the lowest level.

The inferential statistics will include regression analysis, correlation analysis and analysis of variance (ANOVA). The statistical analysis of the data will be carried out with the aid of Statistical Analytical Software (SAS). The analysis will include the respondents' bio-data-section, technological capabilities and innovations; competitition in the selected companies.

3.6 The Study Area

For the purpose of the study, the existing six development zones will be adopted as strata for data collection. In addition the Federal Capital Territory (FCT) will be treated as a zone on its own. A sample of three zones will selected for the survey, in addition to the FCT. Two states will then be selected from each zones with the exception of South west zone with four selected states. Benue and Kogi states will be selected from the North-Central Zone, Abia and Enugu states from the South East Zone. South west zone with Lagos, Oyo, Ogun, and Osun states. The choice of these zones and states is informed by the high concentrations of cassava production and

processing farms/firms, relevant R&D institutions, government policy institutions and agencies, relevant international agencies located in them. The need to extensively cover the states of the federations in this type of national research also informs the choice of these states.

3.7 Population, Sample and Sampling Techniques

The population for this study consists of all cassava farmers in Nigeria, all machinery fabricator, food industries; relevant departs in the universities and research institutes. Multi-stage sampling technique will be adopted for chosing these organizations. The organizations that will be sampled are as discussed below.

3.7.1 Farm Enterprise Sub-sector

In Nigeria, cassava has become primarily a commercial crop and small scale farmers continue to grow cassava although large scale farmers produce the bulk of the commercial crop. In order to elicit necessary information for this study, 300 cassava farmers will be randomly selected across the country through cassava farmers association of Nigeria. Relevant information will be gathered from the farmers.

3.7.2. Government Policy and Regulatory Sub-sector

The government policy and regulatory actors of the CIS that are involved in regulating S&T research and their industrial exploitation will be sampled in this study. A set of questionnaire will be administered on these actors to elicit necessary information on the interactions between actors and the strength of the links taken by the government to facilitate the building of knowledge-based economy. A total of 50 copies of questionnaire will be administered with one copy of questionnaire on each institution.

3.7.3 Knowledge Institution Sub-sector

In Nigeria, public R&D institutes are expected to undertake different lines of research that are of commercial applicability. These institutes vary in their mandates and sizes but derive their funding mainly from government sources. For the purpose of this study, 10 universities will be selected. These will comprise of the 3 Nigerian Universities of Agriculture, 2 Universities of Technology and 5 conventional Universities). The research institutes are Federal Institute of Industrial Research, Oshodi (FIIRO), Lagos, National Root Crop Research Institute (NRCRI), Umudike, National Agency for Science, Engineering and Infrastucture (NASENI), Abuja; Project Development Agency (PRODA), Enugu. The International Institute for Tropcal Agriculture (IITA), Ibadan will also be selected for their roles in the development of Tropical Manioc Species (TMS) in the mid-1980s. One set of questionnaire will also be administered on the relevant research institutes and departments/faculties of the universities. Relevant information on the processing of cassava will be elicited from these institutions and institutes.

3.7.4 Industrial Production Sub-sector

In Nigeria, the industrial development is characterised by low capacity utilisation; low contribution to Gross Domestic Product; low contribution to SMEs total industrial production and weak linkages between SMEs and large-sized firms; absence on local industrial R&D. However, the Nigerian government is encouraging private sector participation in developing technologies for expanded use of cassava as raw materials in the food and non-food industries (Dada *et al.*, 2010). In order to obtain information on the activities of the cassava industrial production sub-sector, a set of questionnaire will be administered on 150 firms relative to the number of actors in each of the categories in this industry. The companies will be puposively selected.

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