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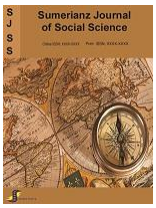

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Issues and Challenges of Research and Experimental Development: Experience of Emerging Economy

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Abstract

Research and Experimental Development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. Every scientific investigation is marred with challenges. Hence, this study examined R&D indicators and the expert experience of R&D survey in Nigeria. The study made use of primary data through questionnaire administration. A total of 75 Universities and 75 Research Institutes were surveyed, 49 universities and 51 research institutes returned their responses. Out of the number returned, 23 universities and 45 research institutes perform R&D. The analysis of data was done with the application of descriptive statistics. The results of the analysis showed the input in terms of human resources and collaboration within the key R&D institutions. It was revealed that there were more male R&D personnel than female in all categories. The M/F ratio was more than 3:1. A total of 633 publications were produced in the various fields of R&D during the reference period. About 42% was from Agricultural sciences, 20.5% from the natural sciences. Engineering accounted for 19.1% while medical sciences and social sciences accounted for 11.8% and 6.5% respectively. Collaborative R&D was carried out with other higher education institutions both in Nigeria and abroad. Only four universities were reported to perform collaborative R&D with foreign NGOs while 11 were reported to conduct collaborative R&D with public research institutes. Results also showed that poor record keeping and retrieval system among institutions and lack of understanding of key terminologies and concepts are the major challenges of R&D activities in country. The study concluded that more R&D personnel are needed in the country, most especially female researchers. It is also concluded that more collaborative R&D activities with local and foreign research institutes will assists in sustainable development.

Keywords: Research and experimental development; Challenges; Research institutes; Collaboration.

1. Introduction

1.1. Background and Literature Review

The role of research and development (R&D) in economic growth is pertinent to every national and international development. R&D has been defined as the "creative work undertaken on a systematic basis to increase the stock of knowledge... and the use of this stock of knowledge to devise new applications" (OECD, 1994). R&D activities are grouped into three distinct types: basic research, applied research and experimental development. Frascasti Manual (2002), defines basic research as “experimental or theoretical work undertaken primarily to acquire new knowledge… without any particular application or use in view (p.77)”. National Science Foundation defines it as “original investigation for the advancement of scientific knowledge…which does not have immediate commercial objectives” (Adams, 1990). These distinctions imply that basic research is fundamental to knowledge breakthroughs. Studies have shown that R&D has a significant role on productivity of firms von Zedtwitz (2005); Govindaraju (2010). Every R&D activities have its-own issues and challenges (Mazurkiewicz and Poteralska, 2015). Observed inquiry supports that R&D increases multi-factor productivity OECD (2001a); Mazurkiewicz and Poteralska (2015). Scholars have shown that there is a link between the conduct of R&D and the ability of countries, sectors and firms to identify and adapt new technologies Talegeta (2014); Mazurkiewicz and Poteralska (2015) .

The R&D input in the current study was measured by human resources and financial indicators. Similar indices has been used in many studies to establish status of R&D in organizations Santoro *et al.* (2018). Each of these factors also constitutes barriers to R&D activities in Nigeria. Collaboration among firms and institutions also affects the success of the R&D activities (Review, 2012). Besides the determinants of R&D collaboration also included the type of collaborations and collaboration partners within the key sectors as well as expenditure Talegeta (2014); Franklin

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et al. (2015); Reeves (2016). In large countries, R&D helps increase the rate of innovation, while in smaller countries; R&D may primarily facilitate the transfer of technology from abroad. Country studies suggest that a 1% increase in the stock of R&D leads on average to a rise in output between 0.05-0.15percent (OECD, 2001a). The R&D intensity of countries and their growth performance tends to be correlated with the share of research financed by business (OECD, 2001a). In principle, long-term economic development is driven by the accumulation of knowledge-based factors of production such as R&D and human capital which prevent the borderline return to physical capital from falling below profitable levels (von Zedtwitz, 2005).

Econometric Specialists found that social rates of return to R&D can be up to five times higher than private rates of return Salter *et al.* (2000); von Zedtwitz (2005); United Nations (2006). The basic and applied research which governments fund and conduct through public universities and institutes is itself an influence on the level of research and development (Guellec and Van, 2000). Furthermore, funding of university R&D has been established to have a positive effect on the knowledge generated through public research Guellec and Van (1999); Mazurkiewicz and Poteralska (2017).

R&D activities are grouped into three distinct types: basic research, applied research and experimental development. Frascasti Manual (2002), defines basic research as "experimental or theoretical work undertaken primarily to acquire new knowledge… without any particular application or use in view (p.77)". National Science Foundation defines it as "original investigation for the advancement of scientific knowledge…which does not have immediate commercial objectives" (Adams, 1990). These distinctions imply that basic research is fundamental to knowledge breakthroughs. Economists and policy makers have long debated its role on productivity. According to Coe *et al.* (2009) succeeding studies on this issue are scarce. Hence, a study that captures basic versus applied and experimental knowledge across all R&D performing institutions is lacking.

2. Methodology

This study contains the results of the 2006/07 Research and Experimental Development (R&D) Survey, the first of its kinds in Nigeria. The survey follows essentially the Frascati Manual developed by the Organisation for Economic Co-operation and Development (Frascasti Manual, 2002). The manual proposes the standard practice for surveys on research and experimental development. The survey was a census of universities established before 2006 and government research institutes. The study made use of primary data through questionnaire administration. A total of 75 Universities and 75 Research Institutes (RI) were surveyed, 49 universities and 51 research institutes returned their responses. Out of the number returned, 23 universities and 45 research institutes perform R&D. The R&D survey collects data mainly on the input into R&D activities performed In-house and that Outsourced by the research institutes and higher education institutions. Data gathered was analyzed using Statistical Package for Social Sciences (SPSS) version 17.

3. Results and Discussion

Table-Ia. Higher Education (HE) R&D Expenditure by Occupation

R&D Personnel	**N'000**	**Percentage**
Researchers	13,752.1	59.1
Administrative Staff	3,127.2	13.4
Executive & Managerial Staff	2,662.1	11.4
Technicians/Technologists	2,423.9	10.4
Masters Students	1,291.6	5.6
Total	**23,256.8**	**100.0**

Table-Ib. Labour Cost of Postgraduate Students

		Percentage
Post –doctoral	114.1	5.6
Doctoral	633.8	31.1
Masters	1,291.6	63.3
Total	**2,039.6**	**100.0**

Total labour cost in Nigeria's universities in 2006/07 was over 23 billion naira. On researchers, the universities spent an average of over 13 billion naira out of a total labour cost of about 23.3 billion naira. This translates to about 60% of total R&D labour cost. The lowest amount was expended on technicians/technologists translating to about 11.0% of R&D labour cost (Table 1a). On postgraduate student R&D, the universities spent a total of about 2 billion, 63.3% of which was accounted for by research Masters' degree students. Doctoral and post-doctoral researchers accounted for the remaining 40.0% (Table 1b). This fund mainly includes research grants, most of which come from external NGOs. Other current expenditure was over 1 billion while capital R&D expenditure was over 5 billion naira.

Table-2. HE R&D Expenditure by Source of Funds

Source of Funds	**₦'000**
Government	28,092.0
Non-Governmental Organizations	791.6
Foreign Sources e.g. World Bank, Carnegie Corp.	467.5
Donations and Requests from Individuals	292.4
Other Higher Education Institutions	1.2
Total	**29,717.5**

Table 2 clearly shows that government is almost totally responsible for funding R&D in Nigerian universities. Government funding through budgetary allocation and university funds accounted for 94.5% of R&D expenditure. Other sources of funds include foreign (1.6%), non-governmental organisations (2.7%) and individual donations (1.0%).

Table-3. HE R&D Expenditure by Type of Research

Type of Research	**Percentage**
Basic Research	48.0
Applied Research	30.0
Experimental Development	22.0
Total	**100.0**

Among Nigerian universities, basic research accounted for over 48.0% of total expenditure on R&D, applied research accounted for 30.0% while experimental development accounted for about 22.0% (Table 3).

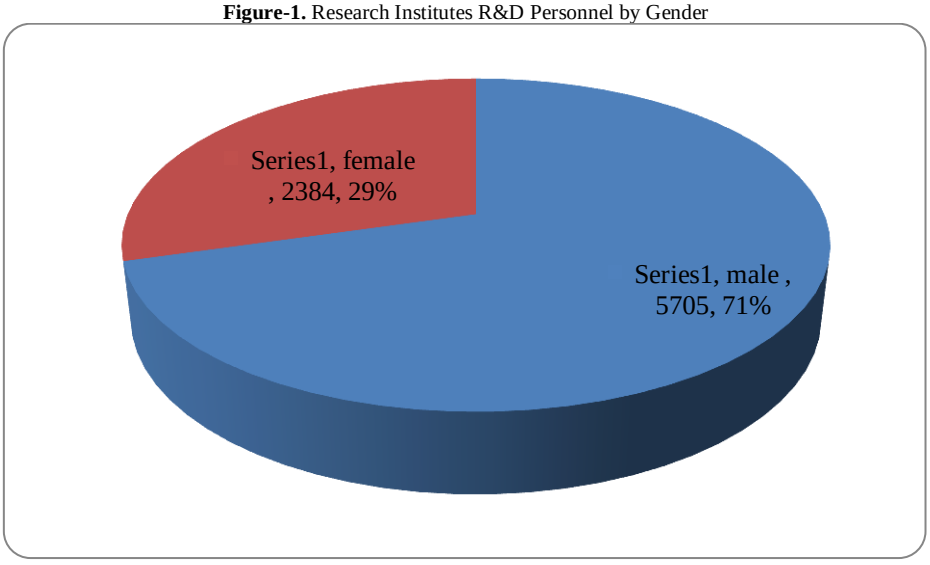
3.1. R&D Expenditure

Table-4. HE R&D Expenditure by Field of Research

Research Field	**Percentage**
Sciences	31.9
Engineering/Technology	28.5
Agriculture	20.7
Social Sciences	8.6
Medical/Health Sciences	7.6
Humanities	2.7
Total	**100.0**

When broken down by academic discipline, it is seen that the highest proportion (31.9%) of the R&D expenditure was expended on the sciences. This includes biological sciences, physical sciences, chemical sciences, mathematical sciences, earth sciences and environmental sciences. This was followed closely by engineering/technology (28.5%), Agriculture (20.7%), social sciences (8.6%), Medical Sciences (7.6%) and humanities (2.7%). Engineering/technology includes applied sciences and technology, information technology, and material sciences (Table 4).

Figure-1. Research Institutes R&D Personnel by Gender



There were more male R&D personnel than female in all categories. In almost every case, the M-F ratio was more than 3:1. This shows a gender imbalance in R&D personnel in Nigerian research institutes. Altogether, there were a total of 5705 male and 2384 female R&D personnel.

Table-5. RI R&D Personnel by Headcount and FTE

Occupation	Headcount		Total HC	FTE
	Male	Female		
Researchers	1435	450	1885	1112.1
Technologists	1257	411	1479	813.5
Executives	396	167	531	270.8
Administrative	2617	1356	3659	1866.0
Total	**5705**	**2384**	**8089**	**4062.4**

The amount of time spent on research by different categories of R&D personnel varies. In research institutes, researchers spent about 59.0%, technologists (55.0%), executives (50.9%) and administrative support staff (51.0%). It is noted that time spent on research in research institutes is more than that of the universities. This is because training takes a significant amount of time of researchers in universities.

3.2. R&D Collaboration

Table-6. Characteristics of Collaborative R&D Activities in Nigerian Universities

Collaboration Partners	No of Universities	
	Nigerian	Foreign
Higher Education Institutions		
Training, Consultancy, Research, Funding and Infrastructural Support	12	8
Science Councils		
Training, Consultancy, and Funding support	4	2
Government Research Institutes		
Training, Consultancy, Funding, Research and Infrastructural Support	11	1
Affiliated Companies		
Training, Consultancy and Research	4	0
Other Companies		
Training, Consultancy and Funding	6	0
Non-Governmental Organizations		
Training and Consultancy	4	1

The extent of collaborative R&D efforts among Nigerian universities was assessed by asking direct questions on whether or not the institutions collaborated and with whom. The overall frequency of collaborations by universities is generally low and largely confined within the national borders. Collaborative R&D was carried out by the universities mostly with other higher education institutions both in Nigeria and abroad. Only four universities reported doing collaborative R&D with foreign NGOs while 11 reported doing collaborative R&D with public research institutes in Nigeria. It was generally observed that collaboration with all stakeholders took the form of training, consultancies, funding and research partnerships.

4. Challenges Encountered During the Study

The outcome of the R&D indicator survey depends largely on the characteristics of the National Innovation System (NIS). For instance, the total number of R&D personnel will be directly proportional to the number of institutions where R&D activities are carried out. This typically includes universities and research institutes. Consequently, the R&D landscape in a country will invariably reflect national peculiarities. The characteristics of Nigeria's NIS have been discussed earlier; this section thus focuses on only the specific national peculiarities that will help in the interpretation and understanding of the findings of this survey.

5. Data Collection

First, it was noted that not all the institutions that supplied the headcount of personnel by qualification supplied the same figures by age. Thereby, the total personnel by qualification is not equal to that of age. Follow-up was rather expensive and time consuming. Thus, the summary figures have been taken from the headcount by qualification, which was established to be more reliable. Considering the challenge that was noted here, it is imperative therefore to propose that relevant authorities that have administrative oversight over the institutions that the R&D survey covers should maintain a computerized up-to-date database of their personnel and of other important indicators such as funding and Intellectual Property (IP) records. In the case of universities, this responsibility will be that of the NUC; and in the case of the research institutes it will be that of the Federal Ministries of Science and Technology, Agriculture, Health and Power. Additionally, institutions themselves need to maintain adequate electronic databases rather than merely keep paper-based records from which the authorities could obtain figures for national planning purposes. In many institutions, data were gleaned from several disjointed records including various files kept by different departments and divisions which varied widely from one institution to the other.

Generally, we obtained better and more reliable data from the research institutes under the Federal Ministry of Agriculture. This is largely so because these institutions have been involved in the collection of agricultural R&D

indicators, through a multinational initiative of the International Food Policy Research Institute (IFPRI), Rome Office, referred to as Agricultural Science, Technology and Innovation Indicators Initiative (ASTIII). The experience and capacity they have built from these previous exercises actually facilitated their response to our survey.

The response rate from the Universities was largely affected by the prolonged national strike of the major Academic and Non-Academic Unions in the universities, particularly the Academic Staff Union of Universities (ASUU), Senior Staff Association of Nigerian Universities (SSANU) and the Non-Academic Staff Union of Universities (NASUU). The labour unrest disrupted the retrieval of the questionnaires because most of the officers and staff who could provide the information needed were on strike. In view of this, it became almost impossible to retrieve any questionnaire from the universities at a particular period of time. The only exceptions were those in the private universities who were not affected by the strike. As a result of this, the project used several methods to improve the response rate such as getting data from secondary sources. However, when this approach was used, attempts were made to get authorization from the institutions concerned before using the data.

During the data collection exercise, it was also observed that most of the newer universities were reluctant to complete the questionnaire because they believed that they had little or no R&D activities to report. Additionally, several institutions had the understanding that since the survey was collecting data on S&T indicators, disciplines such as the arts and humanities should be excluded. This is obviously not in agreement with the provisions of the Frascati Manual which regards R&D as a universal effort. Extra efforts had to be made, therefore, to enhance responses from the institutions in this regard. Nonetheless, the overall data provided by institutions was apparently skewed in favour of the core sciences.

6. Adaptation of Methodology

It was found that some of the respondents did not understand the key terminologies of the survey instruments despite the inclusion of definitions of key terms in the questionnaire coupled with the explanations of field officers. Another issue to note concerns the researchers' Full Time Equivalent (FTE). FTE measures the amount of time used by researchers in conducting research within the normal working time. This constituted a major challenge because there was no demarcation between the time devoted to research and training in most of the universities in Nigeria. Although, Fafunwa (1971), stated that time allocated to academics in universities can be shared as follows: 50% to teaching, 30% to research, 10% to university community and the remaining 10% to the community, however this was not the rule observed in most of these institutions. Also, different categories of R&D personnel spent different amount of time on research. However, the fact that there is a dearth of facilities for R&D in Nigerian institutions made it even worse (Oyelaran-Oyeyinka, 2005; Oyewale, 2005), particularly, the poor state of utilities such as electricity and internet connectivity has given rise to a situation in which a considerable proportion of researchers carry out a sizeable portion of their work after normal working hours, during weekends or even on holidays. As a result, researchers spend less time on research during the normal working time. It therefore becomes difficult to ascertain the correct estimation of FTE for academics. In order to overcome this challenge, a study was conducted to find out the amount of time devoted to research among researchers in the universities and research institutes. This gave a good estimate of the FTE for researchers in Nigeria.

Also is the issue of classification of researchers. In the Nigerian context, most Master's degrees are research-based and they have been included in the analyses. This is different from the general practices of the OECD countries which restrict researchers to students undergoing doctoral training only. The common thinking among these countries is that the research component of Masters Degree is either non-existent or insignificant. Also, our survey instrument did not clearly distinguish between research Master's degrees and Master of Philosophy (MPhil). It simply included a 'Master's category among the postgraduate students. It is therefore possible that some universities would have excluded MPhil from their submissions thus; the total R&D personnel might have been slightly under-estimated. Additionally, there were several researchers who are involved with more than one institution. This is particularly true in the case of universities where some lecturers spend extended leave periods (such as sabbatical leaves or accumulated leave periods) in institutions other than the ones where they are fully employed. Thus, the headcount of R&D personnel could have been over-estimated in some cases. It is expected that the methodological approach to this survey will consistently develop with every subsequent round of survey.

7. Conclusion

Science, Technology and Innovation indicators give new insights into innovative and economic performance globally. STI-related analysis has traditionally focused on inputs (such as expenditures on R&D) and outputs (such as patents, publications). However, the interactions among the actors involved in STI development, investments in R&D and the translation of inputs to outputs are critically important. The survey of STI indicators also helps to understand the linkages or web of interaction within the overall National Innovation System. This study has brought to the fore that the systematic measurement of R&D presents new challenges to the country. R&D activities have distinctive characteristics depending on the sector. This is a reflection of the heterogeneity of structures and the concentration of R&D by institution, sector and even project. Human capital potential for R&D was discovered to be low for a country with population of over 140 million. It also creates a huge challenge not for the ability of the country to undertake R&D at the present but also in the future.

Cirera (2017) opined that innovation is widely seen as central to the growth of developing countries, and available evidence suggests that the returns to R&D investment should be extremely high. Yet low-income countries

invest very little. The findings from our research shows that most of the universities funding on R&D in Nigeria comes from the Government. Very low percentages are from foreign aids and non-governmental organisations

8. Suggestions for Further Study

It is worth mentioning that the exclusion of some tertiary institutions, including Polytechnics and Colleges of Education, from the survey at the outset was due to the stringent application of the recommendations of the Frascati Manual. However, it is imperative to argue that some of the national inputs and investments in S&T are made in these institutions and that they deserve a place in the measurement of national R&D efforts. In subsequent rounds of the survey, this is an issue to which closer attention will be paid. Taken together, these issues suggest the need for a version of the Frascati Manual specifically tailored towards the peculiarities of Africa, very much like what the Latin American nations did in creating their own version of the Oslo Manual; the so-called Bogota Manual.

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