INTERACTIONS BETWEEN UNIVERSITIES AND FIRMS: RESULTS OF THE SURVEY OF NIGERIAN MANUFACTURING FIRMS

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Working Paper
1 April 2008

IDRC Project Number: 103470-009
IDRC Project Title: Knowledge for development: University-firm interactions in sub-Saharan Africa
Country/Region: South Africa, Nigeria and Uganda

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ABSTRACT

The contribution of universities and public research institutes to economic development depends on the extent to which firms are able to employ the knowledge they generate. In Nigeria fostering interaction between universities and firms has been a major challenge. This paper reports a survey of Nigerian manufacturing firms aimed at ascertaining the level and scope of firms' interaction (or lack of interaction) with universities and public research institutes, and their implications for building local technological capability. The results of the study showed that while firms have used existing production processes to manufacture products that are new to Nigeria, R&D capability is still relatively weak. Universities and research institutes took the least position in the perception of firms as sources of information and knowledge that had resulted in new projects or completion of existing innovative projects. Firms generally perceive the quality of R&D in the universities and research institutes to be low, and hence depend largely on their limited in-house R&D. It thus follows that building local technological capability would require raising the quality of R&D in universities and research institutes, and active promotion of collaborative R&D projects between firms and universities/research institutes.

Keywords: university-firm interaction, R&D, manufacturing, Nigeria

INTERRACTIONS BETWEEN UNIVERSITIES AND FIRMS: RESULTS OF THE SURVEY OF NIGERIAN MANUFACTURING FIRMS

1. Introduction

The role of knowledge in economic development cannot be over-emphasized in an increasingly competitive global economy. The contribution of universities and public research institutes to economic and social progress depends on the extent to which firms are able to employ the knowledge they generate to improve firm performance. In Nigeria fostering interaction between universities and firms has been a major challenge. There has been no evidence of significant collaborations between universities and firms (Brautigam 1997; Oyeyinka 1997; Okejiri 2000; Adeoti 2002, 2005). The survey reported in this paper is part of the Africa regional study under the IDRC RoKS programme. The regional study is primarily concerned with an analysis of the changing role of universities as contributors to economic growth and development in sub-Saharan Africa. The survey is aimed at ascertaining the level and scope of firms' interaction (or lack of interaction) with universities and public research institutes, and how this has impacted on the building of local technological capability at the firm level.

The increasing role of knowledge poses challenges to developing economies and their universities as sources of growth that are both similar and different to those faced by advanced countries (OECD 2000; World Bank 2002; Arocena and Sutz 2004; Bloom et al 2005). Theoretical and empirical analyses using the national systems of innovation framework suggest that developing countries that have grown in knowledge generation and use are characterised by productive interactions between universities and firms in networks (Lundvall 1992; Nelson 1993; Kim, 1997; Lall, 2001). However, the relationships of the 'knowledge economy' cannot simply be transplanted from the North to the South. In Africa, the emphasis on knowledge only makes sense if it helps to reduce poverty, the biggest problem for the majority of countries in Africa. It is therefore worthwhile to analyse different articulations of the linkages between universities as knowledge producers and firms as knowledge users, across countries in Africa specifically, where there has been little systematic analysis to date. This report presents the analysis of the Nigerian case as a first step of the cross-country comparative analysis of the African regional study.

The survey focussed on manufacturing firms in Southwest Nigeria and examined the nature and the scale of firms interractions with universities and public reesearch institutes from the perspective of firms. A similar survey has been used in the state of Minas Gerais, Brazil (Albuquerque *et al* 2005). The questionnaire instrument used for the Brazillian survey was an adaptation of that used for a survey undertaken at Yale (Klevorick *et al* 1995) and Carnegie Mellon (Cohen *et al* 2002). The questionaire was further revised to suit the Nigerian context in order to ensure comparability, both within

Africa and between the three developing regions that are involved in the IDRC RoKS project.

The report is organized as follows: the next section presents an overview of the links between knowledge and development with a focus on university-firms interactions; section three presents the research methodology; section four discusses the results of the study; and the final section concludes the report with the summary of findings.

2. University-Firms Interaction: An Overview

Universities are known to be centres of knowledge generation and training for community development. In the linear model of innovation, public research especially in the universities generates basic knowledge, which leads to inventions, and inventions when commercialized becomes innovation. From this simplistic view of the innovation process, the research activities in the universities and public research institutes are isolated from industry. Industrial research and development (R&D) activities that contribute to the technological change required for economic progress are often located outside the ivory towers. It has however been amply demonstrated that interactions among industrial stakeholders must be part of the innovation process (Davis & Carden, 1998). Besides, several studies that illustrated the national system of innovation (NSI) framework have proven that economies that are innovation driven (i.e. knowledge economies) are characterized by evident university-industry collaborations especially in strategic sectors of the economy. The university-industry linkages in such contexts are important feature of interactions among the actors that are involved in the generation and use of technological knowledge. The ability to undertake innovative research and apply its output is complex and embedded in a context of inter-organizational relationships. In advanced industrial economies, the interactions between firms and universities are regarded as products of a developmental orientation of research activities as research is aimed at addressing community problems and in many instances research grants are won in competitive bids. For developing countries, the scope and dimension of community oriented research may not be as elaborate as in developed countries. However, there is a growing concern that universities in the South should be alert to the development challenges in their communities and begin a drive to making research and training activities relevant to the immediate societal needs. In the NSI framework, the educational and training system and the industrial establishments are expected to interact and be involved in mutually beneficial knowledge exchanges that engender innovation. A developmental university in this context would be actively involved in a network of agents that create new products and services or new models of achieving economic objectives. In essence, a developmental university would not only generate new knowledge that improves the stock of knowledge, but also produce change agents that carry knowledge into society and motivate society to employ and build on knowledge from the ivory towers. While the firm is the centre of the innovative activities in the NSI (Kim, 1997), the developmental university interacts with all other elements of the NSI to

create critical skills and impetus for the entrepreneurial functions required to make innovation the engine of growth.

It is also important to note that network relationships are dynamic and changing. Accordingly, the conditions for establishing university-firms interactions tend to differ at national levels. For example, in the United States, university, industry, and government are becoming less isolated from each other. In many Latin American countries industries and universities, formerly under strict governmental control, are gaining relative autonomy from the state. In Europe the unification process paradoxically leads to enhancement of the regional and transnational levels of governance simultaneously, with different effects on network relationships in the various member states (Gibbons et al, 1994; Mytelka, 1998). It is in this regard that Gibbons *et al* (1994) perhaps observed that a redefinition of the public/private divide has come into focus within the interactions in a knowledge-based economy. This is because academic knowledge is a public good, whereas entrepreneurship requires conditions for private appropriation. In contrast to neo-liberal expectations, the direction is thus not toward laissez-faire. There is therefore an important but not dominant role for government and an enhanced role for the university within the spheres of the network relationship needed to sustain innovation activities. (Leydesdorff and Etzkowitz, 2001).

3. Methodology

3.1. Scope of the study

The scope of the study covered the major manufacturing subsectors in Nigeria. These include food, beverages and tobacco; chemical and allied products; pharmaceuticals; rubber and plastics products; paper, printing and publishing; metal and aluminum products; textiles and garments products; wood products and furniture; non-metallic mineral products; and electrical and electronics products.

3.2. Sampling, data collection and sources

There is currently no reliable data on firms' distribution in Nigeria, hence stratified sample is difficult to obtain. Manufacturing firms in Nigeria are known to exist in three main industrial clustering axes, namely:

cluster 1: Lagos-Agbara-Otta-Ibadan-Ilorin
cluster 2: Nnewi-Aba-Port Harcourt
cluster 3: Kano-Kaduna-Jos

Cluster 1 has at least 60% of Nigerian firms in number and value addition (LASEPA, etc.). Nigeria is a relatively expansive country covering an area of 924,000 sq. km. The three industrial clustering axes are geographically dispersed. To ensure good quality data collection within the limits of available resources for the study we selected cluster 1 for the study. Besides, the location of more than half of the firms in cluster 1 suggests that the survey would have significantly captured and gathered information on the essential features of the Nigerian manufacturing firms.

The lists of establishments engaged in manufacturing activities in cluster 1 were collected from the State offices of the National Bureau of Statistics (NBS) located in cluster 1. These states included Lagos, Ogun, Oyo, Ondo, Osun, and Kwara states. Though the lists are fairly comprehensive (except for Lagos State) and all have addresses of the locations of firms, they are not precise on key information required for selecting a stratified sample. The format for the lists is not uniform and not all has the required information on type of manufacturing and firm size. Based on perceived industrial concentration in each of the states 220 firms were selected for questionnaire lodgement as follows: Lagos -100; Ogun -40; Oyo -20; Ondo -20; Osun -20; Kwara -20. For each state, the sample selection was random, but guided by the perceived firm size and sub-sectoral distribution of firms in each state.

Enumerators were recruited and trained for the firm survey. When a firm originally included in the survey sample could not be located or was non-responsive to the survey, such a firm was replaced with a firm of similar characteristics in the same sub-sector. At the end of the survey, we had 153 questionnaires retrieved out of which 14 were rejected because of inadequate responses. Thus the final research sample comprises of 139 firms.

3.3. Data analysis

Data analysis carried out in this report is largely descriptive, using measures of central tendency. For the variables that assessed the respondents' perception on a likert scale of 1 ("not important") to 4 ("very important"), the degree of importance of each factor is analyzed using the weighted average index (WAI). For the computation of WAI, 4 is assigned to the highest level of perception on the likert scale while 1 is assigned to the lowest level. In effect, if for a particular factor all respondents claim the highest degree of importance (i.e. "very important"), then the WAI would be 4.0 while the same would be 1.0 if all respondents claim the lowest degree of importance (i.e. "not important"). The weighted average index is expressed as:

$$WAI = \frac{\sum_{i=1}^{4} F_i W_i}{N}$$

where
F_i is the frequency of response;
W_i is the weight or number assigned to the response on the likert scale; and
N is the total number of responses.

4. Results and Discussion

4.1. Characteristics of the research sample

Table 1 shows the sectoral distribution of the research sample. More than half of the sample belongs to the food, beverages & tobacco; metal and aluminum products; and chemical and allied products contributing 23%, 17%, and 13% of the sample respectively. In literature, firms have been diversely classified into small, medium and large-scale enterprises, either based on sales turnover, capital outlay or persons employed. In Africa, firms employing less than 10 persons are generally regarded as microenterprises. Firms employing 10 to 49 persons are usually considered small-sized, 50 to 199 medium-sized, and firms employing 200 or more persons are regarded as large-sized (Winston, 1981; Liedholm, 1992; Lall *et al*, 1994; Oyeyinka, 1997). Following this classification, table 2 presents the size distribution of firms in the research sample. 26% of the firms are small-sized, 43.5% are medium-sized, while 30.5% are large-sized.

Table 1. Sectoral distribution of the research sample

Sector	Frequency	Percent	Cumulative percent
Food, beverages & tobacco	32	23.0	23.0
Chemical & allied products	18	12.9	36.0
Pharmaceuticals	13	9.4	45.3
Rubber & plastics	13	9.4	54.7
Paper/printing/publishing	10	7.2	61.9
Metal & aluminum products	24	17.3	79.1
Textiles & garments	15	10.8	89.9
Wood products & furniture	4	2.9	92.8
Non-metallic mineral products	8	5.8	98.6
electrical & electronics	2	1.4	100.0
Total	**139**	**100.0**	

Source: Analysis of field data

Table 2. Size distribution of firms in research sample

Size (no. of persons employed)	Frequency	Percent
10-49	34	26.0
50-199	57	43.5
200 or more	40	30.5
Total	**131**	**100.0**
Missing cases	8	

Source: Analysis of field data

4.2. Innovation and R&D activities

4.2.1. Introduction of new products and processes

Table 3 presents the nature of the new or improved products and processes introduced by the sampled firms in the last three years prior to the survey. Except for the case of the

introduction of products or processes that are new for Nigeria but not new for the world, the trend in the product and process changes is fairly similar. Product or process changes that are new to the world are rare among the sampled firms. This is a common feature of immature nationally system of innovation (NSI) as represented by the case of Nigeria. No new product has been introduced by 18% of the respondents, improvement of the existing product was carried out by 74%, about 24% introduced products that are new for the firm but not new for Nigeria, while about 16% has introduced products that are new for the country but not new for the world. No new process has been introduced by 15% of the respondents, 77% has introduced improved processes, about 24% has introduced processes that are new for the firm but not new for Nigeria, while only about 9% has introduced processes that are new for Nigeria but not new for the world. It is apparent from these results that introduction of "products that are new for Nigeria, but not new to the world" is more common than the introduction of "processes that are new for Nigeria, but not new for the world". It thus appears that firms in the research sample are able to manufacture some new products without necessarily embarking on significant process changes.

Table 3. Nature of new or improved products and processes

Nature of innovation	Percent of respondents	
	Product*	Process*
No new product or process	18.1	15.1
Improvement on existing product or process	74.1	77.0
New for firm, but not new for country	23.7	23.7
New for country, but not new for the world	15.8	8.6
New for the world	2.2	2.2

* the sum of this column is not equal to 100 because each response may have more than one option as the nature of the product or process introduced

Source: Analysis of field data

4.2.2. Organization of firms' R&D

Table 4 shows the distribution of the estimated percent of annual sales turnover invested in R&D "in-house" by the sampled firms. The mean estimated percent invested is 1.65% while the median is 0.8%. 41.2% of the respondents have no R&D investment, about 19% invested not more 1.0% of their turnover in R&D, 14% invested between 1.01 and 2.0%, 7% invested between 2.01 and 3.0%, only 1.7% invested between 3.01 and 4.0%, and 11.4 invested between 4.01 and 5.0%. About 5% of the respondents invested more than 5 %. Only one firm indicated the highest estimated investment of 11% while three firms indicated an estimated investment of 10%. As shown in table 5, about 30% of the R&D are carried out in centralized R&D departments. However it is important to also note that most of the R&D is occasional or non-continuous R&D activities. Overall, 44.7% of the R&D is regular or formal type while 55.3% is of the occasional or non-formalized type R&D. A simple cross-tabulation of type of R&D (regular or occasional) by per cent of annual turnover invested in R&D showed that there is some measure of

correlation between the two variables with an indicative Spearman correlation significant at 0.02% level. The higher levels of R&D expenditure are associated with the more regular or formal type of R&D organization.

Table 4. Distribution of the estimated percent of annual turnover invested in in-house R&D

Percent of annual turnover invested	Percent of respondents
0	41.2
0 – 1.00	19.3
1.01 – 2.00	14.1
2.01 – 3.00	7.0
3.01 – 4.00	1.7
4.01 – 5.00	11.4
> 5.00	5.3
Total	**100**
N	**114**
Mean	1.65
Median	0.8

Source: Analysis of field data

Table 5. Organization of firm R&D

Type of R&D organization	Percent of respondents
Regular (continuous) and centralized in a R&D department	30.3
Regular (continuous) and decentralized R&D activities	14.4
Occasional (non-continuous) and centralized in a R&D department	25.0
Occasional (non-continuous) and decentralized R&D activities	30.3
Total	**100.0**

Source: Analysis of field data

4.2.3. Reasons for not investing in R&D

As earlier indicated, 41.2% of firms in the research sample claimed that they have not invested in R&D in the past three years. Table 6 presents the results of these firms' perception of reasons for not investing in R&D. The reasons were rated on a four-level likert scale spanning 1 (for "not important") to 4 (for "very important"). The weighted average index of the responses demonstrate that the importance of universities and public research institutes are rated very low as locations of substitute R&D that could serve as reasons for lack of firms' in-house R&D. As indicated by the weighted average index, the three most crucial reasons (in order of perceived importance) for lack of investment in R&D by firms are insufficiency of external sources of information for innovation, lack of access to credit, and high cost of R&D. Other reasons that are considered more than

"slightly important" by firms are "R&D is not necessary for the firm's innovation" and "R&D investment is too risky".

Table 6. Firms' perception of reasons for not investing in R&D

Reason for not investing in R&D	Weighted average index
The firm does not innovate	1.8
Small market size disallow recovery of R&D invest.	1.9
R&D investment is too risky	2.1
R&D is too costly for the firm	2.3
Lack of access to credit	2.4
Difficulties to appropriate R&D results	1.8
Lack of public support	1.8
R&D is not necessary for the firm's innovation	2.2
External sources of info are sufficient for innovation	2.6
Universities substitute firm's R&D	1.4
Public research institutes substitute firm's R&D	1.6

Source: Analysis of field data

4.3. Sources of information and knowledge

4.3.1. Sources of information or knowledge benefiting innovative activities

There are several sources of information and knowledge that contributes to firm's innovative activities. The decision to employ an information source largely depends on firm's ability to process, adapt and assimilate new knowledge. Firms were provided with a list of various sources of information and knowledge, and they were requested to indicate which of the sources had benefited the firm's innovative activities, in terms of suggestion of new projects or contribution to the completion of existing projects in the last three years. Figure 1 presents a comparison of the firms responses on how each of the sources of information and knowledge had either suggested new projects, or contributed to the completion of existing innovation projects.

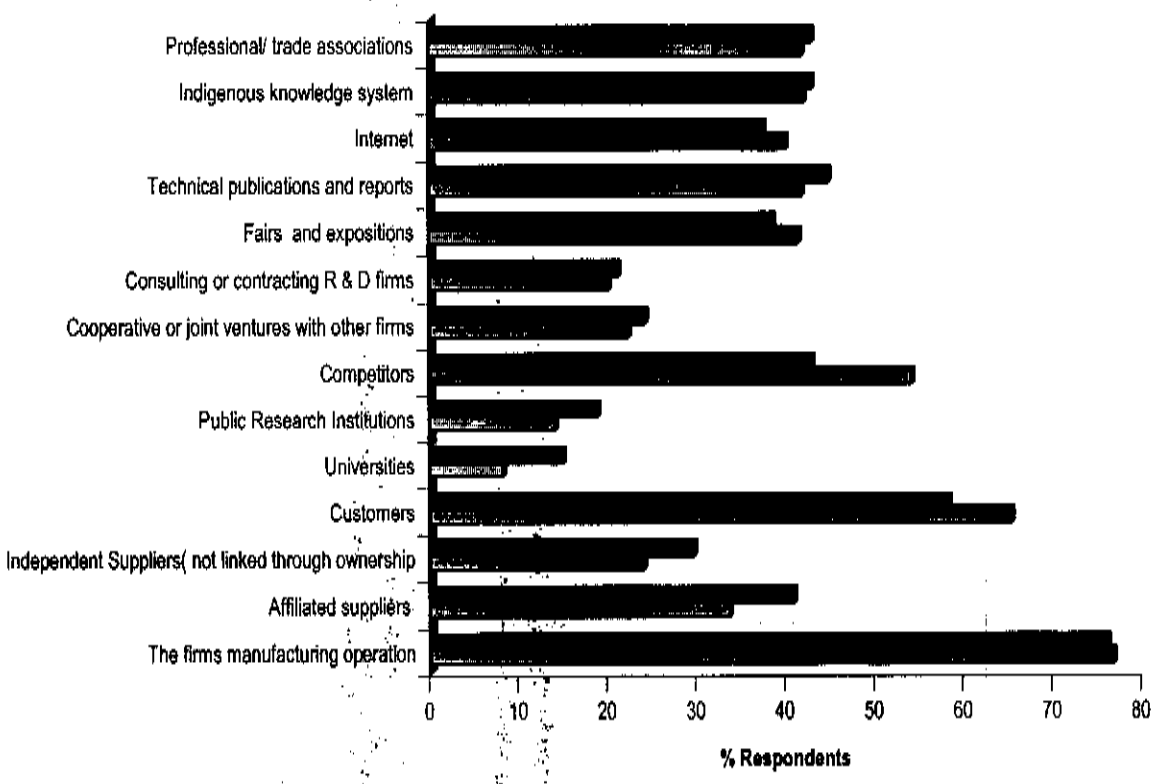

Figure 1: Sources of information and knowledge

Over 70% of the sampled firms indicated that the firms' manufacturing operations were a source of information for the suggestion of new projects as well as a source that had contributed to completion of existing projects. Customers were perceived by nearly two-thirds (65.3%) of the respondents as sources of information for the suggestion of new projects, while about 58% of the firms perceived customers as contributors to the completion of existing projects. Competitors were indicated by about 54% of the sampled firms as sources of information for new projects, while only about 43% of the respondents perceived that competitors had been sources of information that contributed to the completion of existing projects. Universities took the least position in the perception of firms as a source of information and knowledge that had resulted in the

suggestion of new projects (8.1%) and contributed to the completion of existing projects (14.9%). The responses on firms' perception of the research institutes were only slightly better. Only 14% of the respondents considered public research institutes as sources of information on new projects while only about 19% of the respondents claimed that research institutes had been sources of information that contributed to the completion of existing projects. These results suggest that universities and research institutes had not been major sources of information and knowledge that contributed to the innovative activities of the sampled firms.

Figures 2 and 3 show the distribution of the respondents perception of the most important sources of information and knowledge for the suggestion of new projects and for completion of existing projects respectively. For the suggestion of new projects, 32.1% of the respondents claimed customers as the most important source of information, 21.7% claimed firms' manufacturing operations, while affiliated suppliers (suppliers linked through ownership such as parent, sister or subsidiary firm) was indicated by 9.4% of the respondents. For the contribution to the completion of existing projects, 30.4% of the respondents viewed firms' manufacturing operations as the most important source of information, 17.6% indicated customers, while 11.8% mentioned affiliated suppliers (suppliers linked through ownership such as parent, sister or subsidiary firm) as the most important source of information. It thus appears that the three leading sources of information and knowledge for the suggestion of new projects are also the three leading sources of information and knowledge that contributed to the completion of existing innovative projects. It is also noteworthy that universities and research institutes are least considered as most important sources of information and knowledge by the respondents. In fact, none of the firms considered universities as most important source for information for completing existing innovation projects.

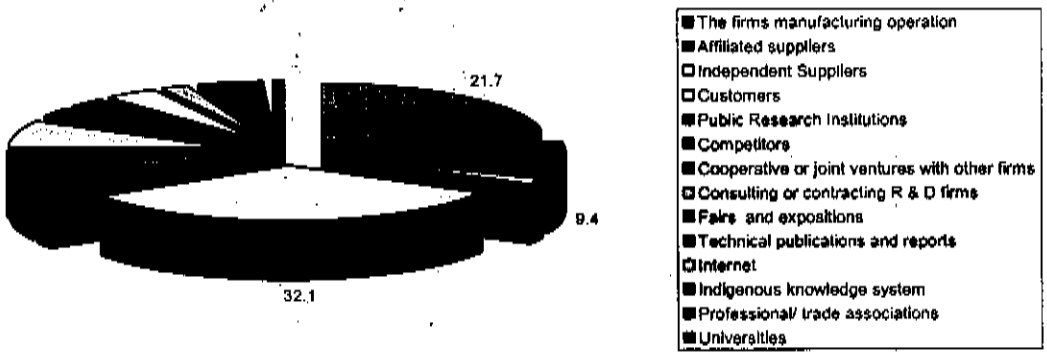

Figure 2. Distribution of most important source of information for the suggestion of new projects

Figure 3. Distribution of most important source of information for the completion of existing projects

4.3.2. Why universities and public research institutes are not important sources of information for innovation

The responses given by the sampled firms on why universities and research institutes are not important sources of information for innovation were rated on a four-level Likert scale spanning 1 ("not important") to 4 ("very important). Table 7 presents the results of the weighted average index analysis of the responses. The two reasons with the highest WAI of 2.3 suggest that universities and research institutes are not rated as important sources of information for innovation because firm's R&D are considered enough to innovate and the quality of research in universities and research institutes are considered low. Added to this, reasons that are perceived by the respondents as more than "slightly important" as indicated by the WAI of 2.2 include the lack of understanding of firms' line of business by universities and public research institutes, and universities' focus on big science. Other reasons mentioned in table 7 have WAI less than 2.0, suggesting that they are generally perceived by the sampled firms to be less than "slightly important" as explanations for why universities and research institutes are not important sources of information for innovation. In effect, the distribution of the responses showed that most of the respondents claimed the reasons listed in table 7 to be either "not important" or "slightly important".

Table 7. Firms' perception of reasons why universities and research institutes are not important sources of information

Reasons	Per cent of respondents				WAI
	1	2	3	4	
Our firm's R & D is enough to innovate	42.9	12.1	20.9	24.2	**2.3**
Universities have no understanding of our line of business	39.4	24.5	16.0	20.2	**2.2**
Public Research Institutions have no understanding of our line of business	39.8	21.5	14.0	24.7	**2.2**
Contractual agreement difficult	49.5	25.3	11.0	14.3	**1.9**
Lack of trust	54.9	22.0	7.7	15.4	**1.8**
Quality of research is low	38.3	21.3	13.8	26.6	**2.3**
University concerned with only big science	46.7	12.0	18.5	22.8	**2.2**
Geographic distance	65.2	12.0	7.9	9.0	**1.6**
Dialogue is very difficult	62.2	14.4	15.6	7.8	**1.7**
Intellectual property issues	53.8	16.5	18.7	11.0	**1.9**

Source: Analysis of field data

4.3.3. Channels of information and modes of interactions

The results of the weighted average index (WAI) analysis for the sampled firms' rating of the importance of channels of information about R&D activities or innovations of other firms are shown in table 8. The WAI ranged between 2.0 and 2.9. This indicates that each of the listed channels of information is considered to be at least "slightly important". The two channels of information that have highest degrees of importance are "publications and report" and "public conferences and meetings" each with WAI equal to 2.9. "Informal information" and "fairs and expositions" are also perceived with considerable degree of importance with each having a WAI of 2.7. The channels of information that have the lowest ratings are "joint or cooperative R&D projects" and "contract research with other firms" with WAI of 2.0 and 2.1 respectively. It thus appears that the most important channels of sharing information about R&D activities and innovations are not channels that enable close interactions or joint investments in R&D projects.

Table 8. Rating of the importance of channels of information about R&D activities or innovations of other firms

Channels of information	Weighted average index
Patents	2.3
Publications and reports	2.9
Public conferences and meetings	2.9
Informal information exchange	2.7
Recently hired technical personnel	2.4
Licensed technology	2.2
Joint or cooperative R&D projects	2.0
Contract research with other firms	2.1
Products (for example, by reverse engineering)	2.5
Trade associations	2.3
Fair and expositions	2.7

Source: Analysis of field data

Table 9 presents the results of the weighted average index analysis of the rating of the importance of channels of information and modes of interactions about the research activities or research findings of universities and research institutes. For most of the channels of information, the ratings of the importance have identical WAI for both universities and research institutes. This suggests that the sampled firms' perception of the importance of the channels of information for universities and research institutes may not be significantly different. The results also demonstrate that, as in the case of respondents' interaction with other firms, the importance of "publications and reports" and "public conferences and meetings" have the highest ratings as channels of

information and modes of interactions that have contributed to the respondent firms' innovative activities. The level of importance is however slightly higher for universities with WAI of 2.7 and 2.6 compared to WAI of 2.6 and 2.5 for the responses for research institutes.

For the universities, other channels of information viewed by the respondents as important and having WAI of at least 2.0 include licensed technology, informal information exchange, recently hired graduates with advanced degree, patents, and consulting with individual researchers with WAI of 2.3, 2.1, 2.1, 2.0 and 2.0 respectively. Similarly, for research institutes, other channels of information viewed by the respondents as important and having WAI of at least 2.0 include licensed technology, informal information exchange, and patents each of which has a WAI of 2.0. For both universities and research institutes firm ownership (WAI=1.3) and spin-offs (WAI=1.3) were considered least important as channels of information by the respondents firms. Incubators were also considered to have very low importance as channels of information by the respondent firms. Thus, firms owned by universities or research institutes, spin-offs, and incubators scored relatively low in terms of the importance of their contribution to the innovative activities of the respondent firms. Overall, the results in table 9 demonstrate that arms length relationships predominate.

Table 9. Channels of information and modes of interactions about the research activities of universities and research institutes

Channels of information/ Modes of interactions	Weighted average index	
	Universities	Research institutes
Patents	2.0	2.0
Publications and reports	2.7	2.6
Public conferences and meetings	2.6	2.5
Informal information exchange	2.1	2.0
Recently hired graduates with advanced degree	2.1	1.9
Licensed technology	2.3	2.0
Consulting with individual researchers	2.0	1.9
Contract research with universities	1.7	n.a
Contract research with research institutes	n.a	1.7
Joint or cooperative R&D projects	1.6	1.6
Participation in networks that involve universities	1.6	n.a
Participation in networks that involve research institutes	n.a	1.6
Temporary personnel exchanges	1.6	1.5
Incubators	1.4	1.4
Science and/or technology parks	1.9	1.9
Firm is owned by an university (URE)	1.3	n.a
Firm is owned by a research institute	n.a	1.3
Firm is a spin-off of an university	1.3	n.a
Firm is a spin-off of a research institute	n.a	1.3

n.a. = not applicable

Source: Analysis of field data

4.3.4. Use of the research outputs and resources from universities and research institutes

Table 10 shows the results of the weighted average index (WAI) analysis of firms' perception of the degree of importance of the usefulness of research outputs and resources over the last three years preceding the survey. New techniques and instruments were rated highest with WAI equal to 2.7. Research findings and laboratories/metrology have WAI of 2.4 and 2.3 respectively while prototypes have WAI of 1.9. These results indicate that the degree of importance of the usefulness of prototypes to the innovative activities of the respondent firms is less than "slightly important", whereas other research outputs or resources are considered to be more than "slightly important".

Table 10. Firms' perception of the importance of the use of research outputs or resources

Research outputs or resources	Weighted average index
Research findings	2.4
Prototypes	1.9
New techniques and instruments	2.7
Laboratories/Metrology	2.3

Source: Analysis of field data

4.4. The relevance of science and engineering fields to firms' innovative activities

Building technological capability depend on the accumulated knowledge and existing opportunities for skills acquisition. The science and engineering fields where knowledge generation and use thrive provide the basis for ascertaining the extent to which a national economy is prepared for absorption, adaptation and assimilation of foreign knowledge. In this respect it is not just the science and engineering fields that are important, but rather the functional science and engineering fields that have particular relevance to the economy. In the case of this study, the science and engineering fields that are relevant to the innovative activities of the firm in the past ten years are the main concern. For the sampled firms, table 11 presents the weighted average index of the importance of the contribution made by science and engineering fields to firms' innovative activities. Science and engineering fields that are generally perceived more than "slightly important" by firms as contributors to innovative activities (in order of importance) are computer science, mechanical engineering, chemical engineering, electrical engineering, industrial design, engineering materials and metallurgy, food science and technology, and chemistry. Other science and engineering fields listed in table 11 are generally rated not more than "slightly important" by the respondents in the research sample.

Table 11. Firms' perception of the contribution of science and engineering fields to firms' innovative activities

Science and engineering field	Weighted average index
Agronomy	1.5
Computer Science	2.6
Food Science and Technology	2.2
Biology	1.9
Industrial Design	2.3
Civil Engineering	2.0
Engineering of Materials and Metallurgy	2.3
Mining Engineering	1.4
Electrical Engineering	2.4
Mechanical Engineering	2.5
Chemical Engineering	2.5
Physics	1.6
Geosciences	1.4
Mathematics	1.8
Medicine	1.6
Veterinary	1.5
Chemistry	2.2
Pharmacy	1.6
Petroleum Engineering	1.7

Source: Analysis of field data

4.5. Collaboration with universities and public research institutes

The results reveal a generally low response rate of less than 30% to the question asking the respondent firms to indicate the degree of importance of the objectives of collaborations with universities and public research institutes. This confirms the findings of previous studies (e.g. Brautigam 1997; Oyeyinka 1997; Okejiri 2000; Adeoti 2002, 2005), which indicated that collaborations between firms and universities/public research institutes are not common in Nigeria. Table 12 shows the results of the weighted average index (WAI) analysis of the respondent firms' perception of the degree of importance of the objectives of collaboration. The objectives "to help in quality control" and "to perform tests necessary for products/processes" were rated as at least "moderately important" by most respondents with WAI equal to 2.9 and 2.7 respectively. This was followed by the objectives "to get technological/consulting advice from researchers and/or professors in solving production related problems" with WAI equal to 2.3 and "to contract research helpful to the firm's innovative activities (complementary research by universities and public research institutes)" with WAI equal to 2.3. Also regarded as more than "slightly important" by most of the respondents are the objectives "to use

resources available at universities and public research institutes", "to augment the firm's limited ability to find and absorb technological information", and "to get information about engineers or scientists and/or trends in R & D in the field" with WAI equal to 2.2, 2.2, and 2.1 respectively. Next to these is the objective of technology transfer from the university which was rated as "slightly important" with WAI equal to 2.0. However, to contract research that the firm cannot perform (substitutive research by universities and public research institutes) as well as to make earlier contact with excellent university students for future recruiting were rated less than "slightly important" by most of the respondents as indicated by the WAI of 1.9 and 1.8 respectively.

Generally speaking from the analysis above, it can be concluded that most of the respondents did not consider the objectives of collaboration mentioned above as "very important" or "moderately important". Majority of the objectives for collaboration are rated as either "slightly important" or "not important". This further shows that there is relatively weak collaboration between firms and universities/public research institutes in Nigeria.

Table 12. Objectives of collaboration with universities/public research institutes by order of importance

Objectives of Collaboration	Weighted average index
Technology transfer from the university	2.0
To get technological/consulting advice from researchers and/or professors in solving production-related problems	2.3
To get augment the firm's limited ability to find and absorb technological information	2.2
To get information about engineers or scientists and/or trends in R & D in the field	2.1
To contract research helpful to the firm's innovative activities (complementary research by universities and public research institutes)	2.3
To contract research that the firm cannot perform (substitutive research by universities and public research institutes)	1.9
To make earlier contact with excellent university students for future recruiting	1.8
To use resources available at universities and public research institutes	2.2
To perform tests necessary for your products/processes	2.7
To help in quality control	2.9

Source: Source: Analysis of field data

As shown in table 13, 27% of the respondents claimed that the objectives of collaboration has been met in their respective firms while a fewer proportion (16.2%) reported that collaboration has not been successful to meet the set objectives. Also, 43.2% of respondents with on-going collaboration in their firms believed that the collaboration

would be successful while 13.6% in that category were pessimistic about the likelihood of success of the on-going collaborative efforts between universities/public research institutes and their firms.

Table 13. Level of success of collaboration between firms and universities/research institutes

Level of success	Frequency	Percent
Collaboration has been successful to meet the objectives	10	27.0
Collaboration not successful to meet the objectives	6	16.2
Collaboration is on but trust that the objectives will be met	16	43.2
Collaboration has not been completed and do not expect the objective to be met	5	13.6
Total	**37**	**100.0**
Missing cases	102	

Source: Analysis of field data

The major reasons why collaboration with universities/research institutes failed to meet the expected objectives are analyzed in table 14. The findings show that "science orientation" of the researchers at the universities/research institutes is the least important reason for the failure of collaborations between firms and universities/research institutes. It thus appears that the lack of collaboration between firms and universities is not because researchers are not interested in deepening knowledge. The three factors that ranked highest as reasons why collaborations failed provide insights into the actual rationales for failure of collaborations. As demonstrated by the weighted average index analysis, the three reasons that ranked highest (in order of importance) are: low sensitivity of universities to firm's demands; mismatch between knowledge available at the university/ research institutes and that needed by the firm; and researchers at the universities/research institutes are too "science oriented" with WAI equal to 2.1, 2.0 and 2.0 respectively. Other reasons mentioned in table 14 were claimed to be less than "slightly important" by most of the respondents. It should also be noted that most of the respondents claimed that the reasons listed for failed collaboration in table 14 are less than "moderately important". Besides, none of the respondents indicated that any of the reasons is "very important".

Table 14. Reasons for failure of collaboration with universities/public research institutes

Reasons why collaboration failed to meet expected objectives	Weighted average index
Mismatch between knowledge available at the university/ research institutes and that needed by the firm	2.0
Differences in timing	1.8
Differences in points of view and/or objectives	1.9
Researchers at the universities/research institutes are too "science oriented"	2.0
Researchers at the universities/research institutes are not enough "science oriented"	1.3
Low sensitivity of universities to firm's demands	2.1
Differences regarding the appropriability of the results of	1.8

the collaborative project (intellectual property issues)	
Lack of preparation of firm's personnel to deal with university	1.8

Source: Analysis of field data

The results in table 15 show that 40% of the respondents that collaborated reported that the periods of collaboration were "not important, so far". The results also show that 25% of the respondents considered their collaboration with universities and research institutes to be important for upwards of over ten years. Only 10% of the respondents claimed collaboration to have been important for less than ten years, while 12.5% of the respondents claimed that their collaboration with universities and research institutes had been important for less than five years. 12.5% of the respondents also claimed that their collaboration with universities/research institutes had been important for less than two years. These results suggest that collaboration with universities and research institutes had so far not been important among a considerable proportion of the firms that collaborated.

Table 15. Period of important collaboration with universities/public research institutes

Period	Frequency	Percent
Not important, so far	16	40.0
Less than two years	5	12.5
Less than five years	5	12.5
Less than ten years	4	10.0
More than ten years	10	25.0
Total	**40**	**100.0**
Missing cases	99	

Source: Analysis of field data

4.6. Role of universities

Higher education is seen as a storehouse of knowledge and it is expected to pursue the goal of knowledge accumulation through teaching, research and dissemination of information. Lately, the emphasis on developmental role of universities as knowledge institutions that make critical inputs into the emerging knowledge economies has resulted in entrepreneurial and social orientations becoming important features of the knowledge outputs of the ivory towers. For the research sample firms, table 16 shows the results of the evaluation of the roles of universities by the respondent firms. The weighted average index (WAI) analysis revealed that the research function is rated highest with WAI equal to 2.8. This is followed by the entrepreneurial role with WAI equal to 2.6. Teaching and social roles have WAI equal to 2.5 each. These results generally indicate that most of the respondents considered the four identified roles of universities to be of appreciable importance for their firms.

Table 16. Role of universities/public research institutes by order of importance

Roles of universities	Weighted average index
Teaching	2.5
Research	2.8
Social	2.5
Entrepreneurial	2.6

Source: Analysis of field data

5. Summary of findings

The results of the study show that introduction of "products that are new for Nigeria, but not new to the world" is more common than the introduction of "processes that are new for Nigeria, but not new for the world". It thus appears that firms in the research sample are able to manufacture some new products without necessarily embarking on significant process changes. The mean estimated percent of sales turnover invested in R&D is 1.65% while the median is 0.8%. 41.2% of the respondents have no R&D investment, about 19% invested not more 1.0%.of their turnover in R&D, 14% invested between 1.01 and 2.0%, 7% invested between 2.01 and 3.0%, only 1.7% invested between 3.01 and 4.0%, and 11.4 invested between 4.01 and 5.0%. About 5% of the respondents invested more than 5 % with maximum investment of 11%. It is also noteworthy that about 30% of the R&D are carried out in centralized R&D departments. However, most of the R&D is occasional or non-continuous R&D activities. As indicated by the weighted average index, the three most crucial reasons (in order of perceived importance) for lack of investment in R&D by firms are insufficiency of external sources of information for innovation, lack of access to credit, and high cost of R&D.

Universities took the least position in the perception of firms as a source of information and knowledge that had resulted in the suggestion of new projects (8.1%) and contributed to the completion of existing projects (14.9%). The responses on firms' perception of the research institutes were only slightly better. Only 14% of the respondents considered public research institutes as sources of information on new projects while only about 19% of the respondents claimed that research institutes had been sources of information that contributed to the completion of existing projects. These results suggest that universities and research institutes had not been major sources of information and knowledge that contributed to the innovative activities of the sampled firms. The three leading sources of information and knowledge for the suggestion of new projects are also the three leading sources of information and knowledge that contributed to the completion of existing innovative projects. These leading sources are customers, firms' manufacturing operations, and affiliated suppliers (suppliers linked through ownership such as parent, sister or subsidiary firm). It is also noteworthy that universities and research institutes are

least considered as most important sources of information and knowledge by the respondents. In fact, none of the firms considered universities as most important source for information for completing existing innovation projects. Generally speaking, universities and research institutes are not rated as important sources of information for innovation possibly because firm's R&D are considered enough to innovate and the quality of research in universities and research institutes are considered low. An alternative interpretation of the results could suggest that firms have no clue what universities and research institutes are doing. Ultimately, in-depth case studies of university-firm interactions may provide clarification of these contrasting hypotheses.

The two channels of information that have highest degrees of importance as means of sharing information about R&D activities or innovations of other firms are "publications and report" and "public conferences and meetings" each with WAI equal to 2.9. "Informal information" and "fairs and expositions" are also perceived with considerable degree of importance with each having a WAI of 2.7. The channels of information that have the lowest ratings are "joint or cooperative R&D projects" and "contract research with other firms" with WAI of 2.0 and 2.1 respectively. It thus appears that the most important channels of sharing information about R&D activities and innovations are not channels that enable close interactions or joint investments in R&D projects.

For most of the channels of information, the ratings of the importance have identical WAI for both universities and research institutes. This suggests that the sampled firms' perception of the importance of the channels of information for universities and research institutes may not be significantly different. The results also demonstrate that, as in the case of respondents' interaction with other firms, the importance of "publications and reports" and "public conferences and meetings" have the highest ratings as channels of information and modes of interactions that have contributed to the respondent firms' innovative activities. However, firms owned by universities or research institutes, spin-offs, and incubators scored relatively low in terms of the importance of their contribution to the innovative activities of the respondent firms.

Science and engineering fields that are generally perceived more than "slightly important" by firms as contributors to innovative activities (in order of importance) are computer science, mechanical engineering, chemical engineering, electrical engineering, industrial design, engineering materials and metallurgy, food science and technology, and chemistry.

Most of the respondents did not consider the objectives of collaboration as "very important" or "moderately important". Majority of the objectives for collaboration are rated as either "slightly important" or "not important". This further shows that there is relatively weak collaboration between firms and universities/public research institutes in Nigeria. Moreover, only 27% of the respondents claimed that the objectives of collaboration has been met in their respective firms while a fewer proportion (16.2%) reported that collaboration has not been successful to meet the set objectives. Also, 43.2% of respondents with on-going collaboration in their firms believed that the collaboration would be successful while 13.6% in that category were pessimistic about

the likelihood of success of the on-going collaborative efforts between universities/public research institutes and their firms.

The results suggest that lack of collaboration between firms and universities is not because researchers are not interested in deepening knowledge. The three factors that ranked highest as reasons why collaborations failed provide insights into the actual rationales for failure of collaborations. As demonstrated by the weighted average index analysis, the three reasons that ranked highest (in order of importance) are: low sensitivity of universities to firm's demands; mismatch between knowledge available at the university/research institutes and that needed by the firm; and researchers at the universities/research institutes are too "science oriented".

40% of the respondents that collaborated reported that the periods of collaboration were "not important, so far". The results also show that 25% of the respondents considered their collaboration with universities and research institutes to be important for upwards of over ten years. Only 10% of the respondents claimed collaboration to have been important for less than ten years, while 12.5% of the respondents claimed that their collaboration with universities and research institutes had been important for less than five years. 12.5% of the respondents also claimed that their collaboration with universities/research institutes had been important for less than two years. These results suggest that collaboration with universities and research institutes had so far not been important among a considerable proportion of the firms that collaborated.

The results of the evaluation of the roles of universities by the respondent firms showed that the research function is rated highest with WAI equal to 2.8. This is followed by the entrepreneurial role with WAI equal to 2.6. Teaching and social roles have WAI equal to 2.5 each. These results generally indicate that most of the respondents considered the four identified roles of universities to be of appreciable importance for their firms.

In conclusion, it is important to stress that the findings of the study demonstrated that university-firms interaction in Nigeria is generally weak from the perception of firms. Firms' interaction with public research institutes showed a remarkably similar character as the interaction with universities. The challenge of firms' collaboration with universities and/or public research institutes on R&D or innovation projects is thus largely an issue of how to remove the constraints on the interactions between firms and universities/public research institutes.

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