

A SURVEY OF COMMERCIALIZATION POTENTIALS OF RESEARCH RESULTS FROM UNIVERSITIES IN NIGERIA

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Abstract: Commercialization of research which is a primary means through which research results are utilized to generate products and services, has become a key component of the research mission of universities such that novel ideas, techniques and products can be generated for the marketplace for the benefit of relevant stakeholders and society in general. In many developed and newly industrializing nations, commercialization efforts at universities have developed into an integral part of research and innovation activities. In these countries, collaborations between industry and the academia present tremendous opportunities for advancing knowledge, applying it to real-world problems, and bringing about various social benefits. Despite global attention to commercialization of research and innovation for sustainable economic development, little attention is given to it by Nigerian universities. The rating of Nigeria as one of the leading producers of scientific publications in Africa and the need to find out the extent to which these research results and innovations are being turned into commercial products and services justify this research work on survey of commercialization potentials of research outputs from Nigerian universities. The survey utilized the questionnaire method of data gathering from selected universities from each of the six geopolitical zones of the country. The findings of the research include an increasing need for demand – driven research to provide solutions to the many socio-economic problems of society, low level intellectual property generation and commercialization by Nigerian universities compared to some selected American and British universities, research success in Nigeria means being published in international journals rather than helping local industries to grow and there are many constraints to effective commercialization of university research in Nigeria. It is concluded that if Nigeria is to achieve sustainable all-round development to enhance the living standard of the populace, Nigerian universities must regard commercialization of technologies as a vital component of university mandates and act as microenvironments for innovation and entrepreneurship. The authors recommend the establishment of appropriate institutional frameworks by government for research commercialization and Nigerian universities should shift research focus towards research outcomes with high commercialization potentials for economic development.

Keywords: Research, Intellectual Property, Innovation, Commercialization, Entrepreneurship, Patent, License

I. INTRODUCTION

Universities and other related tertiary institutions globally are playing significant roles in sustainable economic and industrial development with technology transfer becoming a key objective of universities in addition to teaching and research. Regional economies are being developed by catchment area universities which establish innovation clusters in collaboration with regional or State governments. Tertiary institutions, particularly universities are increasingly being called upon to commercialize their discoveries to boost sustainable national economic development and enhance their internal revenue generation.

Through commercialization, universities and research institutes forge closer links with business and industry to create internship and career opportunities for students and graduates. According to [1], United States-based institutions generated over 24,000 disclosures, obtained over 5,000 new patents, executed over 5,000 licensing agreements, formed over 800 start-up companies, and generated \$2.75 billion in license income in 2013. The unprecedented investments in promoting innovation through increased funding for research and development and through sustained support for universities and innovative small and large businesses by many of the world's leading countries including Germany, USA, Singapore, Japan, China, Israel and some other developing nations on commercialization of research are indications of the global consensus on the importance of innovation as the principal way to address the challenges of economic development, public health, national security, and protection of the environment[2].

From the global perspectives of the benefits and impacts of university research on national economic development, this paper explores the state of intellectual property generation and commercialization in Nigeria. The paper focuses on university research and their commercialization potentials in the six geopolitical zones of Nigeria. The data collection technique involved extensive literature review for primary data and direct interview and questionnaire administration for secondary data.

The choice of this research work on Survey of Commercialization Potentials of Nigerian university research outputs was prompted by several findings including [3]; [4]; [5] on research and innovation commercialization in Nigeria. Three specific findings are worthy of mentioning in relation to the justification of this research work. First, the 2007 publication of the Compendium of Research Results and Innovations in 36 Nigerian Universities shows the very large volume of research results and innovations in Nigerian universities. There is the need to find out the extent to which these research results and innovations are being turned into commercial products and services. Secondly, the findings of the 2015 African Innovation Outlook indicate that Nigeria is one of the leading producers of scientific publications in Africa. This position is collaborated by [3] where he maintained that research success in Nigeria means being published in international journals rather than helping local industries to grow. A confirmation of these positions through a commercialization survey will help to drive a positive advocacy for entrepreneurial universities in Nigeria. Thirdly, in 2011, NOTAP produced Guidelines on Development of Intellectual Property Policy for Universities and R & D Institutions and has established IPTTOs in some universities and polytechnics. It is important to find out the impact of these IPTTOs on linkages with industries and technology commercialization. Fourthly, there is the reported large numbers of invention disclosures, start-up companies formed, and commercialization revenues generated annually by American and British universities. A comparison of intellectual property handling and commercialization practices between American/British and Nigerian universities is a compelling study for change of narratives in Nigerian universities.

The study has brought out three major findings: (i) There is an increasing need for demand – driven research to provide solutions to the many socio-economic problems of society. (ii) Nigerian university research is not focused on commercialization of scientific research outputs to produce products and services for industrial development. (iii) There are many constraints to effective commercialization of university research in Nigeria viz:- poor patent education, poor research facilities, weak institutional frameworks for invention patenting and commercialization and academic focus on publication for promotion.

The research work makes four significant contributions to knowledge. First, it reveals the great impact of technology commercialization on sustainable economic development of nations as seen from the case scenarios of American and British universities. The study further reveals that strong and effective institutional frameworks for intellectual property ownership and protection, and technology commercialization are critical to producing entrepreneurial universities. Secondly, the great disparity in technology commercialization practices in developed countries and developing countries such as Nigeria requires a change to entrepreneurial mindsets by Nigerian university researchers instead of concentrating research work on a mindset of publications for promotion. Thirdly, universities in developed countries create innovation clusters around their catchment regional areas (e.g Silicon Valley established by Stanford university in USA) to stimulate regional economic development through licensing of inventions to local industries and creation of start-up companies. These technology commercialization best practices are good lessons for Nigerian universities. Nigerian universities must become microenvironments for innovation and entrepreneurship. Fourthly, a strong system of university – industry collaboration is pivotal to effective technology commercialization. This requires the involvement of government in a Triple Helix Model of collaboration where government provides the necessary infrastructures and the enabling business environment for the Organized Private Sector to obtain technology licenses from universities for business development.

The rest of the paper is divided into five sections. Section two is the review of relevant literature while section three highlights the data collection method. Section four discusses the findings of the research and their implications. Section five is the conclusion of the study while section six presents the recommendations.

II. LITERATURE REVIEW

According to [6], New York's nanotechnology initiatives attracted investments from 300 companies accounting for an annual in-state payroll of \$1.4 billion annually as of 2012. Commercialization of research takes place in all Israeli universities and research institutes with active involvement of the private sector in technology transfer. Israel's annual budget for competitive Research and Development (R & D) and technology incubation is approximately \$300million and \$30million respectively. The country supports over 1, 000 projects annually from more than 500 companies involved in technology transfer (WIPO, 2009). According to [7] the Hebrew University of Jerusalem, has earned over **\$20 billion** in commercialization revenue over the years. Since it was established in 1964 the university's technology transfer arm, the Yissum Research Development Company, has registered 9300 patents covering 2600 inventions, licensed 800 technologies, and spun off 110 companies. According to [8], "Universities are reinventing

themselves as microenvironments for innovation and entrepreneurship. A university that can't demonstrate its impact on industry and the marketplace will become less relevant in the future,"

University Innovation and Commercialization Statistics from United States of America and United Kingdom

Commercialization of research and innovation has become a major driver of sustainable economic development in the developed and newly industrializing nations of the world. Greater attention is being paid to research funding for intellectual property generation and commercialization for economic and social growth in these nations. This trend is illustrated below with the key performance indicators of some universities in the United States of America and the United Kingdom.

TABLE I: HARVARD UNIVERSITY KEY PERFORMANCE INDICATORS: 2017–2021

S/N	Description	2017	2018	2019	2020	2021
1	New Innovations	522	442	450	443	383
2	New Patent Applications Filed	274	234	224	208	180
3	U.S. Patents Issued	151	181	163	178	193
4	Major License Agreements	46	51	45	45	44
5	Total Commercialization Revenue (MM)	\$35.4	\$54.1	\$97.8	\$58.7	\$106.0
6	Start-up Companies	14	21	15	14	27
7	Corporate Research Partnerships	81	77	74	72	93
8	Corporate Research Funding (MM)	\$51.0	\$53.0	\$66.0	\$50.3	\$64.7

Source : <https://otd.harvard.edu/about/productivity-highlights/>

TABLE II: UNIVERSITY OF MINNESOTA KEY PERFORMANCE INDICATORS: 2017–2021

S/N		2017	2018	2019	2020	2021
1	New Licences	213	230	223	235	236
2	Current Revenue Generating Agreements	545	575	571	601	575
3	Gross Revenue	\$22.6	\$16.1	\$20.7	\$14.1	\$17.4
4	Start-up Companies Formed	18	13	19	19	20
5	Invention Disclosures	406	400	391	397	332
6	New Patent Filing Rate*	57%	45%	42%	38%	38%
7	Issued Patents (US and Foreign)	147	186	187	182	181
8	MN-IP Research Agreements	72	86	103	73	60
9	Companies w/MN-IP Research Agreements	51	58	77	69	51
10	Sponsored Research Commitments (in millions)	\$20.9	\$21.3	\$22.5	\$27.9	\$15.3

*New Patent Filing Rate is number of new patents filed during the fiscal year divided by number of new disclosures in the same time period (<https://research.umn.edu/units/techcomm/about-us/statistics>)

TABLE III: UK HIGHER EDUCATION INSTITUTIONS' PATENT APPLICATIONS FROM 1999 TO 2018 SPLIT BY WIPO TECHNOLOGY FIELD

Rank	WIPO Technology Field	Published Patent Applications		
		1999 – 2008	2009 - 2018	Total
UK HEIs				
1	(C) Pharmaceuticals	4,804	5,382	10,186
2	(C) Biotechnology	4,890	4,845	9,735
3	(I) Analysis of Biological Materials	2,213	2,051	4,264
4	(C) Organic Fine Chemistry	1,837	2,413	4,250
5	(I) Medical Technology	1,716	2,372	4,088
6	(I) Measurement	1,815	2,202	4,017
7	(C) Chemical Engineering	1,064	1,361	2,425
8	(E) Computer Technology	1,007	1,185	2,192
9	(I) Optics	1,012	961	1,973
10	(C) Basic Materials Chemistry	751	1,099	1,850
Spinouts				
1	(C) Pharmaceuticals	260	2,283	2,543
2	(C) Biotechnology	352	1,928	2,280

3	(I) Measurement	252	1,064	1,316
4	(C) Organic Fine Chemistry	113	1,189	1,302
5	(I) Medical Technology	176	872	1,048
6	(E) Computer Technology	154	797	951
7	(C) Chemical Engineering	88	721	809
8	(E) Electrical Machinery, Apparatus, Energy	67	738	805
9	(I) Analysis of Biological Materials	166	625	791
10	(C) Basic Materials Chemistry	75	509	584

Source: govgrant.co.uk/university-spinout report

TABLE IV: UK UNIVERSITIES SPINOUT REPORT 2021 -TOTAL VALUE
OF SPINOUTS FROM EACH UNIVERSITY IN THE LAST TWO DECADES

Rank	University	% of Total Spinouts	Total Value of Spinouts	Total Raised by Spinouts
1	University of Oxford	15.8%	£6.4 billion	£2.9 billion
2	Imperial College London	8.8%	£2.7 billion	£1.2 billion
3	University College London	6.9%	£2.6 billion	£2.1 billion
4	University of Cambridge	11.5%	£2.6 billion	£1.3 billion
5	University of Bristol	3.2%	£905.7 million	£235.4 million
6	University of Dundee	1.5%	£848.8 million	£325.7 million
7	University of Southampton	2.4%	£783.4 million	£394.8 million
8	University of Edinburgh	4.6%	£523.7 million	£241.6 million
9	University of Nottingham	1.8%	£454.4 million	£168.9 million
10	University of Leeds	3.1%	£409.3 million	£190.7 million

Source: govgrant.co.uk/university-spinout report

Inventions and Patenting in Sub-Saharan Africa

According to [9], inventors from Sub-Saharan Africa have not contributed significantly to global inventions and patenting. This has to do with the low level of development in the region. Figure 1 shows the low level of inventions and that overall invention rates in South Africa and in the other countries of Sub-Saharan Africa have not grown significantly since the 1980s. While total inventions per year in South Africa is around 1,200, the number of inventions across the rest of sub-Saharan Africa per year is about 100.

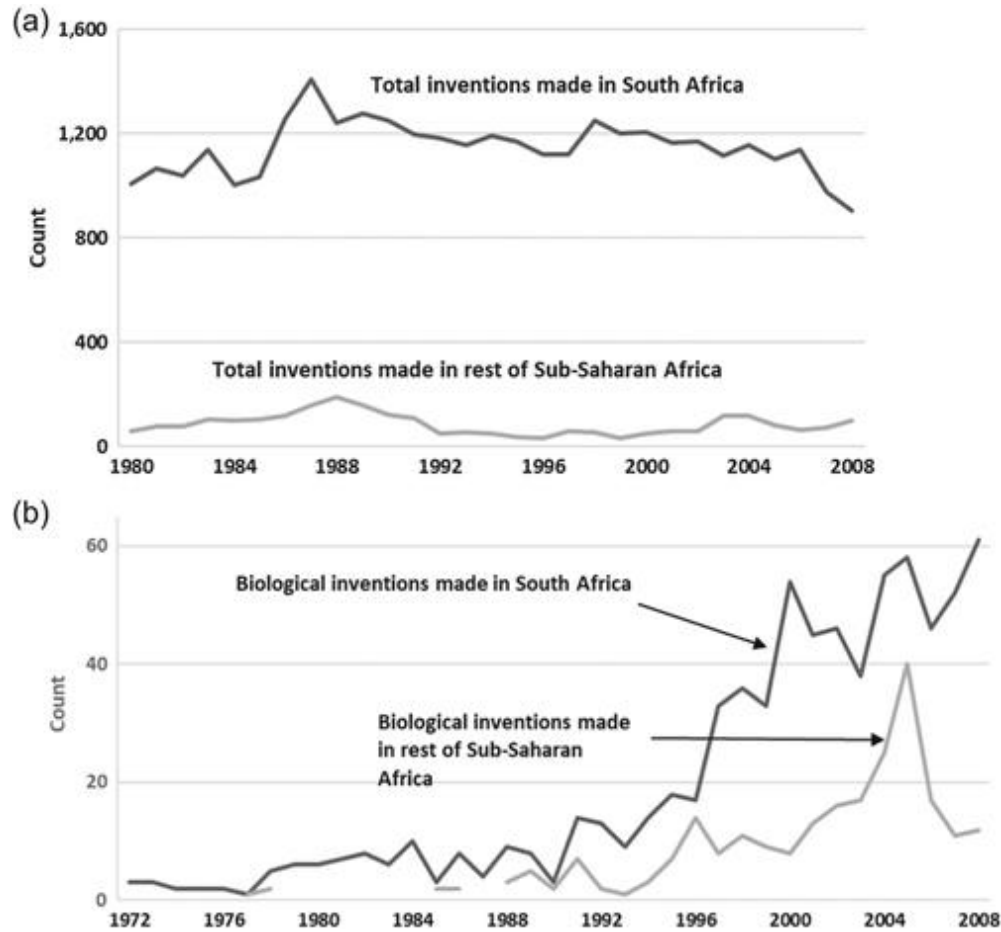


Figure 1: Inventions disclosed in Sub-Saharan Africa from 1972 to 2010

Source: Graff and Pardey (2019)

TABLEV: INVENTIONS PRODUCED IN SUB-SAHARAN AFRICA
FROM 1970 TO 2010

Country of Invention	Total Inventions 1980-2010 (WIPO) (COUNT)	Biological Inventions 1970 – 2010 (InSTePP) (Count)	Biological Inventions assigned to a domestic organization or firm, 1970 – 2010 (InSTePP) (Count)	Share of biological inventions assigned to a domestic organization or firm (%)
South Africa	34,276	755	649	86
African Regional Intellectual Property Organization (ARIPO) member countries				
Botswana	15	0	0	-
Gambia	1	9	3	3
Ghana	16	22	6	6
Kenya	116	46	29	29
Lesotho	5	0	0	0
Liberia	51	2	2	2
Malawi	17	1	0	0
Mozambique	1	0	0	-
Namibia	79	6	6	100
Rwanda	2	0	0	-
Sao Tome & Principe	889	0	0	-
Sierra Leone	44	10	5	50
Sudan	38	0	0	-

Swaziland	7	0	0	-
Uganda	8	6	3	50
Tanzania	7	7	1	14
Zambia	44	4	2	50
Zimbabwe	261	9	7	78
ARIPO countries overall	1,601	126	81	64
Organization Africane de la Propriete' Intellectuelle (OAPI) member countries				
Benin	28	3	3	100
Burkina Faso	12	3	1	33
Cameroon	89	19	11	58
Central African Republic	5	0	0	-
Chad	7	2	0	0
Comoros	4	1	1	100
Congo	31	3	0	0
Cote d'Ivoire	82	6	1	17
Equatorial Guinea	3	0	0	-
Gabon	24	4	3	75
Guinea	57	3	0	0
Mali	29	1	0	0
Mauritania	28	1	0	0
Niger	30	0	0	-
Senegal	71	14	7	50
Togo	23	0	0	-
OAPI members overall	522	56	31	55
Other Countries				
Angola	2	1	0	0
Burundi	19	1	1	100
Cabo Verde	16	1	1	100
Djibouti	0	3	1	33
Eritrea	5	0	0	-
Ethiopia	8	9	1	11
Madagascar	14	11	8	73
Mauritius	224	7	7	100
Nigeria	73	30	11	37
Seychelles	120	6	5	83
Other Countries overall	365	60	40	67

Source: Graff and Pardey (2019)

Patenting and Commercialization of Research Results in Nigerian Universities

Several researchers including [10]; [11]; [12]; [13]; [14] and [5] have reported on the state of intellectual property (IP) generation and technology commercialization in Nigeria. In 2004, the National Universities Commission (NUC) established the Nigerian Universities Research and Development Fair and Exhibition to showcase inventions from Nigerian Universities and promote their commercialization [16]. According to [15] reported in [13], 70% of inventions on display at the 2004 and 2005 Nigerian Universities Research and Development Fairs were not patented. [11] rated the 100 Nigerian patent registration in 21 months (January 2018 to September 2019) as very low. The 2019 Global Innovation Index which measures innovation performance in countries globally, ranked Nigeria among the low – middle income countries that were under performing in the creation and utilization of innovations. The low-level patenting of inventions in Nigeria has been attributed to lack of awareness of the procedure for patenting because of poor patent education in Nigeria.

According to [5], there had been no institutional framework with specific law on intellectual property rights at public funded research institutions in Nigeria before the 2011 Guidelines on Development of Intellectual Property Policy for Universities and R & D Institutions prepared by the National Office for Technology Acquisition and Promotion (NOTAP) to promote interaction and strengthen the linkages between research institutions and industries. Consequently,

NOTAP started the establishment of Intellectual Property and Technology Transfer Offices (IPTTOs) in Universities, Polytechnics and Research Institutions in Nigeria. As of 2021, forty-three (43) IPTTOs have been established to create public awareness, promote IP utilization, and strengthen research – industry linkage in Nigeria. NOTAP is reported to have saved Nigeria over N240 billion in ten (10) years from prevention of capital flight by refusing to approve importation of technologies and services that could be rendered by Nigerians [12].

According to [16], the lack of attention to commercialization of research outputs explains the dearth of local solutions to the nation's economic problems and the country's over dependence on imported products. According to [17], "Considerable research findings abound in Nigerian universities serving no further purpose for society at large because of lack of linkage with industry. This raises the urgent necessity of moving beyond basic research to applied research and innovation, which in addition to creating knowledge/technology would lead to discovering solution and promote global competitiveness of our industries". [18] charged Nigerian scientists to embark on demand driven research which would facilitate the speedy commercialization of Research and Development outputs through industry linkages.

TABLE VI: COMPENDIUM OF RESEARCH RESULTS AND INNOVATIONS IN 36 NIGERIAN UNIVERSITIES SPREADSHEET SUMMARY (BY UNIVERSITY)

S/N	UNIVERSITY	YEAR FOUNDED	GEOPOLITICAL ZONE	TOTAL NUMBER OF RESEARCH RESULTS AND INNOVATIONS
1	ABia State University, Uturu	1981	Southeast	34
2	Abubakar Tafawa Balewa University, Bauchi	1988	Northeast	154
3	Ahmadu Bello University, Zaria	1962	Northwest	636
4	Ambrose Ali University	1992	South south	105
5	Bayero University, Kano	1975	Northwest	77
6	Benue State University	1992	Northcentral	13
7	Delta State University	1992	South South	58
8	Enugu State University of S&T	1981	Southeast	34
9	Federal University of Technology, Akure	1981	Southwest	243
10	Federal University of Technology, Minna	1982	Northcentral	82
11	Federal University of Technology, Owerri	1980	Southeast	165
12	Federal University of Technology, Yola	1981	Northeast	241
13	Imo State University	1992	Southeast	26
14	Ladoke Akintola University of Technology	1990	Southwest	41
15	Lagos State University	1983	Southwest	178
16	Nigerian Defence Academy, Kaduna	1985	Northwest	23
17	Nnamdi Azikiwe University, Awka	1988	Southeast	113
18	Obafemi Awolowo University	1962	Southwest	722
19	Olabisi O. University, Ago – Iwaye	1982	Southwest	112
20	Rivers State University of S&T	1979	South South	276
21	University of Abuja	1988	Northcentral	26
22	University of Ado – Ekiti	1982	Southwest	837
23	University of Agriculture, Abeokuta	1988	Southwest	425
24	University of Agriculture, Makurdi	1988	Northcentral	159
25	University of Agriculture, Umudike	1992	Southeast	71
26	University of Benin	1975	South South	565
27	University of Calabar	1975	South South	298
28	University of Ibadan	1948	Southwest	2800
29	University of Ilorin	1975	Northcentral	157
30	University of Jos	1975	Northcentral	366
31	University of Lagos	1970	Southwest	807
32	University of Maiduguri	1975	Northeast	288
33	University of Nigeria, Nsukka	1960	Southeast	4,501
34	University of Port Harcourt	1975	South south	188
35	University of Uyo	1991	South south	91
36	Usman Danfodiyo University	1975	Northwest	108

Source: NOTAP (2007)

III. METHOD OF DATA COLLECTION

The research approach involves a detailed literature review of intellectual property generation and commercialization statistics from United States of America and United Kingdom Universities to define the possible gaps in technology commercialization practices in Nigerian tertiary institutions. The study was also conducted through surveys using the questionnaire system. Questionnaires were sent to selected universities in each of the six geopolitical zones of the country. The surveys covered the following broad aspects of the study:

1. Invention Disclosures by Universities In the last ten (10) Years
2. Number of Patents issued
3. Number of Start – Up companies formed
4. License Agreements
5. Existence of Intellectual Property and Technology Commercialization Policy in the institution

We sent out questionnaires to selected universities in each of the six geopolitical zones of the country. Fifteen questionnaires were sent to North Central region with ten returned. Eight questionnaires were sent to Northeast region with six returned while twelve questionnaires were sent to Northwest region with six returned. Thirteen, seventeen and twenty-five questionnaires were sent to Southeast, Southsouth and Southwest regions with ten, ten and fifteen questionnaires returned respectively.

**TABLE VII: NUMBER OF UNIVERSITIES IN EACH
GEOGRAPHICAL ZONE OF NIGERIA**

S/N	REGION	NUMBER OF UNIVERSITIES	QUESTIONNAIRES DISTRIBUTED	QUESTIONNAIRES RECEIVED	PERCENTAGE OF QUESTIONNAIRES RECEIVED
1	NORTH CENTRAL	29	15	10	67
2	NORTHEAST	16	8	6	75
3	NORTHWEST	24	12	8	67
4	SOUTHEAST	26	13	10	77
5	SOUTHSOUTH	34	17	10	59
6	SOUTHWEST	55	25	15	60

**TABLE VIII: ENGINEERING AND TECHNOLOGY INVENTION
DISCLOSURES BY UNIVERSITIES IN THE LAST TEN (10) YEARS**

S/N	REGION	CUMMULATIVE INVENTION DISCLOSURES			
		0-5	6-10	11-20	20+
1	NORTH CENTRAL	3	4	3	
2	NORTHEAST	2	4		
3	NORTHWEST		2	3	3
4	SOUTHEAST		4	3	3
5	SOUTHSOUTH	2	3	3	2
6	SOUTHWEST	3	4	4	4

**TABLE IX: NUMBER OF ENGINEERING AND TECHNOLOGY
PATENTS ISSUED IN THE LAST TEN (10) YEARS**

S/N	REGION	CUMMULATIVE NJNUMBER OF PATENTS ISSUED			
		0-5	6-10	11-20	20+
1	NORTH CENTRAL	5	5		
2	NORTHEAST	3	3		
3	NORTHWEST	3	3	2	
4	SOUTHEAST	4	3	3	
5	SOUTHSOUTH	4	5	1	
6	SOUTHWEST	8	4	2	1

TABLE X: NUMBER OF START – UP COMPANIES FORMED

S/N	REGION	CUMMULATIVE NJUMBER OF START -UP COMPANIES FORMED			
		0-5	6-10	11-20	20+
1	NORTH CENTRAL	10			
2	NORTHEAST	6			
3	NORTHWEST	8			
4	SOUTHEAST	10			
5	SOUTHSOUTH	10			
6	SOUTHWEST	15			

TABLE XI: LICENSE AGREEMENTS

S/N	REGION	LICENSE AGREEMENTS			
		0-5	6-10	11-20	20+
1	NORTH CENTRAL	10			
2	NORTHEAST	6			
3	NORTHWEST	8			
4	SOUTHEAST	10			
5	SOUTHSOUTH	10			
6	SOUTHWEST	15			

TABLE XII: DOES THE INSTITUTION HAVE A TECHNOLOGY COMMERCIALIZATION POLICY AND OFFICE OF TECHNOLOGY COMMERCIALIZATION?

S/N	REGION	YES	NO
1	NORTH CENTRAL	3	7
2	NORTHEAST	2	4
3	NORTHWEST	3	5
4	SOUTHEAST	4	6
5	SOUTHSOUTH	3	7
6	SOUTHWEST	5	10

IV. FINDINGS

Best practices in commercialization of university research results

The literature review revealed best practices in commercialization of university research results as shown by the commercialization performance indicators of some American and British universities in Tables I to IV. There are large numbers of invention disclosures, start-up companies formed, and commercialization revenues generated annually by American and British universities.

Comparative performance of Nigeria in technology commercialization among other African countries

Table V shows inventions produced in Sub-Saharan Africa from 197- to 2010 by WIPO Count. It shows the relatively poor performance of Nigeria.

University research focus on publications

The Compendium of Research Results and Innovations in 36 Nigerian Universities prepared by NOTAP in 2007 is a typical example of the large volumes of research results produced by Nigerian universities with limited attention to commercialization. The 2015 African Innovation Outlook rated Nigeria as one of the leading countries in Africa in scientific publications. However, research success in Nigeria means being published in international journals rather than helping local industries to grow.

Engineering and Technology Invention Disclosures

Table VIII shows the responses from the geopolitical zones of Nigeria on the number of Engineering and Technology inventions disclosures. It shows the number of respondents in range of invention disclosures. The low figures is an indication of an educational system which does not pay attention to creativity and innovation.

Number of Engineering and Technology Patents issued

Table IX provides responses in range of cumulative patents issued in the last ten years. The data shows poor attitude to patenting.

Number of Start-up Companies formed

Information on commercialization of research and innovation is provided in Table X. The data shows lack of entrepreneurial culture.

License Agreements formed

Table XI provides information on license agreements for technology commercialization. The very low performance shows the weak linkage between universities and industries.

Existence of Technology Commercialization Policy and Office of Technology Commercialization

Majority of the universities do not have Intellectual Property Policy and Office of Technology Commercialization.

V. DISCUSSION

The study reveals the immense contributions of focused research towards outcomes that result into products and services for economic development. The large numbers of inventions disclosed, start-up companies created, patents licensed, and commercialization revenues generated annually by American and British universities provide classical lessons for Nigerian universities (Tables I to IV). Harvard university in five years (2017 to 2021) produced 2,240 new inventions, got 231 major license agreements with 866 new patents issued. Within the same period, the university formed 91 start-up companies and generated a total of \$352 million in commercialization revenue (Table I). Similarly, from 2017 to 2021, University of Minnesota disclosed 1,926 new inventions with 1,137 new licenses. A total of 2,867 revenue generating agreements were entered into while 89 start-up companies were formed. Gross revenue amounted to \$90.9 million (Table II).

Table III shows the intellectual property generation performance of UK Higher Education Institutions from 1999 to 2018. There were 44, 980 patent applications in ten WIPO technology fields and a total of 12, 429 spinout companies were formed in ten WIPO technology field. According to UK Universities Spinout Report 2021, ten top UK universities raised a total of £6.2 billion from spinouts in two decades (Table IV).

From Table IV, Nigeria's total number of inventions from 1980 to 2010 according to WIPO Count is 73 while South Africa produced a total of 34, 776 inventions in the same period. Other African countries with relatively higher figures than Nigeria include Kenya (116), Sao Tome and Principe (889), Zimbabwe (261), Mauritius (224) and Seychelles (120).

The low level of invention patenting in Nigeria has been reported in several research studies (3, 5, 10, 11, 13, 14). The 2011 Guidelines on Development of Intellectual Property Policy for Universities and R & D Institutions prepared by NOTAP is increasing patenting awareness and driving technology commercialization in Nigeria universities. A lot of research results are produced by Nigerian universities without market values which necessitates a change of focus to demand - driven research. Given the number of universities in Nigeria, a change of focus to applied research will help to drive economic development significantly.

VI. CONCLUSION

University research in developed countries is often business focused with commercialization as the third primary function of universities in addition to teaching and research. This has made these universities to become self-sustaining through the force of commercialization of intellectual properties with substantial revenues from technology licensing and creation of startup companies. In comparative terms, Nigerian Universities and research organizations are not doing enough in intellectual property generation and commercialization of innovations. Commercialization of research is important because it provides a return on public investment in research as it ensures that new and promising ideas are not trapped in laboratories in tertiary institutions and research institutes.

Universities in developed countries create innovation clusters around their catchment regional areas(e,g Silicon Valley established by Stanford university in USA) to stimulate regional economic development through licensing of inventions to local industries and creation of startup companies. These technology commercialization best practices are good lessons for Nigerian universities. Nigerian universities must become microenvironments for innovation and entrepreneurship.

There are several constraints hindering effective research commercialization in Nigeria including weak institutional frameworks, inadequate research funds, poor research facilities and the 'Publish or Perish' concept that makes academics focus research on publications for promotion.

VII. RECOMMENDATIONS

Commercialization of research should be made an explicit role of our tertiary institutions in addition to teaching and research. Our universities must become drivers of national economic growth and development through demand – driven research. A strong system of university – industry collaboration is needed for effective technology commercialization in Nigeria. This requires the involvement of government in a Triple Helix Model of collaboration where government provides the necessary infrastructures and the enabling business environment for the Organized Private Sector to obtain technology licenses from universities for business development.

Nigeria should create strong and effective institutional frameworks for intellectual property ownership and protection, and technology commercialization to turn universities into entrepreneurial institutions. Nigerian university researchers should change to entrepreneurial mindsets instead of concentrating research work on a mindset of publications for promotion. Patent count should be made a component in academic promotion.

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