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# **Academic Entrepreneurship of Technological Universities and Sustainable Development in Nigeria**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author ADD was involved in the design of the study, literature searches, co-ordinated the data collection, statistical analysis and wrote the first draft of the manuscript. Author TMO co-ordinated the activities of the research team was involved in the design of the study, edited the first draft of the manuscript. Author OAJ participated in the design of the study, literature searches, involved in data collection, analysis and report writing. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Universities are recognised as important sources of knowledge for critical innovative performance of industries through commercialisation of their Research and Development (R&D) outputs otherwise called Academic entrepreneurship. This paper examines the approaches and extent of Academic entrepreneurship of the Federal Universities of Technology in pursuit of sustainable development in Nigeria. The study adopted survey technique with population of all the lecturers in the Universities. A sample size of 528 researchers/lecturers were drawn from the rank of Senior Lecturer to Professor in 16 relevant Departments of the Federal Universities of Technology, Akure (FUTA), Owerri (FUTO) and Minna (FUTM) with a response rate of 67.07%. Descriptive statistics such as percentage and mean; and regression analysis as inferential statistics were employed for data

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analysis. The result of analysis revealed that a multiple of R&D outputs generated by the researchers are academic publications (100.0%), copyrights (12.2%), industrial designs (11.40%), patents registered in Nigeria (4.60%), patents registered outside Nigeria (1.6%). Only 20.95% of the researchers claimed to have commercialised their R&D outputs through outright sales of R&D outputs (76.67%), sales of patents (18.33%); and joint venture with industries (8.33%). The regression analysis of data revealed that the academic entrepreneurial and innovative performance of the researchers were influenced by access to research fund ( $\beta=36.49$ ,  $p \leq 0.01$ ), R&D and innovation incentives ( $\beta = 36.67$ ,  $p \leq 0.05$ ), government policy implementations ( $\beta = 36.67$ ,  $p \leq 0.05$ ), infrastructure and research facilities ( $\beta = 36.67$ ,  $p \leq 0.05$ ), business technical support services ( $\beta = 36.67$ ,  $p \leq 0.01$ ), industrial patronages ( $\beta = 36.67$ ,  $p \leq 0.05$ ), industrial partnerships and collaborations ( $\beta = 36.67$ ,  $p \leq 0.05$ ) entrepreneurial drive of the researchers ( $\beta = 36.67$ ,  $p \leq 0.05$ ), field of research ( $\beta = 36.67$ ,  $p \leq 0.05$ ); and business advisory services ( $\beta = 36.67$ ,  $p \leq 0.05$ ). All the variables contributed 29.74% ( $R^2 = 0.2974$ ) to the academic entrepreneurial and innovative behaviours of the researchers. The study also showed that the contributions of the academic entrepreneurship to sustainable development are improved product/process quality (67.32%), utilisation of local raw material (61.97%), eco-innovation (60.73%), product diversification (54.81%), research-industry partnership (49.05%), increased production capacity (47.22%); and generation of new employment (44.18%). The paper concluded that, there is a marginal improvement in the academic entrepreneurship for sustainable development in Nigeria. However, the need for policy intervention to encourage greater and adequate R&D funding support by government and private organisations is required.

*Keywords: Research and development; commercialization; universities of technology; researchers; technological innovations; entrepreneurship; sustainable development.*

## 1. BACKGROUND INFORMATION

The increasing role of knowledge creation through Academic entrepreneurship or commercialisation of Research and Development (R&D) outputs has accentuated the strategic importance of Universities on sustainable development. R&D are creative efforts undertaken on systematic basis in order to increase the stock of knowledge and its applications for economic benefits of mankind [1,2,3]. In developed and emerging economies, Universities are recognised as important sources of knowledge for critical innovative performance of industries. Universities foster national economic development through diverse strategies as direct commercialisation of R&D outputs, establishment of technology incubators and science parks with a view to nurturing spin-off firms. The Universities' spin-offs are new businesses whose venture is to translate knowledge developed within Universities into commercialisable products [4]. Such institutions include Massachusetts Institute of Technology (MIT) and Harvard University in United States of America (USA), Cambridge University in United Kingdom (UK), Hebrew University in Israel, Gothenburg University in Sweden; and Industrial Technology Research Institute (ITRI) in Taiwan. The three reasons for interest towards policy

support for such Universities in Western economies are the need to transfer new knowledge into the market, the pursuit of revenue for Universities as well as the positive impact on the local communities through the promotion of innovative enterprises. Moreover, the need to transfer new knowledge to the industrial sector of the economy to meet societal needs has created a platform for Universities to fulfil the third mission objective known as community services [5,6]. However, this objective remains unachievable until a country pays adequate attention to the development and promotion of R&D and innovations. Innovation, which is the introduction of new products, processes or services, delivers the economic benefits of R&D outputs [7,8,9]. This occurs where R&D is demand-driven and infrastructure for research commercialisation is available to knowledge institutions [10,11]. Innovation plays a central role within the knowledge-based economy and this has led to greater policy attention being paid to the process of technology innovation and diffusion by industrial sector [12,13].

There exists positive relationship among Research, Development and Innovation (RDI) capabilities on the one hand and economic growth, sustainable development and global competitiveness of any economy on the other

hand [14,15,16,17,18]. The effects of knowledge outputs are facilitated through commercialisation of research results and provision of highly educated technological entrepreneurial-oriented individuals in knowledge institutions. The R&D outputs can become income-generating activities when they are made relevant to the entrepreneurship development issues in Nigeria. Prior studies such as Ilori, et al. [19,3]; have developed and established the importance of Universities in developmental process. Yet, there is a dearth of information on the Academic entrepreneurship and innovative strategies of the Federal Universities of Technology in Nigeria. The main thrust of this paper therefore, is to stimulate policy discussion on the potential benefits of Academic entrepreneurship for industrial expansion, economic growth as well as economic development of Nigeria. The paper reveals the methods of R&D outputs commercialisation; factors influencing the commercialization of R&D outputs; and the level of lecturers' involvement in technological entrepreneurship in Nigeria. This is with a view to designing appropriate policies on Academic entrepreneurship as well as innovative activities in the Nigerian universities.

## **2. LITERATURE REVIEW**

### **2.1 Academic Entrepreneurship**

Academic entrepreneurship otherwise known as research enterprise is the effort undertaken by knowledge institutions to promote commercialisation of their R&D outputs [20]. This academic entrepreneurship efforts undertaken by the institutions through commercialisation of R&D discoveries promote establishment of new technological-based enterprises towards sustainable economic development [21,22]. Academic entrepreneurship are activities undertaken to stimulate commercialization of R&D outputs by the knowledge institutions. These engagements have changed dramatically in recent years because more stakeholders have become involved in academic entrepreneurship activities. R&D activities aim at increasing the stock of knowledge and solving several challenges such as technology inadequacy, food insecurity and disease outbreak such as COVID-19 pandemic confronting nations all over the world. The institutions in developed and emerging economies foster national economic development through diverse strategies such as direct commercialisation of R&D outputs,

establishment of technology incubators; and science parks for nurturing spin-off firms, sales of intellectual properties like patents [6,23,22]. Developing technology-based enterprises is important in this context to harvest the returns on investments in R&D engagements transfer from knowledge institutions [24]. Several countries invested in research which has brought multiplier effects on their sustainable development. According to Oyewale et al. [6], the Bayh-Dole Act of December, 1980 in the United States of America (USA) drove America's economic growth and development up till date. Several emerging economies are also increasing the level of their R&D activities. For instance, over the years, nations such as Israel, China, South Korea have increased their expenditures on R&D. A country must therefore, pay adequate attention to the development and promotion of R&D and innovations [7,8,9]. Recently, the government of Nigeria through her Agency, Tertiary Education Trust Fund (TETFUND) has paid attention to research activities in the country to promote sustainable development by supporting and generating innovations for the industrial sector [5]. The development of new or improved products, processes or business systems through technological innovation can help the Small and Medium-scale Enterprises (SMEs) in Nigeria to better satisfy consumers' needs, stay ahead of competition, explore new markets, grow and survive. However, there have been concerns on how the R&D outputs arising from knowledge institutions can be translated into economic values through academic entrepreneurship engagements [23]. The Academic entrepreneurship can be promoted through the Triple Helix Innovation System Model with Three Actors: Knowledge Institutions, Industrial Sector and Government (Policy). The Triple Helix Model was proposed by Etzkowitz & Leydesdorff [25] in university-industry-government collaborations for elucidation of developments in knowledge-based economies. According to Leydesdorff [26], the triple helix model of innovation is a set of interactions between academia, industry and government, to foster socio-economic development in the knowledge economy. The Triple Helix Model encourages the Academics to reflect on more than two possible dynamics.

### **2.2 University–Industry (U-I) Interactions**

Globally, relationship has been established between technology and economic progress of nations which usually depends on the level of

investment in research and development activities which often located in universities or industries that have linkages with universities [27,21].

The triangle of innovation composes of the interaction and relationships among Universities, Industry and Government in a well-known Triple Helix analogy. Innovation is thus an output of research or experimentation that has succeeded in being instrument of value addition in the economic or social activities that contribute to improving livelihood conditions [21]. The industrial sector through accumulation of knowledge plays important roles in the innovativeness of a nation. New technology is critical to the industrial competitiveness as companies can develop their technical capabilities and products either based on internal R&D or through outsourcing. Such outsourcing can be achieved through university-industry cooperation for sustainable development of nations. The existence of university is to nurture a conducive environment for advancement of knowledge and exchange of ideas. The industry on the other hand offers related product or service into the market to gain profits that can sustain the employment of its personnel as well as provides returns on investment. University-industry collaboration is an issue related practices which are claimed to motivate the industry to increase university-industry cooperation. There are several reasons for University-industry collaboration [6,27]. These are because industry provides funds for university; industrial money involves less “red tape” than government money; industrially sponsored research provides students with exposure to real world research problems; industrially sponsored research provides university researchers a chance to work on intellectually challenging research programmes; some government funds are available for applied research, based upon a joint effort between university and industry. To help SMEs start and run a successful technology-based business, SMEs also need the support of R&D institutions. For example, the development of joint initiatives between the public and private sectors for SME development is of considerable interest in Australia as SMEs play strategic role in fostering the Australian innovation process and are a significant source of national wealth creation.

Building partnerships, skills and infrastructure that enable SMEs to experience the full benefits of R&D and produce commercially viable

outcomes that attract global interest are seen as necessary to compete in the global business environment [28]. In order to promote the development of independent and creative SMEs, the Japanese government has been providing various types of support, which are as follows; active support for the self help efforts of motivated SMEs in technical innovation; reinforcement of production technologies and technical development infrastructure, and promotion of smooth access to and use of management resources such as human resources, technologies, funds and information, which are insufficient in SMEs, and related support measures; enhancement of the potential of academia, industry, and government through promotion of collaboration, mutual exchange and education for production technologies and innovation; and holding of training workshops and seminars and improvement of the common infrastructure of SMEs to actively use Information Technology (IT) and promote business innovation to cope with the IT revolution, which has been rapidly advancing [29,30]. The issue of university-industry interactions is particularly important in Nigeria to upgrade her innovative capabilities and move to innovation driven-stage.

### 2.3 Technological Innovation

Technological innovation is the first commercial introduction of a new technology, which may take the form of a product, process or service. Technological innovation has increased in relevance to become a topical issue in policy and economic debates [31,4]. According to OECD [1], technological innovation is the transformation of an idea into a new or an improved saleable product or operational process in industry or commerce. The role of science activities that lead to innovation and technological innovation in economic change and sustainable development is increasingly recognized. These activities include scientific and technological research, experimental development, scientific and technological services, innovation and diffusion [19]. Moreover, globalization has ignited rapid scientific and technological advancement the world over which has brought about newer and faster development and application of information technologies [32]. Many of the economic advances in developed and newly industrializing countries (NIC) stem from innovation – this might be technological innovation, or innovation in organization, processes, and management. The concept of technological innovation in attaining

competitive advantage has recently emerged as one of the most important subjects in the context of the common marketplace. The transition to new economy and knowledge-based economy in the 1990s and early 21<sup>st</sup> century created an atmosphere that entrepreneurs and SMEs became crucial engines of economic growth [33]. The development of new or improved products, processes or business systems through technological innovation can help the industrial sector to better satisfy consumer needs, stay ahead of the competition, explore new markets, and grow. When market competition increases, innovation is viewed as vital to firm survival. Technological innovation has been known as the most important driver of competitive success in many industries [3,21]. At the firm level, technological innovations contribute to technology development, market orientation, cost reduction and quality improvement. Technological innovations also enable enterprises to compete effectively in national and international markets.

Previous studies have established the existence of incremental innovations in the Food and Beverage Industry in Nigeria [34]. New product development is a fundamental factor in stimulating and supporting economic growth, and also a key issue for wealth generation in many industrialized nations. The study is expected to provide valuable data on the extent of technological innovations in the SMEs food and beverage industry, while identifying problems that are hindering the firms to innovate in Nigeria. The findings will also provide an insight into understanding the relationships between technological innovations and firm competition with a view to helping individual managers apply management practices and policy that would help to improve the innovativeness of their firms. The study would assist the policy makers to formulate better policy towards the R&D institutional supports for SMEs in Nigeria.

#### **2.4 Sustainable Entrepreneurship and Development**

This section explores the interaction between sustainable entrepreneurship and development. Sustainable development encompasses economic, social and environmental objectives across sectors in decision making process in order to achieve development that will be sustained [35]. The quest to promote equitable distribution of resources and ensure inclusive

benefit in economic growth necessitate the need for sustainable development. Sustainable development covers a continuous development that is above economic development [36]. That is, economic and social developments in a manner that does not jeopardized the entire natural resources of the society for the present and future generation. The promotion of entrepreneurship and Small and Medium Enterprises (SMEs) remain the keys to employment generation, poverty reduction, and sustainable development [37]. Sustainable development as defined by the United nations in Ibeenwo [38], is the development that helps populations to meet current needs while at the same time not compromising the ability of future generations to meet their own basic needs. This idea can be realised through entrepreneurship, in the process of creating. Entrepreneurship and innovation require critical abilities like collaborations, teamwork, sustainability, foresight towards economic prosperity and sustainable development. Sustainable entrepreneurship is when the conventional business practice is combined with environmental awareness. Sustainable entrepreneurship arises out of the need to conquer environmental degradation, pollution, and to improve the wellbeing of people in the environment [39]. Sustainable entrepreneurship was created as a result for enterprise to be environmental conscious of environmental degradation and harmful pollutants emitted into the environment that often affect ecosystem and biodiversity. Sustainable entrepreneurship is the combination of sustainable development with entrepreneurship [40].

### **3. METHODOLOGY**

The study adopted survey technique involving faculty members in the Nigerian Universities of Technology aimed at informing the sampling and sample size. The population consisted of all the lecturers in the Schools (Faculties) of the five Federal Universities of Technology in Nigeria: Federal University of Technology Akure (FUTA), Ondo-State, Southwest Nigeria; Federal Universities of Technology, Minna (FUTM), Niger State, Northcentral Nigeria; Federal University of Technology Owerri (FUTO); Imo State, Southeast Nigeria; Modibbo Adamawa University of Technology (MAUTECH-Yola), Yola, Adamawa State, Northeast Nigeria, Federal University of Technology, Uyo (FUT-Uyo), Akwa Ibom State, Southsouth Nigeria. Sample of researchers was

drawn from three institutions: FUT-Akure, FUT-Owerri and FUT-Minna. The sample size for this study was a total of 528 researchers/lecturers drawn from the rank of Senior Lecturer to Professor in 16 relevant Departments. The reason for the purposive selection of this category of lecturers was due to the fact that they were more experienced in R&D activities and they have tangible product (s) and/or processes as evidence of output for their R&D activities. A multi-stage sampling procedure was adopted for selecting the Universities and respondents. The first stage involved the purposive selection of four Schools (Agriculture, Engineering, Science and; Environmental Technology) from each of the Universities. The selection of these schools was informed by the level of R&D activities involved in them.

The second stage involved the purposive selection of the following Departments from the four Schools in the universities. School of Agriculture: Animal Production and Health, Crop Sciences, Forestry and Wood Technology, Food Science and Technology and Fisheries/Aquaculture. School of Engineering: Agricultural Engineering, Electrical and Electronic Engineering, Civil Engineering, Mechanical Engineering. School of Science: Biochemistry, Chemistry, Biology/Microbiology and Physics. School of Environmental Technology: Architecture, Building Technology, Estate Management; and Urban and Regional Planning. The selection of these Departments was informed by the uniformity presence of these Departments across the selected Universities. Primary data was obtained with the aid of two research instruments: questionnaire and interview guide. A set of questionnaire was designed to elicit necessary information from the respondents on the objectives of the study. The questionnaire was administered on lecturers/researchers from each of the concerned Departments of the selected Universities. Descriptive statistics such as percentage and mean; and regression analysis as inferential statistics were employed for data analysis. The model and description of variables for measuring the commercialisation and innovative performance of researchers are as follows:

### 3.1 Dependent Variable ( $Y_0$ )

Academic Entrepreneurial Performance of Researchers.

### 3.2 Independent Variables ( $X_i$ )

ARF ( $X_1$ )	=	Access to Research Fund
RDII ( $X_2$ )	=	R&D and Innovation Incentives
GPI ( $X_3$ )	=	Government Policy Interventions
IRF ( $X_4$ )	=	Infrastructure and Research Facilities
BTSS ( $X_5$ )	=	Business and Technical Support Services
IP ( $X_6$ )	=	Industrial Patronage
IPC ( $X_7$ )	=	Industrial Partnerships and Collaborations
QRDP ( $X_8$ )	=	Qualified R&D Personnel
ED ( $X_9$ )	=	Entrepreneurial Drive
BAS ( $X_{10}$ )	=	Business Advisory Services
FR/S ( $X_{11}$ )	=	Field of Research/Study

## 4. RESULTS AND DISCUSSION

Section three presents the results and discusses the consequence of analysis of data in the study. The results and discussion comprise of general information on research and development (R&D) activities, socio-economic objectives of R&D activities as well as commercialisation of new R&D products by the Universities in three years (2016, 2017, 2018); and the engagement of lecturers/researchers in technological entrepreneurship as well as the influencing factors on the R&D outputs commercialisation and innovation performance of the researchers is also presented in this section.

### 4.1 Distributions of Researchers' Engagements by Research Type

Traditionally, universities fulfil the dual purposes of teaching/manpower development and research. However, a third mission of transferring technology to business sector in pursuit of national economic advantage was added to their roles [41]. On the types of R&D engagements of the researchers (Fig. 1), majority (50.00%) of the respondents claimed to be engaged in applied research, 41.96% in basic research and 8.04% in experimental research. To perform the new role of transferring technology to business sector, the institutions commercialise their R&D outputs as bridges between them and the industry. However, the institutions need to be encouraged to commercialize their inventions, especially with government policies.

#### 4.2 Gross Expenditure on Research and Development (GERD) by Funding Sources

The gross expenditure on research and development (GERD) by funding sources is shown in Table 1. The Table reveals that the government is the major (81.09%) source of R&D funding in the Nigerian Universities of Technology. This follows the findings of Akinwale

et al. [2]; that the Federal Government of Nigeria is the major financier of R&D and innovative activities of tertiary institutions in Nigeria. It was also interesting to note that personal research funding was as high as 28.87% while the institutional-based research funding/internally generated revenue was 15.72%. Other consortium sources of R&D funding in the institutions are funds from abroad/foreign sources/Aids such as World Bank, Carnegie Corporation, FATE Foundation,

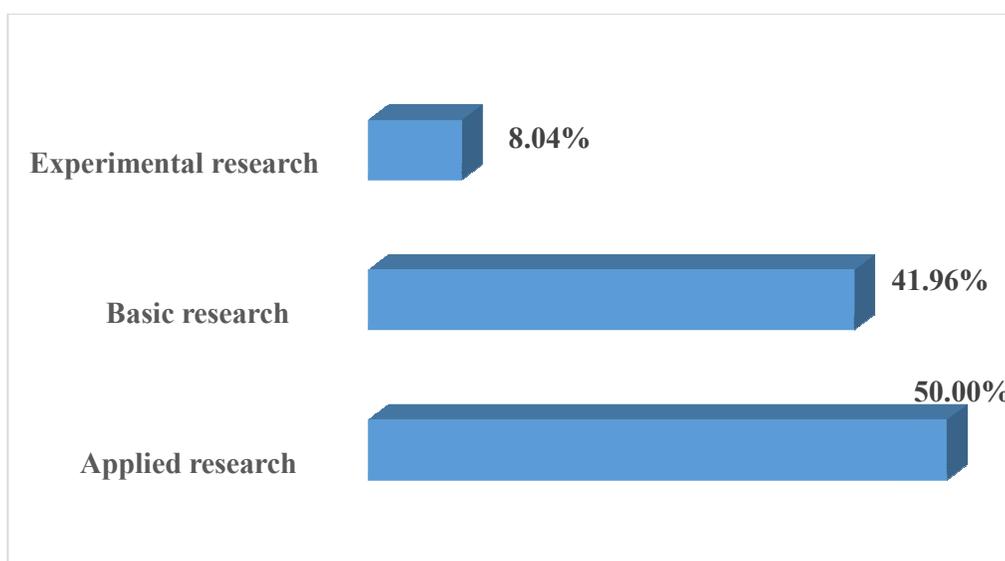


Fig. 1. Types of R and D engagements of the researchers

Table 1. Gross Expenditure on Research and Development (GERD) by funding sources multiple responses allowed

Source (s)	Respondents by institution			Gross total	Percent
	Fut-akure	Fut-Minna	Fut-owerri		
Government Funding e.g. Tertiary Education Trust Fund	52	97	43	192	81.09
Personal Research Funding	31	13	28	72	28.87
Institutional-Based Research Funding/ Internally Generated Revenue	6	23	11	40	15.72
Funds from Abroad/Foreign Sources/Aids e.g. World Bank, Carnegie Corporation, FATE Foundation, Association of Commonwealth Universities	9	13	12	34	13.85
Private Non-Profit Institutions	2	12	4	18	8.12
Group Research Funding	3	9	2	14	6.43
Other Higher Education Institutions	1	6	2	9	4.08
Private Business/Profit Institutions	2	2	4	8	3.93
Donations and Endowments from Individuals	-	3	3	6	2.76
Bank Loans/Cooperative Loans	-	1	2	3	1.39

Association of Common wealth Universities (13.85%), private non-profit institutions/social entrepreneurs (8.12%). Funds from group research funding, other higher education institutions, private business/profit institutions donations as well as endowments from individuals accounted for 6.43%, 4.08%, 3.93%; and 2.76% respectively. The least R&D funding sources was bank loans/cooperative loans was only 1.39%. However, the gross domestic expenditure on R&D as a percentage of GDP is abysmally low at about 0.11% to 0.2 annually [2,3]. An informal interactions/interview with few of the researchers showed that the R&D expenditures were on personnel cost/allowance, equipment supplies/consumables, machineries, travels; and other current expenditures.

#### 4.3 Socio-Economic Objectives of R and D Activities

In order to establish the socio-economic objectives of R&D activities, the researchers were asked to do such classifications. The outcome of the analysis (Table 2) reveals that the respondents contribute to the socio-economic development of Nigeria through manufacturing and production (36.42%), agriculture/food security (27.85%), education and training (21.90%) as well as engineering and technology development (13.01%). Other researchers had socio-economic objectives of energy and power (9.56%), information and communications technologies (6.73%), building and construction

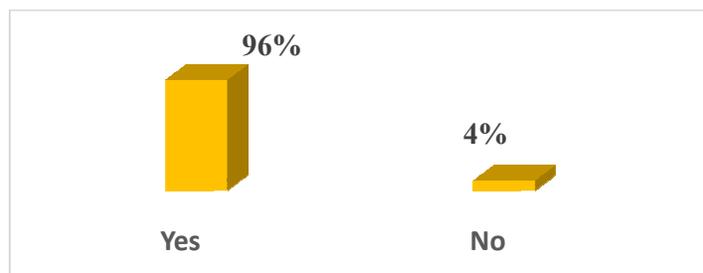
technology (4.28%) environmental management technology (1.62%); and economic development framework (1.23%). A miniscule of the researchers also claimed to have socio-economic objectives of their research as medical and health development (1.11%), social development and community services (1.08%), Technopreneurship (0.94%), transportation management technology (0.63%) as well as project management technology (0.27%).

#### 4.4 Generation of Research and Development Outputs by the Selected Institutions

As shown in Fig. 2, almost (96%) all of the researchers had generated R&D outputs in the institutions. This is not surprising as University lecturers are expected to be engaged in teaching, research and community services. The high number of researchers who were involved in R&D activities in these institutions may not be unconnected with the fact that these lecturers are also research-oriented and experienced as they are Senior Lecturers, Readers and Professors. Sub-Saharan African countries spend less than one per cent of their GDP on R&D, most of which goes into salaries and wages rather than core research [42]. Moreover, the awareness level of intellectual property commercialisation information is inadequate among the researchers [6].

**Table 2. Classification of R and D activities by socio-economic objectives multiple responses allowed**

Classifications	Respondents by institution				
	Fut-akure	Fut-Minna	Fut-Owerri	Gross total	Percent
Manufacturing and Production	57	51	24	132	36.42
Agriculture/Food Security	32	47	26	105	27.85
Education and Training	20	39	32	91	21.90
Engineering and Technology Development	15	27	19	61	13.01
Energy and Power	29	13	12	54	9.56
Information and Communications Technologies	11	23	12	46	6.73
Building and Construction Technology	12	16	10	38	4.28
Environmental Management Technology	6	11	9	26	1.62
Economic Framework	7	9	9	25	1.23
Medical and Health	10	4	8	22	1.11
Social Development and Community Services	12	4	3	19	1.08
Technopreneurship	3	5	8	16	0.94
Transportation Management Technology	2	7	4	13	0.63
Project Management Technology	1	4	3	8	0.27



**Fig. 2. Generation of research and development output (N = 267)**

#### **4.5 Forms of Research and Development Output Generated (N = 256)**

The forms of research and development output generated by the respondents from the three selected Universities of technology are depicted in Table 3. All (100.0%) the respondents have their R&D outputs in the form of publications in academic outfits such as journals, conference proceedings, and contribution to textbooks as well as monographs. This outcome is not surprising since the career advancement in all Nigerian R&D institutions is based on the number of papers/journal publications known as publish or perish syndrome. Most academics therefore engage in research with less consideration for R&D outputs commercialization by the industrial sectors. Other forms of R&D outputs are Copyrights (12.2%), registered industrial designs (11.4%), patents generated in Nigeria (4.6%); and patents generated outside Nigeria (1.6%).

The form of R&D outputs through Brokerage organisations was 3.2%, University's centre of excellence (2.8%), Brokerage organisations are established to facilitate communications between academic and industrial sectors. The organisations also co-ordinate linkage activities, and may supply seed capital to young businesses. Brokerage organisations include industrial liaison offices, technology transfer offices, institution/institute-run development companies, national research and development organisations. It is not surprising then that the incidence of intellectual property in the form of patent was generally low in the universities. This is a far cry from the developed countries' experience where universities generate a lot of spin-offs from their patents.

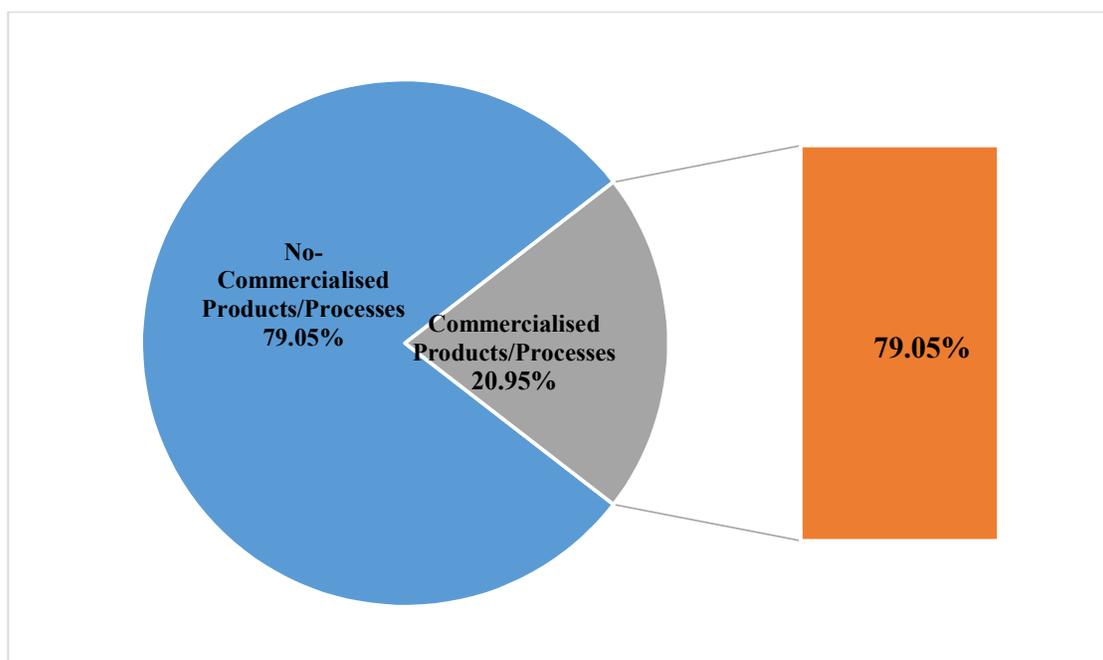
#### **4.6 Commercialisation of New R and D Products by Universities in 2016, 2017, 2018**

Technology commercialisation is a process of stirring research results from research

environments to marketable products or processes. Technology commercialisation does promotes R&D activities; justifies time, efforts, funds committed to research; spurs industrialization; creates investment opportunities; enhances company technological capability/competitiveness; and makes research more demand-driven [43]. The ability to commercialize technologies in the marketplace is central to economic development. As shown in Fig. 3, about one fifth (20.95%) of the researchers claimed to have commercialised either their R&D products or processes. A large proportion (79.05%) of the researchers had not commercialised their R&D products/processes. The ability to commercialize technologies in the marketplace is central to economic development of nations. The influence of commercialization of R&D results on development has been recognized by developed and developing countries such as France, Denmark, Brazil, China, South Korea, and India long ago. However, what obtains in most Nigerian R&D institutions is that most academics engage in scientific research for career upgrading rather for innovations by the industry. Moreover, the level of awareness on intellectual property is still very low among the Nigerian researchers [6]. Moreover, at the heart of continuous innovation process is the commercialisation of R&D results. This can be defined as the process of turning an invention into a product or service which could be sold in the market, thereby, providing profits for industrial sector. Continuous commercialization of R&D products nurtures the process of innovation which is central to sustainable economic development in many economies. In view of this, economic activities globally are becoming more and more knowledge intensive leading to growth of high technology industries and increasing demand for highly skilled people. This has necessitated increased investment in knowledge, such as research and development, education and training and innovation which are germane to economic growth [41,44].

**Table 3. Forms of research and development output generated (N = 256) multiple responses allowed**

Form of R and D Outputs	Respondents by institution			Gross total	Percent
	Fut-akure	Fut-minna	Fut-owerri		
Publications	98	101	57	256	100.0
Claim Copyrights	6	14	11	31	12.2
Registered industrial designs	12	8	6	26	11.4
Patents generated in Nigeria	4	5	2	11	4.6
Patents generated outside Nigeria	-	3	1	4	1.6



**Fig. 3. Commercialisation of new R and D products by the Universities in 2016, 2017, 2018**

**4.7 Means of Commercialisation of R&D Products/Processes (N = 60)**

At the heart of continuous innovation process is the commercialisation of R&D results. Continuous commercialisation nurtures the process of innovation and this is pivotal to sustained economic growth. Fostering the commercialisation of R&D results has become especially important in many emerging market economies. Innovation involves the utilisation of new knowledge or combination of existing knowledge through R&D product/process commercialization efforts. Innovation aims at improving the firms' performance by gaining competitive advantage for their products [2,8]. In the determination of the means of commercialising R&D products/processes,

various indices are always employed for measurement.

Table 4 showed that the means of commercialising R&D products/processes by the majority (76.67%) of the respondents was outright sales of R&D outputs in form of copyrights on textbooks and production of monographs. Moreover, some of the respondents commercialised their R&D products/processes through business incubation centre by spin-off (23.33%); and outright sales of R&D outputs/processes in form of patents (18.33%). It is not surprising then that the incidence of intellectual property in the form of patent was generally low in the universities. This is a far cry from the developed countries' experience where universities generate a lot of spin-offs from their patents. Spin-offs are new businesses whose

venture is to translate knowledge developed within universities into commercialisable products [7]. The three reasons for interest towards policy support for such universities in western economies are the need to transfer new knowledge to the market, the pursuit of revenue for universities as well as the positive impact on the local communities through the promotion of innovative enterprises. A cursory examination of Table 4 also shows that the R&D outputs/processes commercialisation was through establishment of University's centre of excellence (11.67%), establishment of technology pack incubator centre (TECH-PIC) for start-ups (8.33%); and contract research with industry/Joint venture with a firm (8.33%). Research, development and innovation has become the focus for long term economic development [33]. Innovation is an important aspect of business strategy for products development and improved efficiency. The results of studies have increasingly emphasized the link between innovation, underlying research and entrepreneurial effort aimed at commercializing the results of research and development. The level of R&D product/process commercialisation is low in the Nigerian Universities. One major factor leading to this situation is the absence of institutional arrangement to intermediate linkages between University, Industry and government [45,46,6]. Moreover, some of the respondents commercialised their R&D products/processes through business incubation centre by spin-off (23.33%); and outright sales of R&D outputs/processes in form of patents (18.33%).

The level of R&D product/process commercialisation is generally low in the Nigerian universities.

#### 4.8 Factors Influencing R&D Outputs Commercialisation and Innovation Performance of Researchers

We present in this portion the factors influencing R&D outputs commercialisation and innovative performance of researchers/lecturers in the Nigerian Universities of Technology. The performance was measured on a 5-point likert scale. Table 5 reveals that access to research fund ( $X_1 = 4.16$ , standard deviation = 0.45), R&D and innovation incentives ( $X_2 = 4.07$ , standard deviation = 0.39); and government policy interventions ( $X_3 = 3.92$ , standard deviation = 0.44) were the highest influencing factors on the performance of researchers/lecturers. Moreover, infrastructure and research facilities ( $X_4 = 3.81$ , standard deviation = 0.25), business and technical support services ( $X_5 = 3.67$ , standard deviation = 0.52), industrial patronages ( $X_6 = 3.28$ , standard deviation = 0.63); and industrial partnerships and collaborations ( $X_7 = 3.17$ , standard deviation = 0.28). Other influencing factors on R&D outputs commercialisation and innovation performance of researchers were qualified R&D personnel ( $X_8 = 3.04$ , standard deviation = 0.73), entrepreneurial drive ( $X_9 = 2.82$ , standard deviation = 0.46), business advisory services ( $X_{10} = 2.52$ , standard deviation = 0.39); and field of research/study ( $X_{11} = 2.27$ , standard deviation = 0.23).

**Table 4. Means of commercialisation of R and D products/processes (N = 60) multiple responses allowed**

Means	Respondents by institution				
	Fut-akure	Fut-minna	Fut-owerri	Gross total	Percent
Outright Sales of R&D outputs (Copyrights on Textbooks, Monographs)	13	19	14	46	76.67
Through business incubation centre (spin-off)	3	5	6	14	23.33
Outright Sales of R&D outputs (Patents)	2	4	5	11	18.33
Establishment of University's Centre of Excellence	1	3	3	7	11.67
Establishment of technology pack incubator centre (TECH-PIC) for start-ups	2	2	1	5	8.33
Contract research with industry/ Joint venture with a firm	1	2	2	5	8.33

**Table 5. Descriptive statistics of independent variables (N = 62)**

Variables	Minimum	Maximum	Mean	Std. deviation
ARF (X <sub>1</sub> )	3.04	4.79	4.16	0.45
RDII (X <sub>2</sub> )	2.75	4.44	4.07	0.39
GPI (X <sub>3</sub> )	2.61	4.03	3.92	0.44
IRF (X <sub>4</sub> )	2.56	3.96	3.81	0.25
BTSS (X <sub>5</sub> )	2.47	3.88	3.67	0.52
IP (X <sub>6</sub> )	2.38	3.59	3.28	0.63
IPC (X <sub>7</sub> )	2.21	3.31	3.17	0.28
QRDP (X <sub>8</sub> )	2.16	3.17	3.04	0.73
ED (X <sub>9</sub> )	2.09	2.94	2.82	0.46
BAS (X <sub>10</sub> )	1.63	2.70	2.52	0.39
FR/S (X <sub>11</sub> )	1.33	2.58	2.27	0.23

1 - Very low, 2 - Low, 3 - Moderate, 4 - High, 5 - Very high \*Multiple responses allowed

The eleven factors (variables) were further subjected to multiple regression analysis. The outcome of the analysis revealed that commercialisation and innovative performance of the researchers were influenced by access to research fund ( $\beta=69.03$ ,  $p \leq 0.01$ ), R&D and innovation incentives ( $\beta = 52.20$ ,  $p \leq 0.05$ ), government policy implementations ( $\beta = 18.78$ ,  $p \leq 0.05$ ) as well as infrastructure and research facilities ( $\beta = 14.82$ ,  $p \leq 0.05$ ). This confirms the earlier findings of National Universities Commission, NUC [47]; Bello [48]; Akinwale et al. [2]; Siyanbola [9] that the overall level of funding of tertiary institutions research was low, to possess the state-of-the-art equipment for adequate research. Nigerian universities have been underfunded especially in the area of capital development and research grant [6,23]. This had made most of Nigerian universities to be largely dependent on external agencies for fund and equipment to carry out research especially in the field of Science and Technology.

Through adequate R&D funding, more than 50% of wealth created in developed and emerging nations is derived from product of research, experimental development and innovation (RDI) [2,18]. Moreover, innovation, which is the introduction of new products, processes or services, delivers the economic result of R&D outputs [4].

Other factors that positively and significantly influenced the R&D commercialisation and innovative performance of the lecturers are: business technical support services ( $\beta = 0.92$ ,  $p \leq 0.01$ ), industrial patronage ( $\beta = 19.05$ ,  $p \leq 0.05$ ), industrial partnerships and collaborations ( $\beta =$

53.05,  $p \leq 0.05$ ) qualified R&D personnel ( $\beta = 12.55$ ,  $p \leq 0.01$ ), entrepreneurial drive ( $\beta = 14.62$ ,  $p \leq 0.05$ ), field of research ( $\beta = 38.78$ ,  $P \leq 0.05$ ), business advisory services ( $\beta = 18.78$ ,  $p \leq 0.05$ ). A cursory analysis of the influence of field of study of the respondents reveals that researchers/lecturers who are in the field of Engineering and Engineering Technology as well as Sciences were more disposed to commercialization of R&D and entrepreneurship behaviours.

All the variable contributed 29.74% ( $R^2 = 0.2974$ ) to the propensity of R&D commercialization and innovative behaviours of the researchers.

$$Y = 25.41 + 69.03X_1^{***} + 52.20X_2^{***} + 18.78X_3 + 14.82X_4^{**} + 0.92X_5 + 19.05X_6^{**} + 53.05X_7^{***} + 12.55X_8^{***} + 14.62X_9^{****} + 38.78X_{10} + 18.78X_{11}^{***}$$

\*\*\* Significant at 99% level ( $p \leq 0.01$ )

\*\* Significant at 95% level ( $p \leq 0.05$ )

$$R^2 = 0.2974 (29.74\%)$$

Where,

#### 4.8.1 Dependent variable

Y = R&D Commercialisation and Innovative Performance of Researchers

#### 4.8.2 Independent variables (X<sub>i</sub>)

X<sub>1</sub> = Access to Research Fund (ARF)  
 X<sub>2</sub> = R&D and Innovation Incentives (RDII)  
 X<sub>3</sub> = Government Policy Interventions (GPI)

- X<sub>4</sub> = Infrastructure and Research Facilities (IRF)
- X<sub>5</sub> = Business and Technical Support Services (BTSS)
- X<sub>6</sub> = Industrial Patronages (IP)
- X<sub>7</sub> = Industrial Partnerships and Collaborations (IPC)
- X<sub>8</sub> = Qualified R&D Personnel (QRDP)
- X<sub>9</sub> = Entrepreneurial Drive (ED)
- X<sub>10</sub> = Business Advisory Services (BAS)
- X<sub>11</sub> = Field of Research/Study (FR/S)

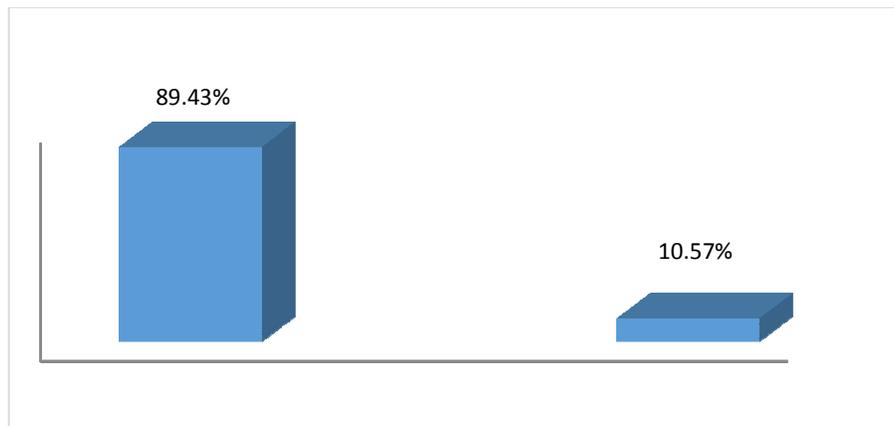
**4.9 Contributions of Commercialised R&D and Innovation Outputs to the Sustainable Development of Nigerian Economy**

There is a growing view that Universities have special capability and larger responsibility to assist in transforming their knowledge into potential sources of economic growth and development. Increasing the commercialisation of R&D outputs, technologies and innovations is one of the major contribution to the economic development of nations. The changing needs of society demand closer collaboration between universities and industry to address some of the significant challenges that are faced in the society. As shown in Fig. 4, a high proportion (89.43%) of the researchers/lecturers believe that the Federal Universities of Technology contribute to the economic development of Nigeria. The breakdown of this view (Table 6) is a form of multiple contributions of commercialisation activities of R&D and

innovation to the development of Nigerian economy. Majority (67.32%) of the respondents claimed that their R&D and innovation commercialisation activities contributed to the growth of Nigerian economy through improved product/process quality. Moreover, the contributions to the growth of Nigerian economy by the utilisation of local raw materials; and reduced environmental impact were 61.97% and 60.73% respectively. Some contributions of the R&D commercialisation are reduced environmental impact (60.73%), product diversification (54.81%), research-industry partnership (49.05%), increased production capacity (47.22%); and generation of new employment (44.18%).

An interaction with some of the respondents reveals that in recent years, there is increase in the number of academics winning research funding, becoming more entrepreneurial and having more influence on the society through technology commercialisation and knowledge transfer activities. There is a growing momentum in the performances of universities to become more entrepreneurial in their organisational outlook and in their offerings. All this has resulted in many forward-looking universities re-evaluating their core activities and research capabilities resulting in the need for a wide range of modes of university knowledge transfer and business engagement which is responsive to the needs of industry.

1 - Very low, 2 - Low, 3 - Moderate, 4 - High, 5 - Very high \*Multiple responses allowed



**Fig. 4. Contributions of R&D and innovation outputs commercialisation to sustainable development in Nigeria**

**Table 6. Contributions of commercialised R and D outputs to sustainable development of Nigerian economy**

<b>Contribution</b>	<b>Extent</b>
Generation of new employmen	4.16
Creation of new firms	4.07
Reduction in the cost of production	3.92
Creation of more market network	3.81
Generation of environmental friendly products	3.67
Improvement in product quality	3.28
Creation of more market network	3.17
Improved sales turnover	3.04
Increased profit margin	2.82
Increased market share	2.52

## 5. CONCLUSION AND RECOMMENDATIONS

This paper touched relevant issues concerning commercialisation of research and development outputs from the Federal Universities of Technology and sustainable development in Nigeria. This study found that government is the major financier of research in the Universities while the level of research funding is still low. The level of R&D outputs commercialisation is also still low due to low partnership between universities and industrial sector. The paper posits that sustainable entrepreneurship development can be driven in Nigeria through adequate R&D commercialisation and greater innovative performance of the knowledge institutions through spin-offs/start-ups, patenting, technology transfer, outright sales of business ideas; and contracting of intellectual properties. The paper also made a case for the promotion of techno-based entrepreneurship performance among University of technology dons and the entire University system in Nigeria. This can be enhanced through industrial sabbatical leaves by the lecturers/researchers, exposure of R&D personnel to state-of-the-art research and innovation networks; as well as improved collaboration/partnership between research and industry. Technological enterprises usually with highly-skilled and knowledgeable entrepreneurs are requisites for economic growth and development of nations. Clearly, knowledge-based enterprises are more impactful in driving sustainable economic progress. Technology-based enterprises play key role in the economic development and competitiveness of countries. There is need to close the existing interaction gap between the R&D institutions and the industrial sector. There is an urgent need for monitoring and evaluation of R&D activities in the Federal Universities of Technology. The paper is

of the view that appropriate policies on R&D commercialisation be formulated and implemented as a matter of urgency. The importance of research, development and innovation policies towards positive entrepreneurship development is vital to sustain and grow the Nigerian economy towards the fourth industrial revolution. Therefore, The appropriate step for Nigeria to move forward is to strengthen the linkage between the university and industry in order to enhance the level of Academic entrepreneurship for sustainable development.

## CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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