Consultancy Study on the Level and Impact of Telecommunications-Based Research Innovations in Nigerian Tertiary Institutions

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FINAL REPORT

Synopsis on Research, Development and Innovation, Preliminary Findings from Field Survey, Assessment and Analysis of Innovation Linkages, SWOT Analysis of the NCC Research Program, Comparative Analysis of ICT & Telecommunications-based Research Programmes, Legal Risks of Research Grant Practices in Nigeria, Commercialization Outlook and Recommendations

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Synopsis:	This final project report contains: a. Synopsis on Research, Development and Innovation b. Nigerian tertiary Institution Landscape c. Structure of Indigenous research grants available in Nigeria d. NCC telecommunications-based research innovation grant process. e. Findings on NCC telecommunication-based research innovation in Nigeria (Mostly from field survey, exercise, engagement with stakeholder and review of relevant reports and documentations). f. Assessment and Analysis of research linkages triple helix linkage in Nigeria g. SWOT analysis of NCC telecommunications-based research grant programme. h. Comparative analysis of the major ICT and Telecommunications-based research grant programmes in Nigeria. i. Legal risks associated with research grant practices in Nigeria. j. Modalities for adopting an efficient research grant framework. k. Recommendations. This document is version controlled.
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List of Abbreviations and Acronyms

3G	Third Generation Mobile Communication Technology
4G	Fourth Generation Mobile Communication Technology
5G	Fifth Generation Mobile Communication Technology
ABU	Ahmadu Bello University Zaria
AFIT	Air Force Institute of Technology
AI	Artificial Intelligence
AR	Augmented Reality
AST&D	Academic Staff Training and Development
ATBU	Abubakar Tafawa Balewa University Bauchi
BMAS	Benchmark Minimum Academic Standards
BOI	Bank of Industry
BUK	Bayero University Kano
CBN	Central Bank of Nigeria
CNC	Computer Numerical Control
COVID-19	Corona Virus Disease - 2019
CPES	Cyber Physical Electronic System
CPI	Consumer Price Index
CSO	Civil Society Organization
DRDB	Defence Research and Development Bureau
ECTS	Executive Commission - Technical Services
ESUT	Enugu State University of Technology
EVC	Executive Vice Chairman
F&A	Finance and Accounts
FABLAB	Fabrication Laboratory
FCT	Federal Capital Territory
FMoCDE	Federal Ministry of Communications and Digital Economy
FMSTI	Federal Ministry of Science, Technology and Innovation
GDP	Gross Domestic Product
GHz	Giga Hertz
GPU	Graphic Processing Unit
GSM	Global System of Mobile communications
HQ	Head Quarters
ICT	Information and Communications Technology
IoT	Internet of Things
IP	Intellectual Property

IPTTO	Intellectual Property and Technology Transfer Office
IT	Information Technology
LAN	Local Area Network
LPWAN	Low Power Wide Area Network
M&E	Monitoring and Evaluation
MDA	Ministry, Department and Agency
MIMO	Multiple Input Multiple Output
MM Wave	Millimetre Wave
MoD	Ministry of Defence
MOQ	Minimum Order Quantity
MOU	Memorandum of Understanding
N	Naira
NASDRA	National Space Research and Development Agency
NASENI	National Agency for Science and Engineering Infrastructure
NBS	National Bureau of Statistics
NBTE	National Board for Technical Education
NCAIR	National Centre for Artificial Intelligence and Robotics
NCC	Nigerian Communications Commission
NCCE	National Commission for Colleges of Education
NCDMB	Nigerian Content Development and Monitoring Board
NCR&DF	Nigerian Content Research & Development Fund
NCS	Nigeria Computer Society
NDEPS	National Digital Economy Policy and Strategy
NDISEP	National Digital Innovation, Entrepreneurship and Start-up Policy
NGN	Naira
NGO	Non-Governmental Organization
NIDF	NCS Innovation Development Fund
NNBP	Nigeria National Broadband Plan
NODITS	Nigeria Office for Developing the Indigenous Telecoms Sector
NOTAP	National Office for Technology Acquisition and Promotion
NPPIC	National Policy for Promotion of Indigenous Content in Telecoms Sector
NRA	National Regulatory Agency
NRF	National Research Fund
NSB	Nigeria Start-up Bill
NSTI	National Science, Technology and Innovation
NUC	National Universities Commission
OECD	Organization for Economic Cooperation and Development

ONDI	Office for Nigeria Digital Innovation
PCB	Printed Circuit Board
PDA	Patent and Design Act
PhD	Doctor of Philosophy
PTDF	Petroleum Technology Development Fund
QoE	Quality of Experience
QoS	Quality of Service
R&D	Research and Development
RDI	Research Development and Innovation
SDG	Sustainable Development Goal
SMEDAN	Small and Medium Enterprise Development Agency
SN	Serial Number
SPV	Special Purpose Vehicle
SSC	Smart and Sustainable Cities
STI	Science, Technology and Innovation
TEIT	Technology Enhancement and Industry Training
Telecom	Telecommunications
TETFund	Tertiary Education Trust Fund
TRL	Technology Readiness Level
TSA	Treasury Single Account
TSNI	Technical Standards and Network Integrity
UAV	Unmanned Aerial Vehicle
UI	University of Ibadan
UJESR	UNIPORT Journal of Engineering and Scientific Research
UK	United Kingdom
UNIJOS	University of Jos
UNILAG	University of Lagos
UNIPORT	University of Port Harcourt
USA	United States of America
USD	United States Dollar
VR	Virtual Reality
WAN	Wide Area Network

Executive Summary

Synopsis

NCC as the Nigerian telecommunications industry's regulator, has the responsibility of ensuring qualitative and efficient telecommunications services in Nigeria - a responsibility which it has lived up to over the years. Amongst others, encouraging effective research and development efforts by all communications industry practitioners, is one of it mandates. NCC, through the award of research grants on telecommunications-based research innovations to Nigerian tertiary institutions, has remained committed to this mandate. These grants are awarded with a goal of assisting with the development of commercially viable prototypes that can address upcoming challenges in Nigeria. Between year 2015 and 2020, NCC awarded 31 research grants valued at about N300 million to 21 Nigerian tertiary institutions for telecommunications-based research innovations.

This project involves evaluating and assessing the different research areas and collaborations, effectiveness, efficiency, gaps, challenges and opportunities with the telecommunications-based and ICT research innovations projects in tertiary institutions across the country.

Methodology

Project implementation was achieved through a combination of methods. These includes:

a. Review of documentations, reports, publications relevant to the project such as OECD reports on innovation, NSTI policy, NDISEP, NDEPS, numerous research papers and journals on research innovation in Nigeria, etc.
b. Census based field survey of lead researchers who were beneficiaries from 2015 to 2020. This involved quantitative data collection, discussion sessions & interviews with researchers. We sampled 25 out 30 beneficiaries (5 were either out of the country or unreachable).
c. Qualitative survey via interviews and discussions sessions with subject matter experts in the Nigerian telecommunications-based research innovation eco-system.
d. Analysis and triangulation of gathered data.

Findings on Research Innovations in Nigerian Tertiary Institutions

There are no fewer than 554 tertiary institutions in Nigeria offering different courses around 13 major fields of discipline (faculties). Several research grants are available to lecturers and researchers in Nigerian tertiary institutions; some of the major sponsors include: TETFund, NCC, CBN, NCDMB, NITDA, PTDF, NCS, NASENI, Ministry of Defence, etc. Research grant values range from as low as N1million to N50million depending on the sponsoring institution. NCC is the major sponsor of telecommunications-based research, development and innovation in Nigeria.

63% of researchers affirmed that the research projects have resulted in collaborations with other lecturers/researchers within the academia community. 52.6% have collaborated with domestic research institutions while only 36.8% of sampled researchers collaborated with international research institutions. 84% of the research projects claimed to have used at least one new or emerging technology (such as 5G, IoT, etc.). Over 90% of sampled researchers have published at least one technical paper inspired by the research project.

Access to funds, access to specialized components and raw materials, inadequately equipped research facilities and lack of basic infrastructure topped the list of challenges faced by researchers in implementing their telecommunications-based research innovation projects. Funds disbursement process from NCC to the institution has the most bottleneck, followed by funds disbursement from the institution to the researcher. Some researchers revealed that it takes well over 30 days from date of payment request to receive payment. "Funding & Investment" and "Branding & Marketing" are the most barriers that researchers anticipate they will have during the commercialization stage of their innovation; 89.5% of researchers agreed or strongly agreed that the market exists to patronise their research innovations outputs when commercialized.

Over 70% of all sampled researchers agreed or strongly agreed that the research innovation program has had the following impacts:

a. Improvements in collaboration between researchers within the academia community.
b. Improvements in collaboration between researchers and stakeholders in the Nigerian telecommunication industry.
c. Building indigenous capacity in Nigerian tertiary institutions around telecommunication engineering, new and emerging technologies, etc.
d. Good potential for job creation when commercialization commences.
e. Strong Potential for attracting foreign investments into the telecommunication sector, etc.

The OECD defined 9 Technology Readiness Levels (TRL) which starts from TRL 1 (basic research) and ends at TRL 9 (early deployment of near-commercial technologies). Most of the research projects are at TRL 4-5 and TRL 6-7. Nigeria is currently at strength level 2 of the triple helix linkage framework i.e. the push-pull stage. An assessment of the triple helix innovation linkages in Nigeria (i.e. government-academia, government-industry and academia-industry) showed that the government-academia linkage performs above average, government-industry linkage is at average level while the academia-industry linkage has a below average.

The research projects were analysed and found to have viable applications for different user groups such as: service providers, individuals & households, physical & online

businesses, government MDAs, national regulatory agency, agriculture, health, military and security-provision institutions.

The legal risks generally associated with research grant practices in Nigeria include: IP ownership, IP theft, plagiarism and Force Majeure.

SWOT Analysis of NCC Telecommunications-based Research Programme

Strengths:

a. Funding from NCC (Over N500million has been invested in research grant).
b. Applied research regime based on strong research needs-assessment by NCC.
c. Integration of several new and emerging technologies (5G, IoT, AI, etc.).
d. Knowledge and skillset of Researchers.
e. Good Government-Industry linkage.
f. Strong Collaboration between researchers in academia community.
g. Capacity building vehicle for tertiary institution.

Weaknesses:

a. Weak Academia-Industry linkage.
b. Collaboration bottlenecks between researchers and NCC.
c. Funds disbursement bottlenecks (NCC to institution and institution to researcher).
d. Low IP protection enforcement.

Opportunities:

a. Investment opportunities (local and foreign) in commercialization of research outputs.
b. Socioeconomic development post commercialization.
c. Export potential for commercialized products and services.
d. Multi-sector application of research outputs e.g. telecoms, health, security, regulation, military, etc.

Threats:

a. Economic Instability (high inflation and high exchange rates
b. Problem of Insecurity.
c. IP theft due to early publication of research papers without patenting as well as prototype fabrication abroad.
d. Legal risks in research grant practices.

A comparative analysis of the major ICT and telecommunications-based research grant programmes in Nigeria was also conducted (see chapter 4.11).

Conclusion

The NCC telecommunications-based research innovation programme has been effective in driving interest among researchers in Nigerian tertiary institutions to engage in and collaborate on various applied research and development activities. The program has also helped in building indigenous capacity within the academia in this regard. A good number of these research projects are nearing the prototype completion stage and have good commercialization potentials for use in telecommunications service provision, homes & businesses, telecoms industry regulatory services, security, agriculture, health, etc.

NCC has also been instrumental in facilitating and strengthening linkages between academia, industry and government through this programme. Bottlenecks in the funds administration process, access to specialized components & raw materials, impacts of the

COVID-19 pandemic and high foreign exchange rates have been the biggest barriers faced by lead researchers in the NCC telecommunications-based research grant programme. The commercialization of prototypes, once fully developed, is essential to addressing existing and emerging socio-economic challenges in Nigeria and promotion of investments.

Recommendations

a. Design, Development and Deployment of a centralized online portal platform for management of the NCC research grants program. This will assist in workflow automation and streamlining of key processes involved in the research grant management process amongst others.
b. Establishment of a state-of-the art design and fabrication facility/laboratory to facilitate access to digital design and production technologies.
c. Strategic collaboration & partnership between NCC and CBN to facilitate lead researchers' access to FOREX for purchase of specialized components.
d. Strategic collaboration & partnership between NCC and Nigerian Customs Service to facilitate importation of "restricted items" needed by lead researchers in research projects that require such.
e. NCC should consider increasing the maximum grant value owing to the prevailing inflation rates in Nigeria.
f. NCC should consider an upward review of the initial tranches especially for hardware-centric projects that require fabrication at initial stages.
g. Conduct a separate consultancy for Commercialization of the R&D outputs.
h. Creation and promotion of policies that will drive local content adoption in the Nigerian telecommunications industry.
i. NCC should foster academia-industry linkage by encouraging private sector participation (e.g. telecommunications service providers) in telecommunication-based research and development activities.
j. NCC should consider benchmarking innovation outputs with regional and international standards to ensure future-proof R&D outcomes.
k. NCC should consider conducting entrepreneurship development workshops for lead researchers during the research & development phase of their projects.

1. Background and Introduction

1.1 Synopsis

Over the last decade, the world has seen and sometimes marvelled at advancements and innovations in telecommunications and computing technologies. This is evident in the number and maturity levels of new and emerging technologies available today; examples include: Artificial Intelligence (AI), 5G, Internet of Things (IoT), Cloud computing, Smart and Sustainable Cities (SSC), Augmented Reality and Virtual Reality (AR/VR), etc.

The Nigerian telecommunications industry has also grown remarkably over the years and has contributed immensely to socio-economic growth and development; for instance, the Nigerian telecommunications industry contributed 12.45% to the nation's GDP in 2020, which was vital in taking Nigeria out of recession.

The Nigerian Communications Commission (NCC) is the independent national regulator for the Nigerian telecommunications industry and is responsible for ensuring qualitative and efficient telecommunications services in the country; one its mandate is to encourage effective research and development efforts by all communications industry practitioners. Throughout the years, NCC has remained committed to this mandate via the award of research grants on telecommunications-based innovations to different tertiary institutions across the country. From year 2015 to 2020, NCC awarded 31 telecommunications-based innovations research grants valued close to N300million to 21 Nigerian tertiary institutions.

On the 8th of April 2022, NCC announced the award of N233 million in research grants and professorial chair endowments; N172.5m of this sum (i.e. 74%) was earmarked for telecommunications-based research innovations on new and emerging technologies – an indication of its dedication to sustain growth and development of the Nigerian telecommunications industry. The goal of these grants is to assist with the development of commercially viable prototypes that can address upcoming challenges in Nigeria.

Some government organizations, private sector businesses and civil society organizations (CSOs) have also been involved with promoting research innovations in Nigeria. Notably, Tertiary Education Trust Fund (TETFund), Central Bank of Nigeria (CBN), Petroleum Technology Development Fund (PTDF), etc.

have been remarkable in their commitment to supporting different research innovations in Nigeria through research grants.

There is no doubt that millions of Naira have been injected into the Nigerian ICT research innovation ecosystem, which is not without challenges in producing the expected ICT innovation outputs and commercializing them.

This study is on "The Level and Impact of Telecommunications-based Research Innovations in Nigerian Tertiary Institutions." This broadly involves evaluating and assessing the different research areas and collaborations, effectiveness, efficiency, gaps, challenges and opportunities with the telecommunications-based and ICT research innovations projects in tertiary institutions across the country.

1.2 Project Aim and Objectives

The aim and objectives of the project are to:

a. Provide an insight into the level and impact of research grants in Nigeria;
b. Understudy the benefits of such grants to the Commission and its Stakeholders;
c. Evaluate the challenges experienced in the fund allocation, disbursement and beneficiary access and suggest solutions;
d. Streamline all research works into possible commercialization opportunities for the industry which is critical for our national development and sustainability;
e. Review the level of research grants awarded by other industry practitioners and suggest ways to encourage their support to Nigerian tertiary institutions and technology research companies.

1.3 Project Scope

Period of coverage for the study: Year 2015 to 2020.

The scope of coverage includes:

a. Types and structures of research grants available in Nigeria;
b. Modalities for adopting an efficient research grant framework;
c. Benefits and challenges of research grants, especially to support the digital economy agenda and meet challenges during and after the pandemic;
d. Identifying the challenges facing researchers from proof of concept to prototypes - its legal risks and the ramifications associated with standard practice delivery of research grants in Nigeria.

2. Synopsis on Research, Development and Innovation

Research, Development and Innovation (RDI) is the process of developing and commercializing new ideas, improving existing products, services, processes as well as implementing new ones. Research and Development promotes innovation which in turn drives competition and economic growth and development.

Research and Development (R&D) can either be basic or applied; basic research mainly expands knowledge and is limited in its commercial applicability while applied research solves practical problems and results in innovation. Most applied research and development projects are conducted within the walls of tertiary institutions, research institutions or specialized high-tech companies. The figure below shows conceptual differences between basic and applied research.

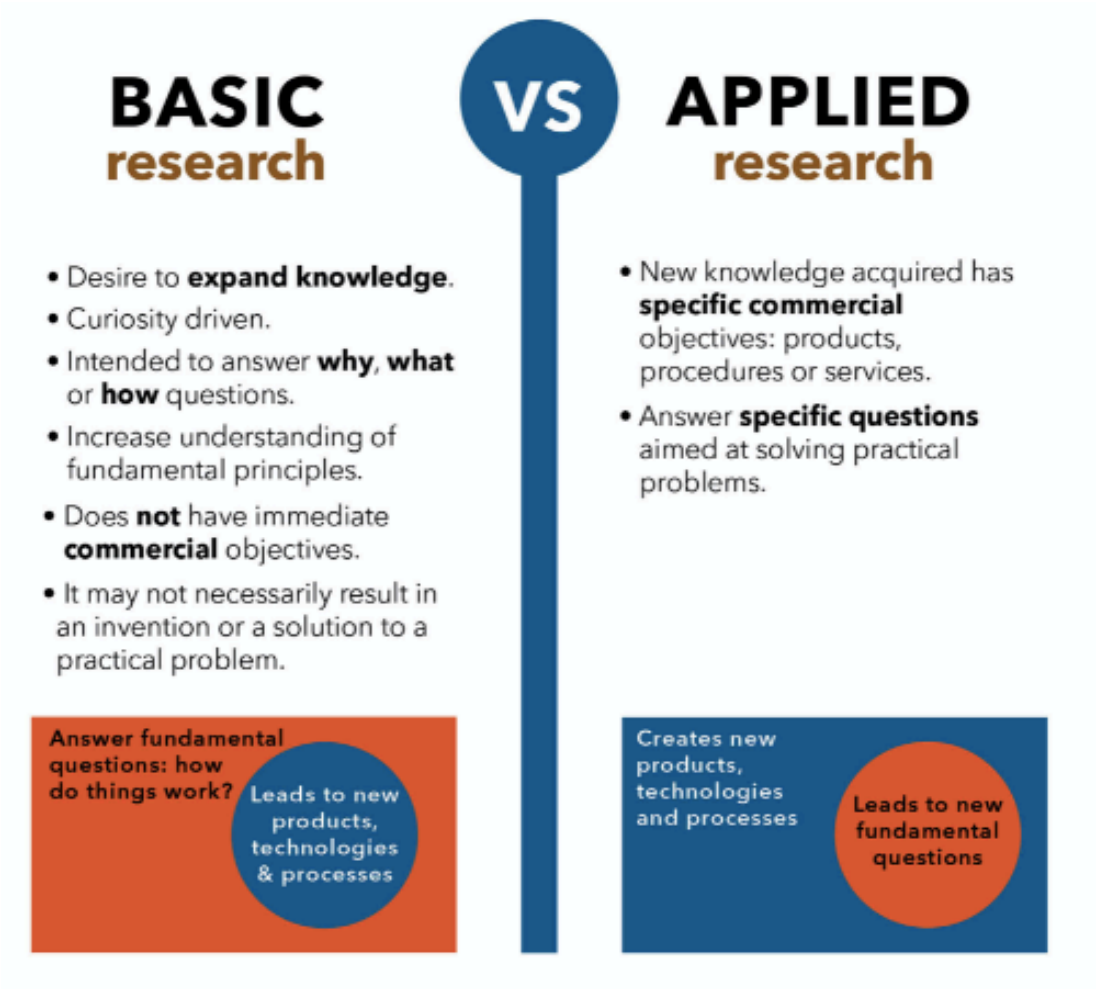


Figure 1: Basic versus Applied Research

Image Source: RespectUs (2021), Online available at: https://www.respectus.space/post/basic---fundamental---applied-research-some-clarifications

2.1 Research Innovation Cycle

Several stages are involved in research innovation and typically starts from the ideation stage and ends with commercialization and knowledge diffusion. The stages include:

a. RDI Needs Assessment, Ideation and Screening.
b. Prototype Design, Development, Testing and Patenting.
c. Full Implementation.
d. Commercialization.

The figure below shows the RDI process flow.

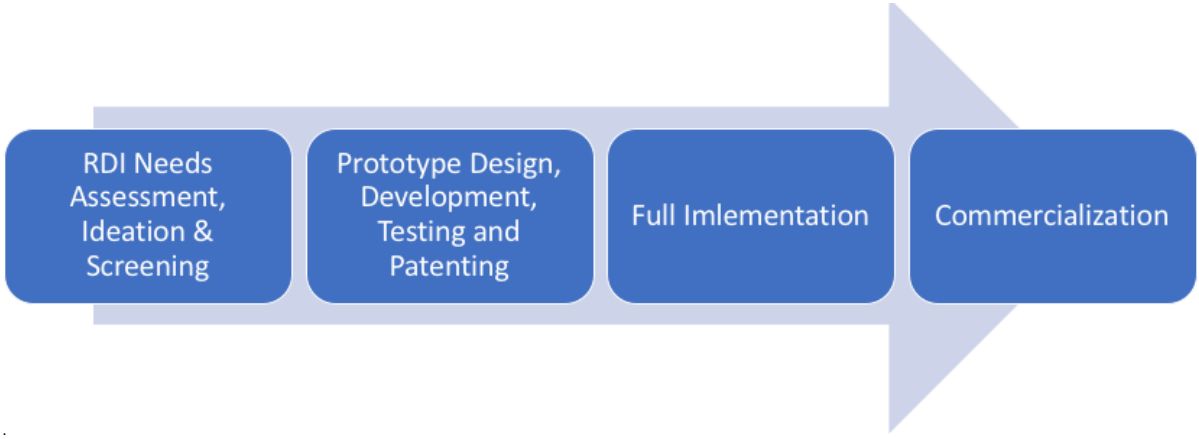


Figure 2: Research, Development and Innovation Process Flow

a. RDI Needs Assessment, Ideation and Screening: This involves assessing research, development and innovation needs of an economic sector, geographic location or technology. Ideation involves coming up with ideas and proposals to solve the RDI needs identified. Screening is the process of validating and fine-tuning the ideas to attain suitability status for the identified RDI needs.

b. Prototype Design, Development, Testing and Patenting: This stage of the RDI cycle involves design & development, prototype creation as well as testing of prototypes. This stage is usually iterative to address limitation and defects identified in the prototype testing process. Patents for designs and developments are usually registered at this stage.

c. Full Implementation: Upon successful test certification, full implementation of the prototype follows suit. The full implementation stage reflects recommended improvements and correction of defects identified in the prototype. Early adopters are usually first users of the full implementation outputs. Licensing and standards certification are obtained at this stage of the RDI cycle.

d. Commercialization: This is process of taking the innovation output to market for distribution to consumers.

2.2 Research & Development Linkage Model for Innovation

The knowledge-base for driving research, development & innovation majorly lies with the academia community. What typically starts as a personal R&D project for a researcher, often has the potential of ending up as a fully commercialized product or service. Several enablers such as funding & investments, collaboration, linkages etc are needed for successful transition from ideation stage to commercialization stage. Conversely, the transition process is not fully immune to barriers and challenges.

Government support in the form funding & investment is required to accelerate and facilitate the rate of RDI outputs. Early adoption and collaborations are also required from the industry to aid commercialization efforts for the innovation outputs. Hence, there exists the need and possibility of linkages between academia, government and the industry on different aspects of the RDI cycle. This interaction was described by Etzkowitz and Leydesdorff (1995) and popularly known as the **Triple Helix Model of Innovation**. The theory stipulates that "***interactions between academia, industry and government is required to foster economic and social development***".

Academia holds the key of knowledge, government holds the key of stable interaction and industry holds the key of production.

The figure below shows the different strengths of interactions in the Triple Helix framework for RDI linkages between academia, industry and government.

Strength Level 1: **Silo Confinement**

This occurs mostly in developing countries where all institutions are in silos and there is no form of interactions between academia, industry and government.

This level is often characterized by low innovation outputs and poor commercialization potentials.

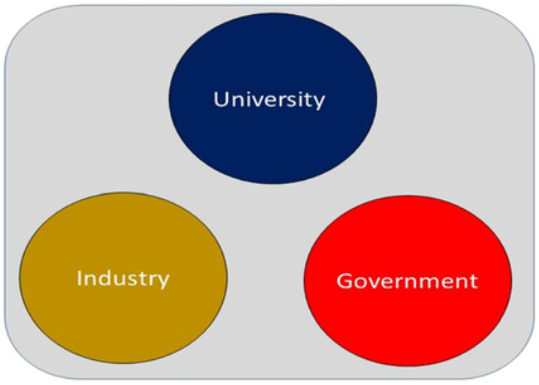


Figure 3: Triple Helix Interaction in Developing Countries

Strength Level 2: **Push-Pull**

This mostly occurs in middle income countries. At this level, there are emerging strategic interactions between academia, industry and government. Barriers affect interaction between academia, industry and government. This level is often characterized by early stages of new product ideas, innovations, job creation, infrastructure, strategic RDI needs, funding, etc.

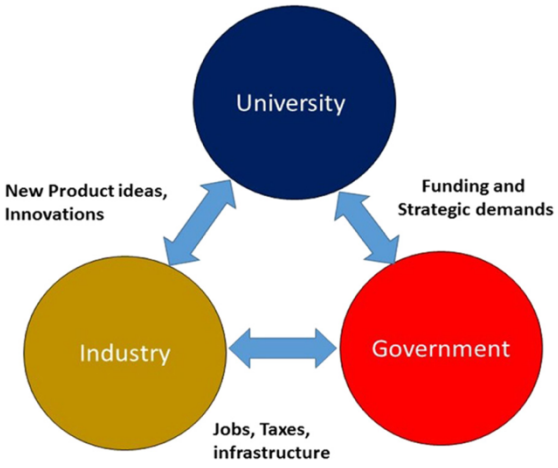


Figure 4: Emergence of Triple Helix Interactions

Strength Level 3: Triple-Helix

This occurs mainly in developed countries. Seamless strategic interactions between academia, industry and government occurs at this level. Barriers are at their barest minimum. This level is characterized by sustained new product ideas, robust infrastructure, adequate funding, skilled jobs, etc.

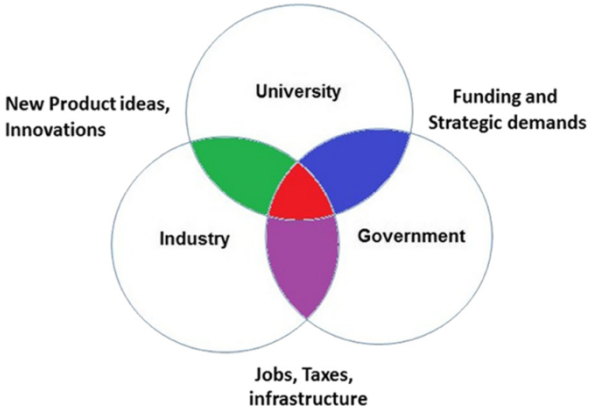


Figure 5: Triple Helix Strategic Interactions

The expected outcomes from the strategic interactions between parties in the Triple Helix model is shown below.

Table 1: Expected Outcomes from Strategic Interactions in the Triple Helix Model

SN	Interaction/Linkage	Expected Outcomes
1.	Government-Academia	a. Funding & Investments b. Strategic RDI Demands
2.	Government-Industry	a. Infrastructure b. Innovation Adoption c. Job Creation d. Policies & Regulations
3.	Industry-Academia	a. New Product Ideas b. Innovation c. Early Adoption

2.3 Nigerian Tertiary Institutions Landscape

2.3.1 Nigerian Tertiary Institutions

Nigerian tertiary institutions comprise of universities, polytechnics, colleges of education and specialized institutions regulated by different government agencies. The table below shows the number of Nigerian tertiary institutions and their corresponding regulators.

Table 2: Nigerian Tertiary Institution Statistics

SN	Institution Category	Regulator	Number of Institutions
1.	Federal University	NUC	49
2.	State University	NUC	57
3.	Private University	NUC	11
4.	Federal Polytechnic	NBTE	40
5.	State Polytechnic	NBTE	49
6.	Private Polytechnic	NBTE	76
7.	College of Education	NCCE	219
8.	Specialized Institutions	Different Organizations	53
		Total	**554**
Source: NUC, NBTE, NCCE, etc.			

2.3.2 Major Fields of Tertiary Education in Nigeria

The Benchmark Minimum Academic Standards (BMAS) published by the National Universities Commission (NUC) lists thirteen (13) major **fields of discipline** (faculties) in Nigerian tertiary institutions. These fields are:

a. Administration; Management and Management Technology.
b. Agriculture, Forestry, Fisheries and Home Economics.
c. Arts.
d. Basic Medical and Health Science.
e. Education.
f. Engineering and Technology.
g. Environmental Sciences.
h. Law.
i. Pharmaceutical Sciences.
j. Medicine and Dentistry.
k. Science (Natural, Applied, Physical, Biological)
l. Social Sciences.
m. Veterinary Medicine.

Source: https://nuc.edu.ng/wp-content/uploads/2015/09/Education%20Draft%20BMAS.pdf

This suggests that R&D activities in Nigerian tertiary institutions stem from these top-level fields since the researchers are mostly lecturers in these faculties.

2.4 Types and Structure of Research Grants Available in Nigeria

The R&D scenery in Nigerian tertiary institutions cuts across different fields and is intended for different sectors of the economy. Government organisations are major sponsors of R&D programs in these institutions through award of research grants. Several R&D needs are usually identified and researchers are expected to send in their proposals or concept notes to the sponsoring organization for evaluation and subsequent award of research grant. Despite the volume of research grants awarded for years to researchers in Nigerian tertiary institutions, the utilization of R&D findings in Nigeria has remained low, resulting in low innovation turnover from the academia community as most research innovations outputs are yet to be fully implemented and commercialized.

2.4.1 Major Indigenous Sponsors of R&D in Nigerian Tertiary Institutions

The major **indigenous** sponsors of R&D in Nigeria tertiary institutions are:

a. Tertiary Education Trust Fund (TETFund)
b. Central Bank of Nigeria (CBN)
c. Nigerian Communications Commission (NCC)
d. Nigerian Content Development and Monitoring Board (NCDMB)
e. National Information Technology Development Agency (NITDA)
f. Petroleum Technology Development Fund (PTDF)
g. Nigeria Computer Society (NCS)
h. National Agency for Science and Engineering Infrastructure (NASENI)
i. Ministry of Defence (MoD)

2.4.2 Types of Research Grants in Nigeria

The major types of research grant available in Nigeria are as follows:

a. National Research Fund (NRF) Grant: This is managed by TETFund and has been in existence since 2009. It is a special intervention approved by the Federal Government for promoting the conduct of applied research and innovation by academics in public tertiary educational institutions. The main objective is to drive the socio-economic development of Nigeria in an increasingly globalized and highly competitive knowledge-driven world economy. NRF grants are capped at N50 million per awardee. The NRF grants are categorized into three (3) thematic areas with 25 research focus areas; the table below enumerates these thematic and research focus areas.

Table 3: NRF Grant Thematic and Research Focus Areas

SN	Thematic Area	Research Focus Area
1.	Humanities and Social Science	a. National Security, National Integration & Peace Studies
		b. Education & Training
		c. Economic Development
		d. History, Culture and Religion
		e. Languages, Literature and Media
		f. Social Development and Welfare
		g. Population Studies
		h. Politics, Law and Governance
		i. Tourism
		j. Sports and Recreational Development
		k. Gender, Equity and Social Inclusion
2.	Science, Technology and Innovation	a. Agriculture and Food Security
		b. Health & Social Welfare
		c. Transport
		d. Energy & Power
		e. IT, Computing and Telecommunications
		f. Space Science and Technology
		g. Geosciences
		h. Engineering
		i. Water and Sanitation
3.	Cross-Cutting	a. Environment, Housing and Urban Development
		b. Entrepreneurship and Wealth Creation
		c. Resource Governance
		d. Science, Technology and Innovation System Management
		e. Cross-cutting Issues in Sustainable Development Goals (SDG)
Eligibility and Rules: a. Beneficiaries must be a Nigeria lecturer or researcher employed in a Nigerian tertiary institution. b. Research projects must be completed within 24 months of award.		

TETFund has awarded grants of about N10.4 Billion for research projects in the last two NRF grant cycles (2019/2020 & 2020/2021) - a total of 128 new research projects valued at N3.9Billion for the 2019/2020 cycle and 217 research projects valued at N6.39 Billion for the 2020/2021 cycle. It has also increased its funding envelope to N8.5 Billion per grant cycle.

b. Academic Staff Training and Development (AST&D) Intervention: This is an academic staff training intervention grant program introduced by TETFund to address the growing needs of Nigerian tertiary institutions. The AST&D intervention provides grants to lecturers for studies aimed at acquiring higher degrees (mostly done abroad). The Director of AST&D in TETFund noted that: "***before the AST&D program, only 40% of Nigerian lecturers has PhD and Masters degree but that figure has risen to about 90% since the introduction of the AST&D intervention grant***."

The AST&D intervention grant favours 60% of Science and Technology based courses and 40% of Arts and Social Sciences courses.

Table 4: Course Area Allotment for the AST&D Intervention

SN	Course Area	Allocation Ratio
1.	Science and Technology Courses	60%
2.	Arts and Social Sciences Courses	40%
Eligibility Criteria: Must be a Lecturer in a Nigerian Tertiary institution		

c. Telecommunications-based Research Innovations Grant: This is managed and awarded by NCC. It is aimed at funding and commercializing RDI projects from academics in Nigerian tertiary institutions that have feasible research ideas, capable of replacing or enhancing foreign technologies in the telecommunications ecosystem in Nigeria. It is expected that the initiative will help build capacity in increase Nigerian content in the Nigerian telecommunication industry. The focus areas of research depend on RDI needs assessment identified by NCC. For 2021, the grant focused on 5 research focus areas.

Research Focus Areas for 2021:

1. 5G deployment.
2. Innovative Clean Energy
3. Advanced Method of Quality of Service (QoS)/Quality of Experience (QoE) Management and Test Mechanism
4. IoT Low Power Wide Area Network (LPWAN) Technology and
5. Monitoring and Localizing of Drones.

Eligibility Requirements:

1. Lecturer teaching Academics in Nigeria's tertiary institutions.
2. Two-page executive summary on the research innovation proposal as well as project timeline, deliverables and detailed cost schedule.
3. Research must be completed within two (2) years.

For 2021, the research grant values were capped at N14 million per project although NCC reserved the right review this amount.

Since its inception in 2013, NCC has awarded over N500 Million to researchers in Nigerian Tertiary institution for telecommunications-based research innovations. Over the years, it has progressively increased the envelope for its research grant program. In July 2022, NCC hosted a regional roundtable with Academia, Industry and other Stakeholders in Kano; NCC's Executive Commissioner Technical Services (ECTS), Engr Ubale Maska disclosed that "***the Commission has awarded 49 telecom-based research grants to the academia out of which 10 prototypes were successfully developed and displayed to industry stakeholders***".

The EVC, Prof Umar Danbatta also disclosed that "***NCC is now focused on supporting the academia in the commercialisation of the prototypes from these innovative researches as this is relevant to the Federal Ministry of Communications and Digital Economy's policy towards achieving indigenous technology for sustainable development of our country***".

d. NITDA Research Grant: This focuses majorly on ICT development and advancement in Nigeria. NITDA has two (2) broad categories of grants:

a. Professor Ajayi Research Grant
b. IT Research Grant

Under its scholarship program, NITDA has successfully sponsored over 247 Nigerians for post graduate studies in IT fields.

In recent years, NITDA has channelled more of its grants toward technology start-up ecosystem as against tertiary institutions.

e. PTDF Scholarships and Research Grant: The Petroleum Technology Development Fund (PTDF) has granted over 10,000 overseas and local scholarships to Nigerians for post graduate studies in different petroleum and related fields. Under its Technology Enhancement and Industry Training (TEIT) program, PTDF has also awarded grants to several Nigerians for indigenous technology development in the petroleum sector.

f. Federal Ministry of Science, Technology and Innovation (FMSTI) Grants: The FMSTI grants are periodically awarded based on RDI needs assessment. Research institutions, technology start-ups, technology incubation centres, indigenous manufacturers, etc are typical beneficiaries of this research grant program.

g. **NCS Innovation Development Fund (NIDF) Grant:** The NIDF is anchored the Nigeria Computer Society (NCS) - the umbrella body for all Information Technology (IT) practitioners and interest groups in Nigeria. NCS created the NIDF grant program to support existing governments efforts in area of research grants for IT development in Nigeria and to help improve Nigeria's ranking in ICT development and digital readiness. The NIDF grants support individuals in private or public organization willing to conduct developmental research and innovations in Information Technology.

Research Focus Areas

NDIF grant focuses on the following research areas:

a. Connectivity (5G Network)
b. System Automation and Design Digital Economy
c. Robotics
d. Artificial Intelligence
e. Cybersecurity
f. Internet of Things and Smart City
g. Virtual Reality and Environment
h. e-Health, e-Agriculture and e-Learning
i. Software defined everything
j. And others.

The screening of applications is handled by the NCS's innovation executive council. The table below summarizes the different grant categories under the NIDF program.

Table 5: NCS NIDF Research Grant Categories

SN	Category	Maximum Research Delivery Period (Years)	Maximum Grant (NGN)	Number of Awards per Year
1.	Grade A	3	5 million	1
2.	Grade B	2	2.5 million	4
3.	Grade C	1	1 million	5
4.	Grade D	1	500,000	10
			Total	**20**

NCS awards N25 million annually for 20 new RDI projects in Nigeria.

h. **Defence Research Project Grant:** This is sponsored by the Defence Research and Development Bureau (DRDB) and beneficiaries are typically within specialized military institutions and academia community. The DRDB grant program is tailored to promote indigenous military research and development programs in Nigeria. In June 2022, DRDB concluded talk s with the Airforce Institute of Technology (AFIT), Kaduna on collaborations for military-based research and development.

i. **Other R&D Grants:** Other grantors include: The Central Bank of Nigeria (CBN) and National Agency for Science and Engineering Infrastructure (NASENI). The table below summarizes their grant programs.

Table 6:Other Sponsors of R&D Grants in Nigeria

SN	Sponsor	Grant Program Summary
1.	Central Bank of Nigeria (CBN)	The CBN grant is for healthcare research and development in Nigeria. The grant was inspired by the COVID-19 pandemic and is aimed supporting R&D activities that will lead to indigenous drug production, improvement of Nigeria's maturity level on the WHO scale and facilitation of partnerships between the academia and the industry. In 2021, CBN awarded N254 million to 5 researchers under this grant program.
2.	National Agency for Science and Engineering Infrastructure (NASENI)	NASENI has been tasked with managing the Nigeria-Czech Republic's $20m research grant for Nigerian scientists and engineers. Between 18th May 2022 and 17th July 2022, a total of 285 research proposals were submitted to NASENI for consideration and evaluation.

3. Approach and Methodology

Data was gathered from stakeholders in the telecommunications and ICT research ecosystem in Nigeria with a view to addressing the defined aim and objectives of the study. Project implementation was achieved via the following steps:

a. Review and Evaluation of reference programme materials specific to the NCC telecommunication-based research grant programme;
b. Study and Review of reference documentations and reports relevant to the research topic;
c. Qualitative and Quantitative survey;
d. Assessment of other ICT-based Research Innovations Programmes;
e. Triangulation and Analysis of Gathered Data;
f. Documentation of Findings and Recommendations;
g. Consolidation and Report Writing.

Combination of these steps gave a comprehensive implementation of the project.

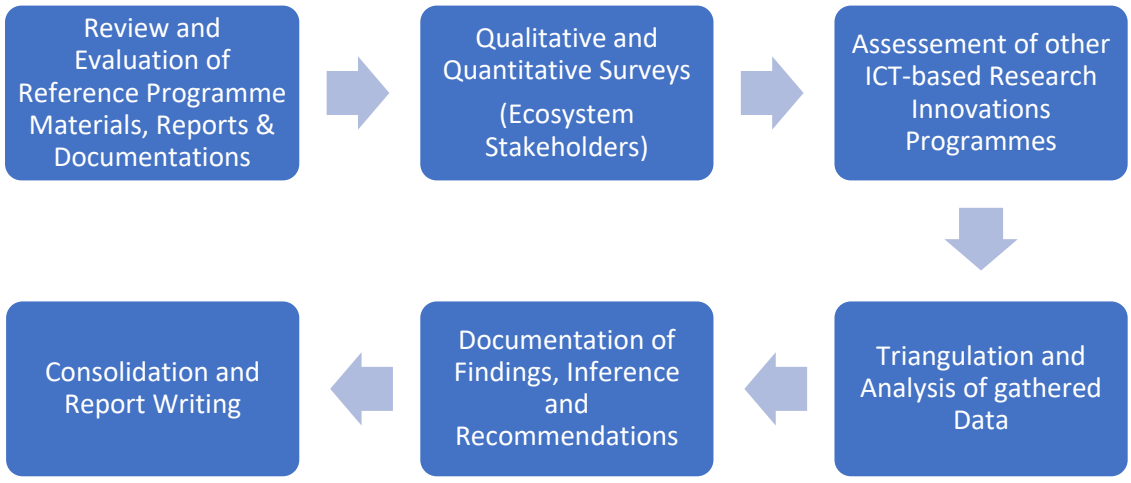


Figure 6: Implementation Approach

3.1 Review and Evaluation of Programme Reports and Relevant Documentations

Between year 2015 and 2020, NCC awarded several grants for telecommunications-based research innovations. This aspect of project implementation involved requesting for, review and evaluating different reports specific to the NCC research grant programme such as list of beneficiary institutions, list of research projects, sample memorandum of understanding (MOU) between NCC and beneficiary institutions, sample award letter, etc. The

goal of the review and evaluation of the Programme reports/documentations were to:

a. Identify target tertiary institution for the field survey;
b. Identify the lead researchers per project who will be key respondents;
c. Determine the status and stage of each research innovation project within the specified period (i.e. from year 2015 to 2020);
d. Determine the grant value for each research project; and
e. Gain insight into the telecommunications-based research innovations projects sponsored by NCC.

Other publications and reports relevant to the research topic were also reviewed.

3.2 Qualitative Survey

The qualitative survey was done through interviews with key stakeholders in the ICT and telecommunication research innovations eco-system. The categories of interviewees are shown below:

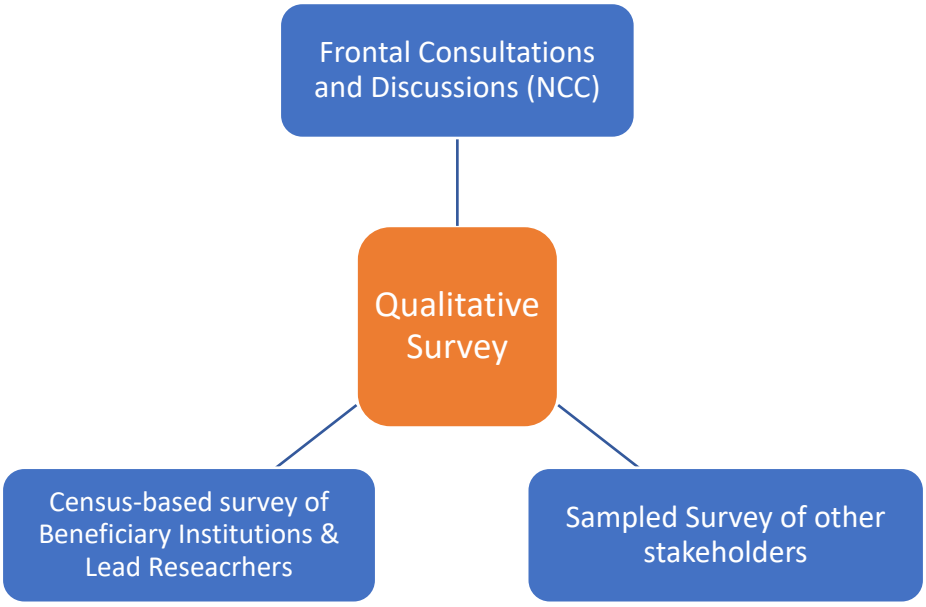


Figure 7: Dimensions for the Qualitative Survey

3.2.1 Frontal Consultations and Discussions with NCC

This was achieved via interviews with relevant departments in NCC directly involved with the telecommunications-based research innovations programme such as:

a. Research and Development (R&D);

b. Finance and Accounts (F&A); and
c. Technical Standards & Network Integrity.

3.2.2 Census-based Qualitative Survey of Tertiary Institutions & Lead Researchers

A **census-based survey** was used to sample and conduct **interviews** with beneficiary institutions and lead researchers. This method was used because there is a finite number of beneficiary tertiary institutions within the specified period. This method was also pivotal in obtaining first-hand information from researchers. See **Appendix A** for key interview questions.

3.2.3 Sample-based Qualitative Survey of Other Stakeholders

A **sample-based** survey method was used to select and interview other key stakeholders in the ICT and telecommunication-based research innovation ecosystem. Some of the target interviewees for this are:

a. ICT Research Institutions;
b. Technology Research and Development Companies and
c. Other Research Innovation Grant Donors (mostly government).
d. Legal Experts in Intellectual Property Law.

3.2.4 Summary of Target Respondents for Qualitative Survey

The table below summarizes the different interviewee groups for the survey.

Table 7: Summary of Target Respondents from Qualitative Survey

SN	Group	Target Interviewees	Respondents
1.	Tertiary Institution	a. Lead Researchers. b. Research Funds Administrators.	All beneficiary institutions from 2015 to 2020. (Lead Researchers, Bursars)
2.	NCC	a. Research & Development (R&D) Department. b. Finance & Accounts Departments. c. Technical Standards & Network Integrity, etc.	3 Respondents.
3.	Other Stakeholders	a. ICT Research institutions. b. Technology Research and Development Companies. c. Other Research Grant Donors. d. IP and Competition Law Experts	TETFund, NCS , PTDF, NASENI, NASDRA, Blue-Ribbon Attorneys, F.M Nworah & Co. etc.

3.3 Quantitative Survey

This was conducted using **questionnaires** with close-ended and open-ended questions. The primary target respondent were the lead researchers from beneficiary tertiary institutions from year 2015 to 2020. Analysis of data gathered from the quantitative survey provided extensive insights on the research topic.

Key aspects of the quantitative survey are enumerated below.

Table 8: Key Parameters for the Quantitative Survey

SN	Parameter	Value
1.	Study Population	Beneficiary Tertiary institutions conducting telecommunications-based research innovations in Nigeria.
2.	Target Respondents	Lead Researchers of telecommunications-based research innovation projects in Nigeria.
3.	Sampling Technique	Census-based Sampling.
4.	Sample Size	31 lead researchers from 21 Nigerian tertiary institutions (based on data received from Research and Development department).
5.	Study Period	Year 2015 to 2020.
6.	Geographic overage	Nationwide.
7.	Data Collection Method	Paper-based questionnaires (for physically available researchers). Electronic questionnaires (for researchers who were not physically).
See **list of tertiary intuitions** in **Appendix B** See **survey questionnaire design** in **Appendix C**		

3.4 Assessment of other ICT-based Research Innovations Programmes

This was done via consultations and discussions with subject matter experts in organizations who sponsor and promote ICT-based research innovations in Nigeria. The goals of this engagement were to:

a. Identify the different ICT-based research innovations projects being sponsored by other organizations;
b. Determine the effectiveness and efficiency of the programme with respect to their set objectives;
c. Identify current challenges being faced; and
d. Identify and discuss possible areas of collaboration with other industry partners.

3.5 Triangulation and Analysis of Gathered Data

The qualitative and quantitative data gathered was analysed using descriptive, inferential and exploratory statistical analysis techniques.

Data triangulation method was used to corroborate findings from the quantitative data and qualitative data analysis. This helped to increase the credibility and validity of the research findings for the study. The figure below shows the data triangulation model.

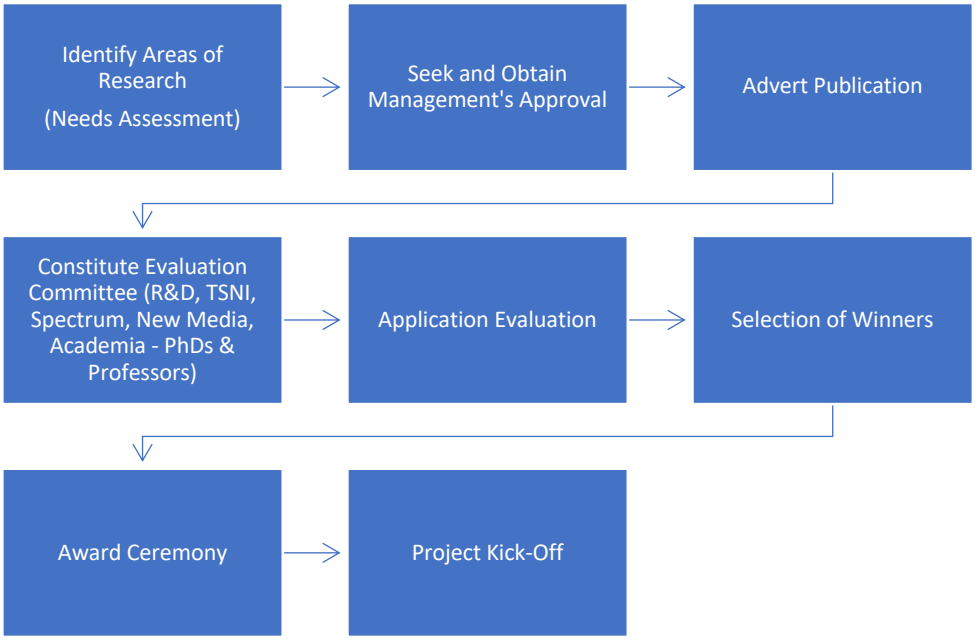
Figure 8: Data Triangulation Model

4. Findings from Survey Exercise

A field survey exercise was done to engage with and collect data from stakeholders in the NCC telecommunications-based research innovations. All gathered data were subsequently analysed to arrive at findings for the study. The following section show the findings on telecommunications-based research in Nigerian tertiary institutions.

4.1 Stages in the NCC Research Innovation Grant Process

Stages in the NCC research grant process is shown in the figure below.



4.2 Beneficiaries of NCC Telecommunications-based Research Innovation Grants (2015 – 2020)

Between 2015 and 2020, a total of 31 grants were awarded by NCC to 21 Nigerian tertiary institutions in 5 phases. The table below shows details of the grants.

Table 9: List of Telecommunications-based Research Innovation Projects

SN	Research Project	Year	Institution	State of Location	Lead Researcher	Amount (N)
1.	Development of Implementation of Multiple Noise Attenuation Device for Mobile Telephony End Users	2015	University of Maiduguri	Borno	Dr. Abdulfatah Abaoba 08135980435	2,609,500.00
2.	Design and Construction of a Power Line Communication Modem for Domestic LAN	2018	Airforce Institute of Technology	Kaduna	Engr. Seun Oyeleke 08036546874	5,000,000.00

3.	GSM-Based Smart Energy Meter	2018	Elizade University	Ondo	Dr. Kehinde Agbele 08088268717	5,000,000.00
4.	Development of Wearable E-Band Tracking system	2018	Ahmadu Bello University Zaria	Kaduna	Prof. S.B Junaidu 07032154610	6,995,180.00
5.	Design, Fabrication, Experimental Characterisation of Plastic Optical Fibre cable and the exploitation of its potentials in Nigeria Telecommunication Industry	2018	Ahmadu Bello University Zaria	Kaduna	Dr S.M Sani 08036012170	12,332,000.00
6.	Development of low–cost GSM System for Rural Areas	2018	Covenant University Ota	Ogun	Dr. Francis Idachaba 08039570321	9,321,400.00
7.	Design & Construction of customer identification system by their voices in telecoms industry	2018	Abubakar Tafawa Balewa University	Bauchi	Engr. Mahmud Abdulhameed 08038139649	5,916,000.00
8.	Development of a Home-Grown Electrical Power Charger for cell phones from cooking heat	2018	Enugu State University of Science and	Enugu	Prof. Cyprian Mgbachi 08036718801	1,381,000.00
9.	Development of wireless Communication Based vehicle crash detection and reporting system	2018	Obafemi Awolowo University Ife	Osun	Dr. Peter Awe 08057742141	3,545,266.00
10. *	Design and Construction of 1 to 10GHz Anechoic Chamber for 3G,4G and Future 5G antenna measurement	2018	University of Port Harcourt	Rivers	Mrs. Stella Orakwe 08035812519	5,265,000.00 (cancelled)
11.	Chemically engineered and safe organic-inorganic hybrid perovskites as optical gain media	2018	University of Nigeria Nsukka	Enugu	Prof. Fabian Ezema 08036239214	14,550,180.00
12.	Development of a Smart Repeater cell for Rural Broadband penetration in Nigeria	2018	University of Lagos	Lagos	Dr. Abiodun Gbenga-Ilori 08034731440	14,465,300.00

13.	Design and Development of Transition Avoidance Wireless Communications system for enhanced spectral Efficiency	2018	Ahmadu Bello University Zaria	Kaduna	Dr. M.B Abulrazaq 08065669124	13,975,083.00
14.	Development of a Bi-Directional, Multilingual Speech to Speech translation System Communication	2018	Federal University of Technology Akure	Ondo	Prof. Adebayo Adetunbi 08039617525	14,990,000.00
15.	Development of secure prototype and framework for data harvester and monitoring system to secure large farmlands	2018	University of Ibadan	Oyo	Prof. Oladayo Olakanmi 08068730815	14,135,537.00
16.	Vital Signs Monitoring Using Sparse Representation Based on Smart Phone Video Camera	2018	University of Jos	Plateau	Aliyu Nuhu Shuaibu 09063200704	14,500,000.00
17.	Implementation of Low-Cost 5Kw Microwave oscillator for 0.9 to 8Ghz	2018	Abubakar Tafawa Balewa University	Bauchi	Prof. E. C. Anene 08184220714	10,181,500.00
18.	Design, Simulation and Fabrication of Millimetre Wave (mm-Wave) Antenna for Next Generation Mobile Communication Networks	2018	Bayero University Kano	Kano	Engr. Suleiman Babani 08062500674	4,671,000.00
19.	Fabrication of intelligent wireless mobile Phone Battery Charger	2018	Federal University of Technology Minna	Niger	Engr. Adeyinka Adedigba 07062789033	6,078,000.00
20.	Mobile Broadband Mapping of Major Urban Centres in South-South Nigeria	2018	University of Port Harcourt	Rivers	Mrs. Stella Orakwe 08035812519	14,300,000.00
21.	Neuroendocrine and metabolic Studies of Mobile Phone Radiation	2018	Ahmadu Bello University Zaria	Kaduna	Prof. Abdulsalam Magaji 08151000200	8,752,000.00
22.	Design and Fabrication of Wireless Power Transmission through Resonant Coupling for Charging Small CPES	2019	University of Abuja	Abuja	Dr. Evans Ashigwuike 08036335397	12,839,883.00

23.	Design and Development of a Prototype High Gain Metamaterial MIMO Antenna Array for wireless Communications Systems and Energy Harvesting in Urban and Rural Areas.	2019	Abubakar Tafawa Balewa University	Kaduna	Aminu Baba 08038027880	11,419,849.14
24.	Design and Construction of Environmentally Friendly Paper Battery for Mobile Phones and Communication Devices.	2019	Kano State Polytechnic	Kano	Dr. Aliyu Umar 07030955044	10,530,000.00
25.	Development of Infrastructure for Independent Measurement of Mobile Broadband Penetration in Nigeria	2019	Akwa Ibom State University	Akwa Ibom	Dr. Uwana Ekpe 07080125430	12,835,000.00
26.	Spectrum Utilization Assessment for better Cellular Coverage and Connection quality using Machine Learning.	2019	National Space Research and Development Agency (NASRDA), Jos	Plateau	Dr. Eze +447939976085	12,659,220.00
27.	Development of all-weather solar system for energy optimization in a mobile communication base station	2020	Enugu State University of Science & Technology	Enugu	Prof. Greg Onoh 08037265722	10,147,000.00
28.	Design and Fabrication of Metamaterial Inspired UWB/ MIMO Antenna for 5G sub 6GHz Applications	2020	Taraba State University Jalingo	Taraba	Engr. Dr. Halilu Adamu Jabire 08036570803	9,911,811.39
29.	Weather WAN: A Wide Area Network of Low-Cost IoT – Compliant Weather Stations	2020	Obafemi Awolowo University Ile-Ife	Osun	Dr. Kayode Ayodele 07030705929	11,686.500.00
30.	Intelligent and Autonomous Multi-UAVs (Multiple Drones) Swarm Monitoring for Effective Surveillance and Situation Awareness in the Nigerian	2020	Gombe State University	Gombe	Mohammed Sagir Yusuf 0708356307	11,668,758.75

	Telecommunication Industry					
31.	Development of Intelligent Cognitive Smart Engine for Quality of Service Management in 5G Network	2020	Air Force Institute of Technology	Kaduna	Prof. Godfrey Onyiagha 07035493741	11,291,562.00
					Total	**289,886,030.26**

Between 2015 and 2020, NCC awarded 31 research grants valued at N291.2m to researchers in Nigerian tertiary institutions for telecommunications-based research innovation purposes.

The tables and charts below summarize the research grants by parameters such as year of award, grant value, institution type, institution and geopolitical zone.

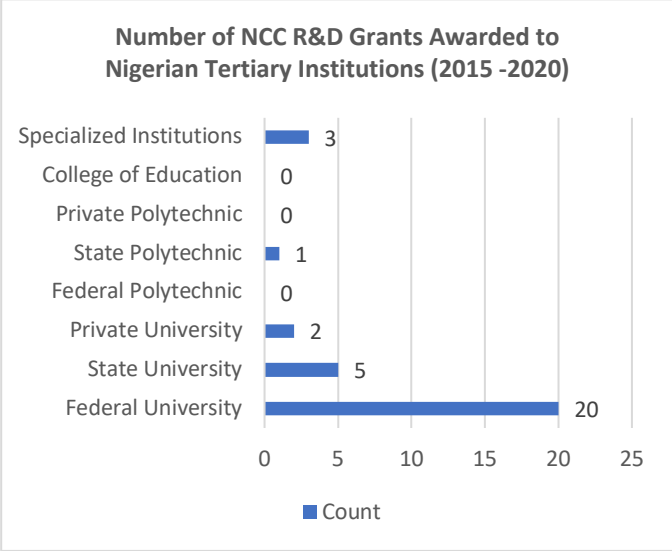


Figure 9: Number of NCC R&D Grants Awarded to Nigerian Tertiary Institutions

Table 10: Number of NCC R&D Grants Awarded to Nigerian Tertiary Institutions

Institution Type	No. of Awards
Federal University	20
State University	5
Private University	2
Federal Polytechnic	0
State Polytechnic	1
Private Polytechnic	0
College of Education	0
Specialized Institutions	3
Total	**31**

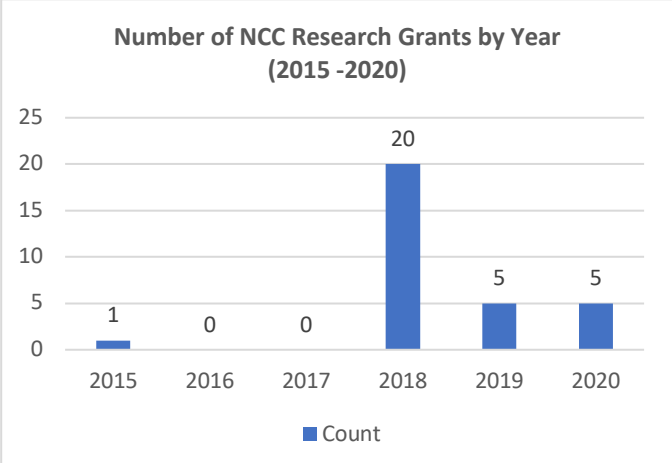


Figure 10: Number of NCC Research Grants by Year

Table 11: Number of R&D Grants per Year

Year of Award	No. of Awards	Grant Award Value (NGN)
2015	1	2,609,500.00
2016	0	0.00
2017	0	0.00
2018	20	183,973,446.00
2019	5	60,283,952.14
2020	5	43,019,132.14
Total	**31**	**289,886,030.26**

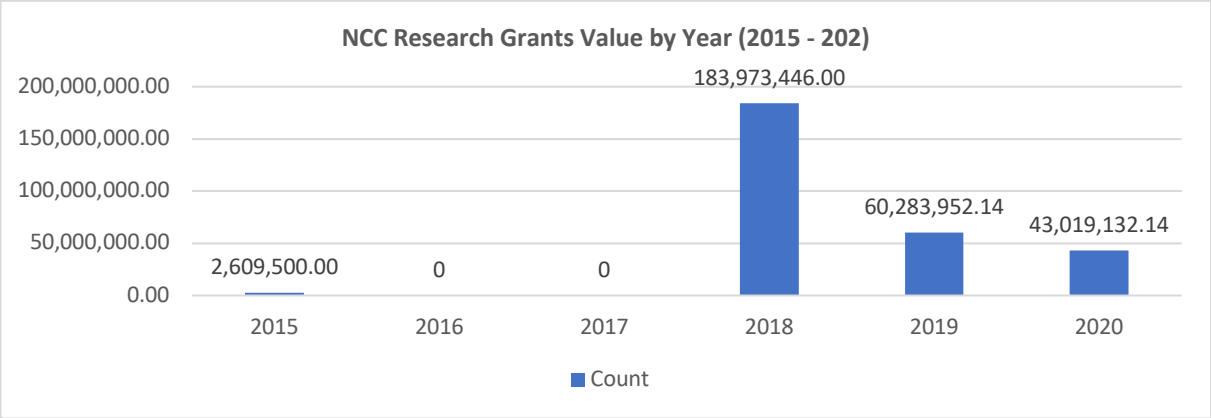


Figure 11: NCC Research Grants Value per Year

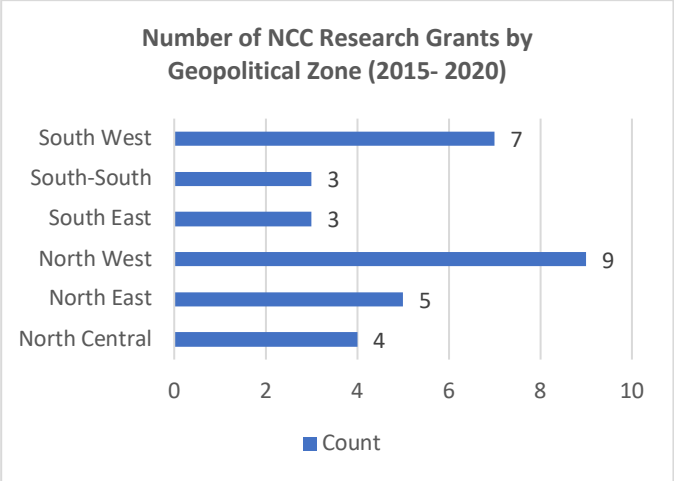


Figure 12: Number of NCC Research Grants by Geopolitical Zone (2015- 2020)

Table 12: Number of NCC R&D Grants Awarded by Geopolitical Zone

Geopolitical Zone	No. of Awards
North Central	4
North East	5
North West	9
South East	3
South-South	3
South West	7
Total	**31**

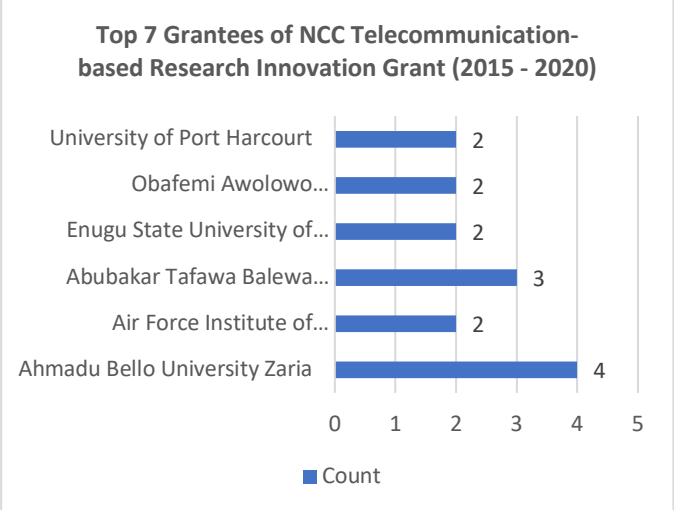


Figure 13: Top 7 Awardee Institutions (2015 – 2021)

Table 13: Top 6 Grantees (Institutions) of NCC Research Grant - based on Number of Grants (2015 – 2020)

University	No. of Awards
Ahmadu Bello University Zaria	4
Abubakar Tafawa Balewa University	3
Air Force Institute of Technology	2
Enugu State University of Science & Technology	2
Obafemi Awolowo University Ife	2
University of Port Harcourt	2

Federal Universities topped the list of awardees of NCC Telecommunications-based research innovations. The most applications and grants came from institutions in the North West region. Ahmadu Bello University (ABU) Zaria topped the list of grantees for the research grant between 2015 to 2020 with a total of 4 grants.

4.3 Field Survey Response Rate

The targets respondents for the quantitative survey were lead researchers in beneficiary institutions while the target respondents for the qualitative survey included lead researchers and Bursars of beneficiary institutions, stakeholders within NCC (R&D, Technical Standards & Network Integrity, Spectrum Administration, New Media and Information Security, and Finance Department), external stakeholders in academia research innovation grants.

The table below shows the response rate from lead researchers for the quantitative and qualitative survey.

Table 14: Field Survey Response Rate (Lead Researchers)

SN	Target Respondents	Quantitative Survey Response Rate	Qualitative Survey Response Rate
1	30	22 (73.3%)	25 (83.3%)

The qualitative survey was fashioned to cater for all survey questions contained in the quantitative survey questionnaire – this ensured to cater for no-response scenarios in the quantitative survey component of the survey.

4.4 Demographic and Socioeconomic Attributes of Lead Researchers

The following tables and charts show the demographics and socioeconomic attributes of lead researchers across beneficiary institutions.

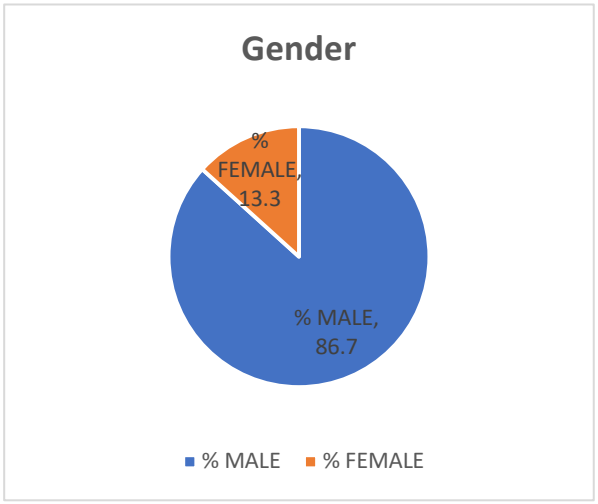


Figure 14: Gender Distribution of Lead Researchers

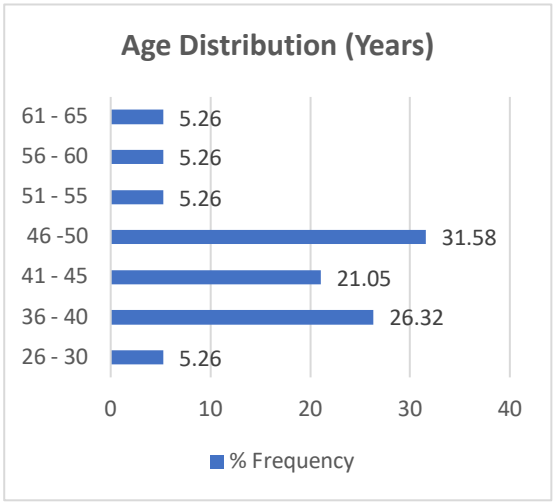


Figure 15: Age Distribution of Lead Researchers

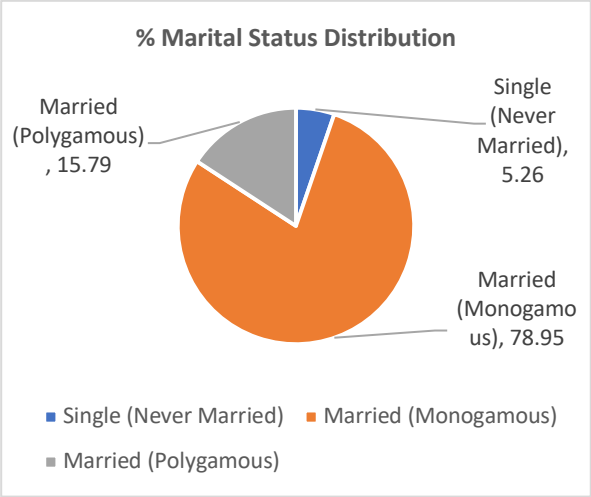


Figure 16: Marital Status Distribution

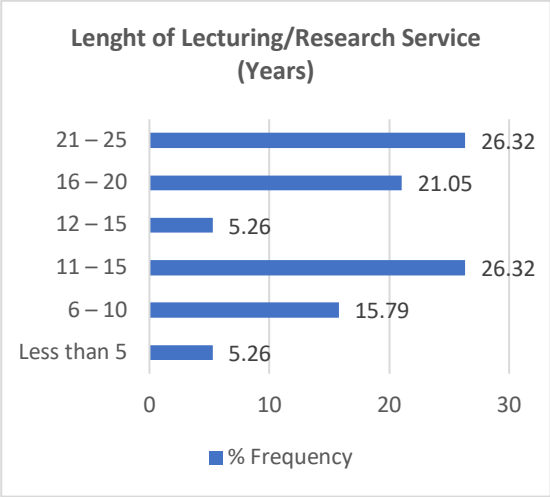


Figure 17: Length of Lecturing/Research Service (Years)

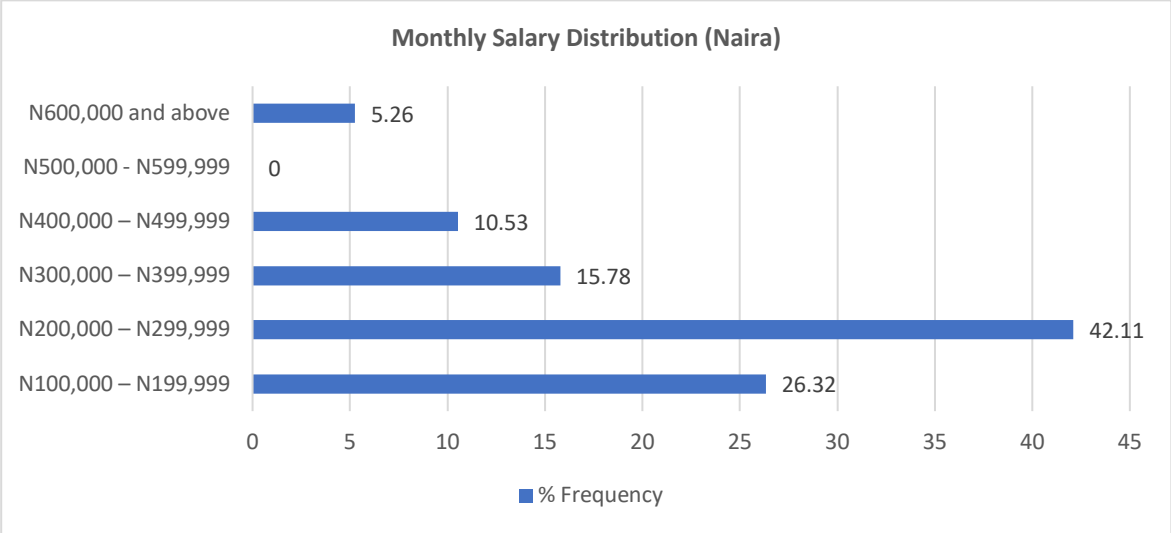


Figure 18: Monthly Salary Distribution (Naira)

The lead Researchers are predominantly males; 79% of the researchers are between the ages of 36 to 50 years and mostly monogamous. 79% of the researchers have over 10 years of working and research experience and 68% of the researches earn below N300,000 monthly.

4.5 Findings from Quantitative Survey

4.5.1 Specific Research Area/Category

The specific areas/categories of the research innovation (2015 – 2020) includes: Artificial Intelligence and Machine Learning, Drones, Hardware Design and Development, IoT, Electronics and Communications, IT, Computing, Neuroscience, Precision Agriculture, Security, Biomedical Engineering and Core Telecommunications systems.

Table 15: Specific Research Areas

SN	Specific Area	% Frequency
1.	Artificial Intelligence and Machine Learning	5.0
2.	Drones	10.0
3.	Energy Systems	5.0
4.	Hardware Design and Development	5.0
5.	IoT, Electronics and Communications	5.0
6.	IT, Computing and Telecommunications	5.0
7.	Neuroscience/Medicine	5.0
8.	Precision Agriculture, Security & Communications	5.0
9.	Telecommunications Systems	50.0
10.	Biomedical Engineering	5.0
	Total	**100.0**

4.5.2 Status of Research Projects

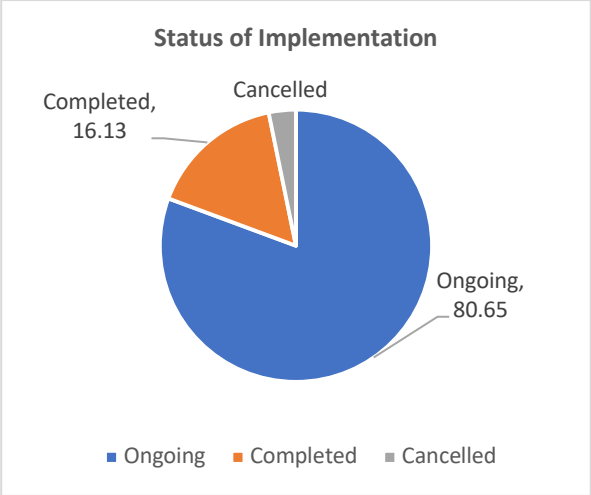


Table 16: Status of Research Projects (2015 – 2020)

Research Status	% Frequency
Ongoing	80.65
Completed	16.13
Cancelled	3.22
Total	**100.00**

4.5.3 Level of Collaboration due to the Research Innovation

Responses for the following questions provide details on the level of collaboration due to the telecommunication-based research innovation program.

Table 17: Level of Collaboration due to Research Innovation

SN	Question	%YES	%NO	%BLANK
1.	Are you collaborating with other individuals who are researchers in the telecommunications industry for your project?	63.16	36.84	0.00
2.	Are you collaborating with any domestic research institution for your project?	52.63	47.37	0.00
3.	Are you collaborating with any international research institution for your project?	36.84	57.89	5.26
4.	Is/Was your research innovation area on any of the new and emerging technologies?	84.21	15.79	0.00
5.	Has/Did your research inspire you to publish any technical paper?	94.74	0.00	5.26

63% of researchers affirmed that the research projects have resulted in collaborations with other lecturers/researchers within the academia community. 52.6% collaborated with domestic research institutions while only 36.8% of sampled researchers collaborated with international research institutions. 84% of the research projects claimed to have used at least one new or emerging technology (such as 5G, IoT, etc.). Over 90% of sampled researchers have published at least one technical paper inspired by the research project.

4.5.4 Top-level Challenges to the Research Innovation Program

The table below ranks challenges faced by researchers in the research project.

Table 18: Challenges faced by Researchers

Challenge Experienced	% Frequency
Access to Funds	30.56
Access to Specialized Components and Raw Materials	35.00
Inadequate Research Facilities	22.22
Poor Basic Infrastructure	16.67
Difficulty in finding collaborators	2.77
Technical related issues	2.77
Others	0.00
None	0.00
Total	**100.00**

Access to Funds, Access to Specialized Components and Raw Materials, Inadequately Equipped Research Facilities and lack of basic infrastructure topped the list of challenges faced by researchers in implementing their project.

The figure below shows the distribution of top-level challenges faced by researchers.

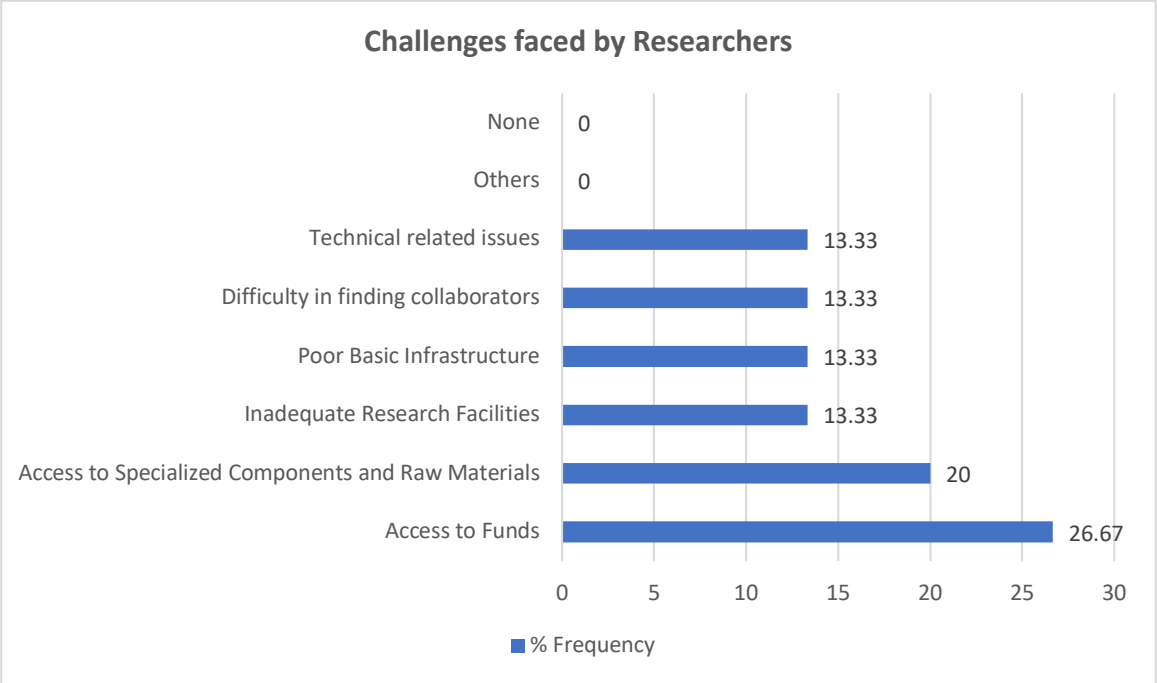


Figure 19: Challenges faced by researchers.

4.5.5 Funds Disbursement Process

The typical funds disbursement process involves correspondences between the researcher, the tertiary institution and NCC. Funds request/application emanates from the researcher upon meeting up with project implementation milestones. The request is reviewed, verified and processed by different departments in NCC (internal workflow); finally, payment is made to the beneficiary institution via the Remita payment platform. Within the tertiary institution, the bursary unit disburses the funds to the researchers.

Ideally, the internal payment processing within from NCC to the institution should take between 5 to 10 days.

Summary of Stages in this include:

a. Payment request from the researcher.
b. Operational process to verify attainment of project milestone and approve payment request.
c. Internal memo from R&D department confirming 'b' above.
d. Internal workflow for payment approval and processing.
e. Funds disbursement to the beneficiary institution via Remita.
f. Funds disbursement from the beneficiary institution to the researcher.

Figure 20: Funds Disbursement Chain

The table and figure below show researchers' feedback on the stage of the fund administration process with the most bottleneck.

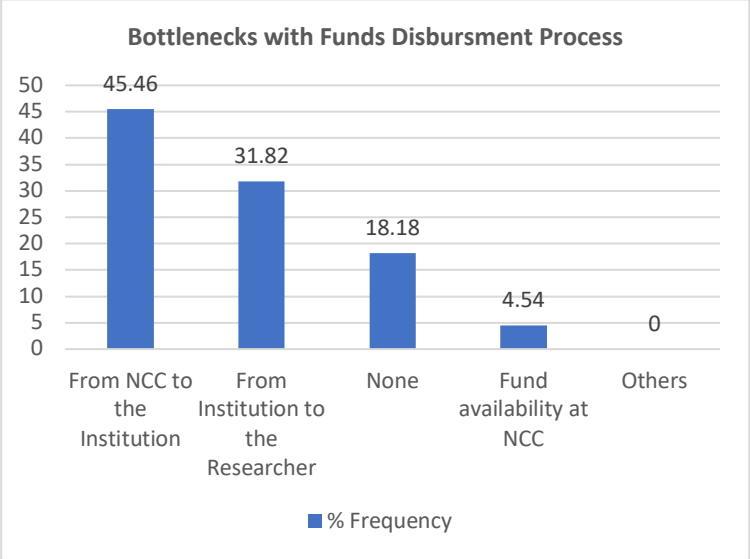


Figure 21: Bottlenecks with the Funds disbursement process

Table 19: Funds Disbursement Stage

Funds Disbursement Stage	%
From NCC to the Institution	45.46
From Institution to the Researcher	31.82
None	18.18
Fund availability at NCC	4.54
Others	0.00
Total	**100.00**

Funds disbursement process from NCC to the institution has the most bottleneck, followed by funds disbursement from the institution to the researcher. Some researchers revealed that this takes well over 30 days from date of payment request to receive payment.

4.5.6 Anticipated Barriers to Commercialization

The following statistics show researchers' anticipated barriers to commercialization of their research innovation.

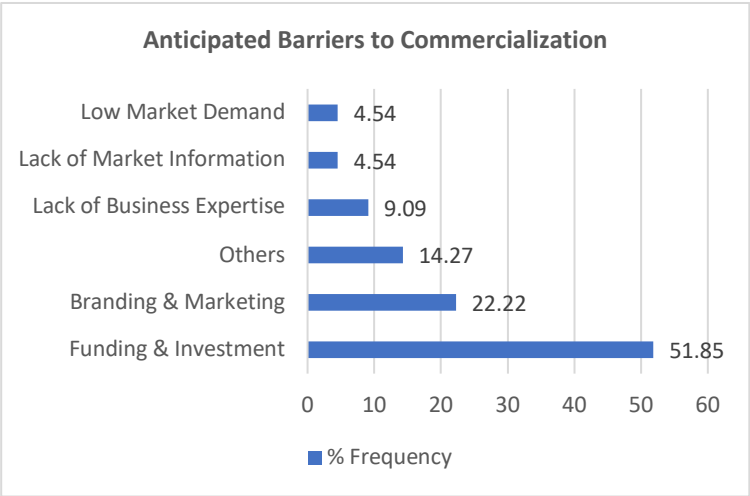


Figure 22: Anticipated Barriers to Commercialization

Table 20: Anticipated Barriers to Commercialization

Barriers to Commercialization	%
Funding & Investment	51.85
Branding & Marketing	22.22
Others	14.27
Lack of Business Expertise	9.09
Lack of Market Information	4.54
Low Market Demand	4.54
Total	**100.00**

"Funding & Investment" and "Branding & Marketing" are the barriers that researcher mostly anticipate they will have during the commercialization stage of their innovation.

Table 21: Researchers' perception on market existence for indigenous products

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The market exists to patronise the research innovations outputs when commercialized.	42.11	47.37	10.53	0.00	0.00

89.5% of researchers agreed or strongly agreed that the market exists to patronise their research innovations outputs when commercialized.

4.5.7 Benefits of the Research Innovation Program

The table below shows responses from different researchers on impacts and benefits of the research innovation program.

Table 22: Responses on benefits of the research innovation program

SN	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	The research innovation programme has improved collaboration with other researchers and stakeholders in the telecommunications industry	36.84	36.84	26.32	0.00	0.00
2.	The research innovation programme is closing the gap between the academia community and the telecommunications industry.	42.11	36.84	21.05	0.00	0.00
3.	The research innovations programme is building indigenous capacity in tertiary institutions.	63.16	31.58	5.26	0.00	0.00
4.	The research innovations programme has the potential of creating job opportunities in Nigeria.	63.16	36.84	0.00	0.00	0.00
5.	The research innovations programme has the potential of attracting foreign investors.	52.63	42.11	5.26	0.00	0.00

Over 70% of all sampled researchers agreed or strongly agreed that the NCC telecommunication-based research innovation program has had the following impacts:

a. *Improvement in collaboration between researchers within the academia community.*
b. *Improvement in collaboration between researchers and stakeholders in the Nigerian telecommunication industry.*
c. *Building indigenous capacity in Nigerian tertiary institutions around telecommunication engineering, new and emerging technologies, etc.*
d. *Potential for job creation when commercialization commences.*
e. *Potential for attracting foreign investments into the telecommunication sector, etc.*

4.6 Findings from Qualitative Survey and Interviews

Stakeholders within the research innovation ecosystem were also interviewed to augment the quantitative survey findings. The sections below show findings from interview sessions with lead researcher on their research innovation projects.

25 of the 31 lead researchers (83.3%) were available; 5 were unreachable and 1 project had been cancelled. The serial numbering of research projects in chapter 3.2 is maintained in the enumerations below.

4.6.1 Design and Construction of a Power Line Communication Modem for Domestic LAN

Research Project	Year	Institution	State	Researcher	Grant Value
Development of Implementation of Multiple Noise Attenuation Device for Mobile Telephony End Users	2015	University of Maiduguri	Borno	Dr. Abdulfatah Abaoba 08135980435	2,609,500.00
NOTES: The lead researcher was unreachable to provide data on this research project.					

4.6.2 Design and Construction of a Power Line Communication Modem for Domestic LAN

Research Project:	Design and Construction of a Power Line Communication Modem for Domestic LAN
Category:	Communication Systems
Lead Researcher:	Engr. Seun Oyeleke
Phone Number:	08036546874
Name of Institution:	Air Force Institute of Technology (AFIT)
State of Location:	Kaduna
Institution Type:	Specialized Institution
Year of Award:	2018
Grant Value:	N5,000,000.00
Project Status:	**Completed**
Synopsis:	The project started as a personal academic research. It is about creating additional ways of connecting devices without new network cables. The primary goal is to achieve effective data transmission. In terms of composition, the project is 60% research and 40% prototyping.
Specific Innovation & Problems to Solve:	Reuse of electrical cables for data connection.
Patent Status:	Pending
Target Market:	a. Real estate b. Homes and Businesses, Government, MDAs, etc.
Limitations:	Noise effects in the communication channel
Challenges Experienced:	Access to funds when proceeding to next stage Production of printed circuit boards (all were done in china)
Impacts of the Research	a. The research has led to development of indigenous capacity for smart and sustainable city within the institution b. Writing of 4 research papers inspired by the research project (2 completed and 2 published).

	c. Collaboration with about 2 external consultants.
Anticipated Barriers to Commercialization:	Funding & Investment
Commendations to NCC:	Good Monitoring, Enforcement and Encourage from NCC Team
Recommendations:	a. NCC should do more feasibility studies to identify projects that can solve the country's needs. b. Need for researchers to wrap up projects fast because technology is forward progressive. c. Funding of start-ups is needed to accelerate innovation d. Need for sustainability & continuous engagement with researchers to ensure continuous innovation outputs e. NCC should include researchers as participants in their capacity building programs.
Current & Next Steps:	a. Added IoT to the design b. Updated the scope to now support wired and wireless modes of communication using an embedded GSM module

4.6.3 GSM-Based Smart Energy Meter

Research Project:	GSM-Based Smart Energy Meter
Category:	Energy, Telecommunication
Lead Researcher:	Dr. Kehinde Agbele
Phone Number:	08088268717
Name of Institution:	Elizade University
State of Location:	Ondo
Institution Type:	Private University
Year of Award:	2018
Grant Value:	N5,000,000.00
Project Status:	**Ongoing**
Synopsis:	The research innovation is aimed at preventing economic leakages due to power meter by-pass.
Specific Innovation & Problems to Solve:	Detection and Prevention of meter tampers.
Patent Status:	Pending
Target Market:	a. Distribution Companies in Nigeria b. Possible Tech export to other African countries
Limitations:	N/A
Challenges Experienced:	Cost implications which limits the ability to create versioned prototypes and this also reduces the number of simulations.
Impacts of the Research	a. Increased R&D investment to the university because a research laboratory was setup because of the grant. b. Promoted capacity building initiatives within the institution c. Sparked up interest in R&D among telecommunications-related researchers and departments in the institution.
Anticipated Barriers to Commercialization:	Funding & Investment
Commendations to NCC:	a. The stakeholder consultation forums have been very helpful. b. Good Monitoring System.
Recommendations:	a. NCC should improve the funds disbursement process via streamlining the payment process.
Current & Next Steps:	Integrating the hardware components to the system software

4.6.4 Development of Wearable E-Band Tracking System

Research Project:	Development of Wearable E-Band Tracking System
Category:	Wearables, Communication Systems
Lead Researcher:	Prof. S.B Junaidu
Phone Number:	07032154610
Name of Institution:	Ahmadu Bello University Zaria
State of Location:	Kaduna
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N6,995,180.00
Project Status:	**Completed**
Synopsis:	The project involves development of a smart wristband that will help to identification and tracking especially in events of unplanned disasters. The product has a software and hardware component. The hardware component continuously interfaces with sensors and sends location information continuously. The software component includes a web and mobile App which serves as readers.
Specific Innovation & Problems to Solve:	a. Portability b. Mobility
Patent Status:	Pending
Target Market:	a. Tracking (vehicles, valuables, humans) b. Security Agencies c. Homes and Businesses, Government MDAs, etc.
Limitations:	N/A
Challenges Experienced:	a. Communication gaps which resulted in delay of first tranche payment that took 6 months to process. b. Issues with funds access due to poor notification whenever funds are released. c. Internal bureaucracy of the tertiary institution resulted in accessing funds 2 months are they have been received at the university. d. Difficulty accessing components. Most of the components were sourced from South Africa, Dubai, China and Malaysia. e. Asides from high cost of components, export restriction from countries In SN d above were also an issue. f. Difficulty accessing miniaturized (5cm) Printed Circuit Board (PCB) facilities; All PCBs were fabricated abroad and extra costs were incurred due to minimum order quantity (MOQ) for the PCB.
Impacts of the Research	a. Collaboration with Post Graduate students for R&D (2 Master students collaborated on the project). b. Capacity development, especially for post graduate students. c. The project resulted in in-depth research and development. d. Drafted research papers but not published yet.
Anticipated Barriers to Commercialization:	Funding & Investment, Early Adopters
Commendations to NCC:	N/A
Recommendations:	a. NCC should improve the project management process for its research grant program b. NCC should also improve correspondence management c. There should be reduction of frequent changes in personnel who handle project monitoring and evaluation without any form of notification to the researcher
Next Steps:	Commercialization

4.6.5 Design, Fabrication, Experimental Characterisation of Plastic Optical Fibre cable and the exploitation of its potentials in Nigeria Telecommunication Industry

Research Project	Year	Institution	State	Researcher	Grant Value
Design, Fabrication, Experimental Characterisation of Plastic Optical Fibre cable and the exploitation of its potentials in Nigeria Telecommunication Industry	2018	Ahmadu Bello University Zaria	Kaduna	Dr S.M Sani 08036012170	12,332,000.00
NOTES: The lead researcher was unreachable to provide data on this research project.					

4.6.6 Development of Low-Cost GSM System for Rural Areas

Research Project:	Development of Low-Cost GSM System for Rural Areas
Category:	Telecommunication System
Lead Researcher:	Dr. Francis Idachaba
Phone Number:	08039570321
Name of Institution:	Covenant University
State of Location:	Ogun
Institution Type:	Private University
Year of Award:	2018
Grant Value:	N9,321,400.00
Project Status:	**Completed**
Synopsis:	The project is a low-cost transceiver system aimed at extending GSM service to rural areas. The system has been successfully tested
Specific Innovation & Problems to Solve:	Low-cost solution for increasing service coverage to rural areas.
Patent Status:	Pending
Target Market:	a. Service Providers b. Government c. Universal Access Organizations (e.g. USPF, NCC)
Limitations:	N/A
Challenges Experienced:	a. Key bottleneck was production of printed circuit boards (PCB) b. Issues with funds access due to poor notification whenever funds are released. c. Internal bureaucracy of the tertiary institution resulted in accessing funds 2 months are they have been received at the university. d. Difficulty accessing components. Most of the components were sourced from South Africa, Dubai, China and Malaysia. e. Asides from high cost of components, export restriction from countries In SN 'd' above were also an issue. f. Difficulty accessing miniaturized (5cm) Printed Circuit Board (PCB) facilities; All PCBs were fabricated abroad and extra costs were incurred due to minimum order quantity (MOQ) for the PCB.
Impacts of the Research	a. The project motivated students to take part in proect design and other related designs. b. Capacity building for students. c. The research resulted in showcase of the project at ITU conference of 2018/2019 d. Capacity development, especially for post graduate students. e. The project resulted in in-depth research and development. f. Drafted research papers but not published yet.

Anticipated Barriers to Commercialization:	a. In country capacity for PCB production b. Awareness to the industry of existence of such design and product c. Access to service provider to help with real world use cases
Commendations to NCC:	N/A
Recommendations:	NCC should base its payment plans from discussions with researchers 'specific milestones so as not to generalize. No two research projects are entirely design.
Next Steps:	Works for version 2.0

4.6.7 Design & Construction of Customer Identification System by their Voices in Telecoms Industry

Research Project:	Design and Construction of Customer Identification system by their Voice in Telecoms Industry
Category:	Artificial Intelligence & Communication Systems
Lead Researcher:	Engr. Mahmud Abdulhameed
Phone Number:	08038139649
Name of Institution:	Abubakar Tafawa Balewa University (ATBU)
State of Location:	Bauchi
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N5,916,000.00
Project Status:	**Ongoing** (Almost done; awaiting last tranche)
Synopsis:	The research project focuses on improving the accuracy of voice identification system and making it work for large datasets.
Specific Innovation & Problems to Solve:	Customer identification by Voice
Patent Status:	Pending
Target Market:	a. Telecoms Service Providers b. Businesses and organizations with huge customer base requiring identity verification and management e.g. banks, airlines, government, e-commerce, etc. c. Security agencies for criminal identification and detection. d. Access control application for visitors' management.
Limitations:	N/A
Challenges Experienced:	a. Access to funds caused by delays at NCCs end in processing funds b. Slow review process by NCC's internal team c. Difficulty accessing licensed software for voice learning since the project has potential applications within security space (using open source software may limits security of the solution in this regard).
Impacts of the Research	a. Collaboration with other researchers b. Writing of research papers (almost ready for publication).
Anticipated Barriers to Commercialization:	Funding & Investment
Commendations to NCC:	N/A
Recommendations:	a. NCC should promote more research activities in this area technology is forward progressive. b. NCC to promote creation of more collaboration opportunities between researchers and the industry because most of the research are multi-faceted and may require industry expertise e.g. Database Expert, AI programming, etc.
Current & Next Steps:	a. Project finalization

4.6.8 Development of a Home-Grown Electrical Power Charger for Cell Phones from Cooking Heat

Research Project:	Development of Home-Grown Electrical Power Charger for Cell Phones from Cooking Heat
Category:	Energy
Lead Researcher:	Prof. Cyprian Mgbachi
Telephone:	08036718801
Name of Institution:	Enugu State University of Science and Technology
State of Location:	Enugu
Institution Type:	State University
Year of Award:	2018
Grant Value:	N1,381,000.00
Project Status:	**Completed Prototype** (Awaiting Submission)
Synopsis:	Cell phones have replaced a lot of devices and power is a determinant for use of mobile phones. The project focuses on use of surrounding heat or cooking heat to charge phone batteries. Access to electricity is a major challenge in this part of the world.
Specific Innovation & Problems to Solve:	a. Solves the problem of poor access to electricity b. Portability in Design
Patent Status:	Pending
Target Market:	a. Individuals b. Households c. Private Businesses d. Government Organizations, etc.
Limitations:	N/A
Challenges Experienced:	a. Difficulty in packaging the project b. Tough partnership conditions with individual investors c. Difficult access to local production facilities d. Problem of minimum order quantity when fabricating prototypes in China.
Impacts of the Research	a. 4 post graduate and under graduate students got involved and collaborated in project implementation. b. Capacity building for students. c. Increased interest in applied research within the institution.
Anticipated Barriers to Commercialization:	a. Access to local production factories b. Funding and Investment
Commendations to NCC:	There has been no delay in payment. "Thank God for NCC helping us"
Recommendations:	a. Need for NCC to promote involvement of local manufacturers so that they can assist with the challenges of assembly and fabrication. b. Delay is dangerous: Need for NCC to swiftly take actions aimed at commercializing the research innovation outputs. c. Need to speedup patent registration and issuance process to protect intellectual property. d. NCC should facilitate exposure to strategic investors.
Current & Next Steps:	b. Project finalization

4.6.9 Development of Wireless Communication Based vehicle crash Detection and Reporting system

Research Project	Year	Institution	State	Researcher	Grant Value
Development of wireless Communication Based vehicle crash detection and reporting system	2018	Obafemi Awolowo University Ife	Osun	Dr. Peter Awe 08057742141	N3,545,266.00
NOTE: The lead researcher was out of country and unreachable to provide data on this research project.					

4.6.10 Design and Construction of 1 to 10GHz Anechoic Chamber for 3G, 4G and Future 5G Antenna Measurement

Research Project	Year	Institution	State	Researcher	Grant Value
Design and Construction of 1 to 10GHz Anechoic Chamber for 3G,4G and Future 5G antenna measurement	2018	University of Port Harcourt	Rivers	Mrs. Stella Orakwe 08035812519	5,265,000.00 (cancelled)
NOTE: This Project was Cancelled.					

4.6.11 Chemically Engineered and safe Organic-inorganic Hybrid Perovskites as Optical Gain Media

Research Project:	Chemically engineered and safe Organic-inorganic Hybrid Perovskites as Optical Gain Media
Category:	Energy (Renewable)
Lead Researcher:	Prof. Fabian Ezema
Telephone:	08036239214
Name of Institution:	University of Nigeria Nsukka
State of Location:	Enugu
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N14,550,180.00
Project Status:	**Ongoing** (Last Stages)
Synopsis:	The project is to develop perovskites as key material for solar cell to allow for high absorption of light and cause electrons to be generated. This technology is not yet available on the global market; most researchers are trying to develop this material.
Specific Innovation & Problems to Solve:	Use of ambient conditions to create the materials
Patent Status:	Pending
Target Market:	a. Households b. Private Businesses c. Government Organizations d. Service Providers for Base stations, etc.
Limitations:	N/A
Challenges Experienced:	a. COVID-19 pandemic b. Export ban to Nigeria from countries with raw materials e.g. India c. Importation issues affects the time to deliver.

	d. Funding & Investment e. Absence of a vacuum lab in Nigeria.
Impacts of the Research	a. The research led to publication of one article that referenced NCC and has been acknowledged by NCC. b. Collaboration with post graduate students. c. Student involvement in the project has resulted in capacity building.
Anticipated Barriers to Commercialization:	a. Access to raw materials b. Funding and Investment
Commendations to NCC:	N/A
Recommendations:	a. NCC should promote more applied researches within the Academia community. b. NCC should facilitate provision of infrastructure that will improve local production capabilities in Nigeria
Current & Next Steps:	c. Project finalization

4.6.12 Development of a Smart Repeater cell for Rural Broadband Penetration in Nigeria

Research Project:	Development of a Smart Repeater Cell for Rural Broadband Penetration in Nigeria
Category:	Telecommunication System (Hardware)
Lead Researcher:	Dr. Abiodun Gbenga-Ilori
Telephone:	08034731440
Name of Institution:	University of Lagos
State of Location:	Lagos
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N14,465,300.00
Project Status:	**Ongoing**
Synopsis:	The project is aimed at investigating the best method for deploying broadband in a cost-effective manner. Lack of broadband coverage has made some people to give up or discontinue ambitions for higher education simply because they cannot check results or register for computer-based tests, etc. The project is currently being test and successful tests have been conducted in a rural community in Abeokuta, Ogun state.
Specific Innovation & Problems to Solve:	a. Low cost b. There are still broadband issues in Nigeria
Patent Status:	Pending
Target Market:	a. Service Providers b. Universal Access Provision Organizations e.g. NCC, USPF, etc.
Limitations:	N/A
Challenges Experienced:	a. Access to components; almost all components used were imported. b. Herculean and long production process for printed circuit boards (PCB). All PCBs were produced in China. (NOTE: UNILAG has a PCB making machine but it is obsolete NOTE: Some organizations print PCB at Oshodi in Lagos but the output is very prone to errors due to poor quality control.) c. Access to 2nd Tranche has been a huge problem; application was sent 5months ago but no feedback yet.

	d. Access to NCC liaison person (the M&E staff is always travelling and rarely available). e. Communication and Collaboration problems with NCC (You have to go through several persons before getting results). f. Delays in processing funds from the university to the researcher. g. Delays in processing payments from NCC to the university. h. Foreign exchange rate issues. i. Unsteady foreign exchange rates. j. Naira depreciation issues results in lowering specifications or selecting cheaper & less quality components just to stay within budget. k. The current tranche model poses a problem as it does not reflect the true funds requirement to achieve milestones. l. Effects of COVID-19 restrictions. m. ASUU strike effects
Impacts of the Research	a. University has benefited from purchase of research equipment e.g. Spectrum Analyzer b. Capacity building for students as a result of 'a' above. c. UNILAG now has a research and innovation office for processing grants to lecturers. d. The Communications lab within the university was transformed with equipment procured for the project. e. Several post-graduate related projects have sprung up on campus. f. People in test communities (mostly rural) are feeling the true meaning of engineering as they are part of the test process. g. Published one paper and 2 more have been sent for approval. h. The project has resulted in obtaining a foreign grant from Alexander von Humboldt Foundation (AVH) Germany, for an antenna related research (this went to a student researcher who was part of this research project). i.
Anticipated Barriers to Commercialization:	a. Access to early adopters within the telecommunication industry b. Access to high quality in-country fabrication and production facilities for making printed circuit boards (PCB)
Commendations to NCC:	N/A
Recommendations:	a. Tranche model should be updated to allow access to good percentage of the money at early stages of the business. b. NCC staff need to change their attitude towards researchers because they usually behave like they are doing researchers a favour. c. The university needs to streamline its funds access process and find a way around the Treasury Single Account (TSA).
Current & Next Steps:	a. Testing and Project Finalization

4.6.13 Design and Development of Transition Avoidance Wireless Communications System for Enhanced Spectral Efficiency

Research Project:	Design and Development of Transition Avoidance Wireless Communications system for enhanced spectral Efficiency
Category:	Communication System
Lead Researcher:	Dr. M.B Abulrazaq
Telephone:	08065669124
Name of Institution:	Ahmadu Bello University Zaria
State of Location:	Kaduna
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N13,975,083.00
Project Status:	**Ongoing**
Synopsis:	The project involves developing wireless transmission technology to improve bandwidth usage to allow for more data transmission.
Specific Innovation & Problems to Solve:	Transition avoidance
Patent Status:	Pending
Target Market:	a. Universal Access and Service Providers b. National Regulatory Agency c. Military
Limitations:	N/A
Challenges Experienced:	a. Funds disbursement from the university to the researcher. b. ASUU strike effects. c. Access to components especially chips. d. Export ban on specialized components. e. COVID-19 impacts.
Impacts of the Research	a. Capacity building within the institution for students involved.
Anticipated Barriers to Commercialization:	a. Access to components and chips.
Commendations to NCC:	N/A
Recommendations:	a. NCC should follow-up more with researchers on progress of their projects
Current & Next Steps:	a. Incremental implementations

4.6.14 Development of a Bi-Directional, Multilingual Speech to Speech Translation System Communication

Research Project:	Development of a Bi-Directional, Multilingual Speech to Speech translation System Communication
Category:	Artificial Intelligence
Lead Researcher:	Prof. Adebayo Adetunbi
Telephone:	08039617525
Name of Institution:	Federal University of Technology Akure
State of Location:	Ondo
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N14,990,000.00
Project Status:	**Ongoing** (Currently doing modelling)
Synopsis:	The research innovation is to develop a multilingual speech to speech translation. System using local languages: Hausa, Igbo, Yoruba and

	English. Data sources for the model were gathered mainly from transportation (air and road) and trading sectors.
Specific Innovation & Problems to Solve:	Speech to speech translation using local languages
Patent Status:	Pending
Target Market:	a. Embassies for speech translation b. Translation and Communication companies c. Security agencies for use by security personnel who are operating in locations where they do not understand the local language.
Limitations:	N/A
Challenges Experienced:	a. Access to funds from the institution to the researcher (Yet to receive 2nd tranche from the institution although it has been over 2weeks since funds were disbursed from NCC to the institution). b. The university asked for an 'illegal' 5% processing fee; this matter was escalated to NCC for intervention and resolution. c. Inflation effects. d. Unstable exchange rates.
Impacts of the Research	a. The research project as led to an exhibition to the Nigerian military. b. More involvement and interest from other researchers in similar areas. c. Collaboration on dataset generation. d. Publication of gathered dataset. e. The project has birthed other local grants and partnerships with persons in Agricultural extension. f. Involvement of several PhD students. g. Recognized as an achievement in the campus magazine.
Anticipated Barriers to Commercialization:	a. Access to early adopters within the telecommunication industry b. Access to high quality in-country fabrication and production facilities for making printed circuit boards (PCB)
Commendations to NCC:	"*We appreciate their efforts, NCC's M&E team is doing well with follow-up; the research grant is a good booster for NCC as the funding has helped a lot."*
Recommendations:	a. NCC needs to address the funds access issue so that researchers can meetup with timelines. b. Need for NCC to engage with administrators of tertiary institutions aimed at encouraging more research work within the academia community. c. Need for NCC to collaborate with academia and industry to foster commercialization of research ouptuts. d. NCC staff need to change their attitude towards researchers because they usually behave like they are doing researchers a favour. e. The university needs to streamline its funds access process and find a way around the Treasury Single Account (TSA).
Current & Next Steps:	a. Modelling

4.6.15 Development of Secure Prototype and Framework for Data Harvester and Monitoring System to Secure Large Farmlands

Research Project:	Development of secure prototype and framework for data harvester and monitoring system to secure large farmlands
Category:	Unmanned Aerial Vehicle (UAV) - Drone
Lead Researcher:	Prof. Oladayo Olakanmi
Telephone:	08068730815
Name of Institution:	University of Ibadan
State of Location:	Oyo
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N14,135,537.00
Project Status:	**Ongoing** (Almost done)
Synopsis:	Drones and robotics vehicle used to remotely collect data from farm lands. The technology is aimed at promoting precision farming. The technology will be able to measure & transmit data on temperature, humidity and other details that affect farm yield.
Specific Innovation & Problems to Solve:	Speech to speech translation using local languages
Patent Status:	Pending
Target Market:	Agriculture
Limitations:	N/A
Challenges Experienced:	a. Bureaucracy by institutions in releasing funds to researchers. b. Access to components c. Export ban and import limitation on some component such as specialized battery, military-grade chips. d. Loss of 1st drone prototype which was hijacked in Germany. e. High Exchange Rate and Naira deprecation issues.
Impacts of the Research	a. The research project as led to an exhibition to the Nigerian military. b. Involvement & interests from other researchers in related areas. c. Collaboration on dataset generation. d. Publication of gathered dataset. e. The project has birthed other local grants and partnerships with persons in Agricultural extension. f. Involvement of several PhD students in the research project. g. Recognized as an achievement in the campus magazine.
Anticipated Barriers to Commercialization:	a. Restricted access to specialized batteries. b. Access to high quality fabrication machines like Photera, CNC, etc. c. Funding and Investment
Commendations to NCC:	*"I initially thought that this was going to be a white elephant program but to my surprise, NCC has been living up to expectations."*
Recommendations:	a. NCC should intervene to solve the customs restriction for importation of specialized components b. NCC should consider creating a prototyping laboratory in tertiary institutions that have good R&D track record – this will create a fulcrum to support innovation and development. c. NCC should mandate all researchers to document key points of their research projects for reference purposes. This documentation should be digitized and backed-up. d. Need for NCC to engage with the Ministry of Education to revamp the secondary school curriculum to include science, technology, engineering and embedded systems. (Prof. Oladayo Olakanmi has a framework for this and it has been tested successfully in Ibadan)
Current & Next Steps:	Project Finalization

4.6.16 Vital Signs Monitoring Using Sparse Representation Based on Smart Phone Video Camera

Research Project:	Vital Signs Monitoring Using Sparse Representation Based on Smart Phone Video Camera
Category:	Software
Lead Researcher:	Aliyu Nuhu Shuaibu
Telephone:	09063200704
Name of Institution:	University of Jos
State of Location:	Plateau
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N14,500,000.00
Project Status:	**Completed**
Synopsis:	Non-contact technology for measuring vitals of patients. It operates as a software application on a mobile phone. The software application has been tested successfully on Samsung Note 8 mobile phone. The innovation involves transmission of data (extracted) via the frequency domain. The technology can measure heart rate and respiratory rates. Heart rate measurement used high frequency while respiratory rate measurement uses low frequency.
Specific Innovation & Problems to Solve:	Use of non-contact technique to read and interpret vitals from patients. (Current available techniques are contact-based e.g. Apple and Samsung Apps)
Patent Status:	Pending
Target Market:	Health
Limitations:	N/A
Challenges Experienced:	Technical challenges in creating the algorithm and coding.
Impacts of the Research	a. Encouraged other lecturers to take applied research seriously b. Capacity building for students involved in the project.
Anticipated Barriers to Commercialization:	a. Funding & Investment b. Staffing and Startup Requirements
Commendations to NCC:	N/A
Recommendations:	a. NCC should increase value of the research grant value to become comparable with the likes of TETFund (i.e. N50 million). b. NCC should facilitate the exposure of indigenous innovations like this one to large companies like Samsung, Apple, Huawei, etc. so that they can include our technology on their phones
Current & Next Steps:	N/A

4.6.17 Implementation of Low Cost 5kKW Microwave Oscillator for 0.9 to 8GHz

Research Project:	Implementation of Low Cost 5KW Microwave oscillator for 0.9 to 8GHz
Category:	Hardware
Lead Researcher:	Prof. E. C. Anene
Telephone:	08184220714
Name of Institution:	Abubakar Tafawa Balewa University
State of Location:	Bauchi
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N10,181,500.00
Project Status:	**Ongoing**
Synopsis:	To get/develop an indigenous oscillator that can meet up with at least 3G requirements
Specific Innovation & Problems to Solve:	Low cost Indigenous oscillator
Patent Status:	Pending
Target Market:	Universal Access and Service Providers
Limitations:	N/A
Challenges Experienced:	a. Access to components, equipment and testing facilities b. Dependence on foreign companies or partners to fabricate prototypes. c. Exchange rate and Naira devaluation issues d. Longer turnaround time from NCC on correspondences
Impacts of the Research	a. Capacity building for students. b. Writing of journal articles and papers.
Anticipated Barriers to Commercialization:	a. Access to components b. Access to production facilities. c. Access to strategic partners for adoption and commercialization.
Commendations to NCC:	N/A
Recommendations:	a. NCC should look at projects holistically to specifically identify targets and desired impact from each project. b. Need to conduct more demand-driven research that address socio-economic challenges in Nigeria. c. NCC need to embrace more futuristic based research e.g. 6G (might involve collaboration with private sector and NGOs). d. NCC should benchmark innovative outputs. e. NCC should facilitate partnerships with international fabrication companies for easy access to integrated circuits, embedded systems, etc.
Current & Next Steps:	Incremental implementation.

4.6.18 Design, Simulation and Fabrication of Millimetre Wave (mm-WAVE) Antenna for Next Generation Mobile Communication Networks

Research Project:	Design, simulation & fabrication of millimeter wave (mm-Wave) Antenna for Next Generation Mobile Communications Networks.
Category:	Communication Network Antenna
Lead Researcher:	Engr. Suleiman Babani
Telephone:	08062500674
Name of Institution:	Bayern University Kano
State of Location:	Kano
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N4,671,000.00
Project Status:	**Ongoing** (Almost done)
Synopsis:	NGN Antenna specifically for 5G
Specific Innovation & Problems to Solve:	Use of new technology that is not based on the FR4 which was for previous generations of antennas.
Patent Status:	
Target Market:	Service Providers
Limitations:	N/A
Challenges Experienced:	a. Difficulty accessing to components needed. b. Difficult access to Network Analyzer for 5G research.
Impacts of the Research	a. The research project has created more awareness on NCC telecommunication-based research grant program. b. The project has encouraged other researchers (especially in same field of research) to visit the University.
Anticipated Barriers to Commercialization:	a. Access to components. b. Access to quality check (QC) and testing equipment.
Commendations to NCC:	*"I commend NCC for creating the R&D department handling the Monitoring and Evaluation of the research program"*
Recommendations:	NCC should increase support to the Research and Development department in NCC to increase its capacity as regards facilitating the telecommunication-based research grant program.
Current & Next Steps:	Project Finalization

4.6.19 Fabrication of Intelligent Wireless Mobile Phone Battery Charger

Research Project:	Fabrication of Intelligent Wireless Mobile Phone Battery Charger
Category:	Hardware
Lead Researcher:	Engr. Adeyinka Adedigba
Telephone:	07062789033
Name of Institution:	Federal University of Technology Minna
State of Location:	Niger
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N6,078,000.00
Project Status:	**Ongoing** (completed internally, Pending simulation).
Synopsis:	Cross compatible battery charger for numerous devices (compatible with industrial standards). 80% to 90% of the materials can be sourced locally e.g. resistors, etc. The special wires and coils were soured abroad.
Specific Innovation & Problems to Solve:	a. Use of AI for optimization of the coil design b. Long range wireless charging capability c. Improved mobility d. Reduced/friendly radiation emission. e. If extended, the technology has huge potential for wireless charging of electrical vehicles
Patent Status:	Pending
Target Market:	Mobile Phone Users (Individuals, Homes, Businesses, government, etc)
Limitations:	N/A
Challenges Experienced:	a. Devaluation of the Naira & inflation rate. b. Exchange rate c. Importation of components (mostly from China, USA). d. Access to funds. e. Use of personal funds.
Impacts of the Research	a. Received new grant for a similar research. b. The project encouraged student involvement as some has graduated and are continuing independent research in this research area i.e. capacity building.
Anticipated Barriers to Commercialization:	a. Initial cost of rollout (Funding & investment) b. Brand recognition.
Commendations to NCC:	*"I must commend NCC for the initiative and the Monitoring and Evaluation for NCC are up and doing"*
Recommendations:	N/A
Current & Next Steps:	Pending Simulation

4.6.20 Mobile Broadband Mapping of Major Urban Centres in South-South Nigeria

Research Project:	Mobile Broadband Mapping of Major Urban Centres in South-South Nigeria
Category:	Software
Lead Researcher:	Mrs. Stella Orakwe
Telephone:	08035812519
Name of Institution:	University of Port Harcourt
State of Location:	Rivers
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N14,300,000.00
Project Status:	**Ongoing**
Synopsis:	The research project involves mapping the existing broadband coverage areas using GIS technology and techniques.
Specific Innovation & Problems to Solve:	Broadband mapping is the innovation which is very different from broadband penetration. An app has been developed for the project; test mappings are currently being done.
Patent Status:	Pending
Target Market:	a. National Regulatory Agency (NRA) for telecommunications industry b. Service Providers
Limitations:	N/A
Challenges Experienced:	a. Getting trusted resource persons for data collection. b. Long turn-around time in corresponding with NCC (e.g. I have written NCC since March and no response till date). c. ASUU strike effects. d. Access to funds (delays from NCC). e. Unfavourable tranch model for payment.
Impacts of the Research	a. Published a paper in the UJESR (UNIPORT Journal of Engineering and Scientific Research - UJESR).
Anticipated Barriers to Commercialization:	N/A
Commendations to NCC:	N/A
Recommendations:	a. NCC should improve its correspondence culture to reduce delays. b. NCC should review its tranche model so that larger percentage of the grants are made available at early stages of the research. c. NCC should consider allowing flexibility of allowing "variation" in the grant model so
Current & Next Steps:	Mapping activities

4.6.21 Neuroendocrine and Metabolic Studies of Mobile Phone Radiation

Research Project:	Neuroendocrine and metabolic Studies of Mobile Phone Radiation
Category:	Study (for Health Applications)
Lead Researcher:	Prof. Abdulsalam Magaji
Telephone:	0815100200
Name of Institution:	Ahmadu Bello University Zaria
State of Location:	Kaduna
Institution Type:	Federal University
Year of Award:	2018
Grant Value:	N8,752,000.00
Project Status:	**Completed** (Debriefing done)
Synopsis:	The study was to determine the impacts of mobile phone radiation.
Specific Innovation & Problems to Solve:	N/A
Patent Status:	Pending
Target Market:	Health
Limitations:	N/A
Challenges Experienced:	a. It took a long time to receive funds from NCC. b. COVID-19 impacts. c. Funds for the study were insufficient (No room for variation).
Impacts of the Research	a. Became close to R&D department of NCC. b. Created a lab for the study within the institution. c. Written about 4 papers and currently targeting high impact journals. d. Capacity building for lecturers in the institution (2 lecturers were part of the project).
Anticipated Barriers to Commercialization:	N/A
Commendations to NCC:	N/A
Recommendations:	a. NCC should create awareness on findings from the research. b. NCC should engage more with researchers.
Current & Next Steps:	5G studies (radiation impacts)

4.6.22 Design and Fabrication of Wireless Power Transmission through Resonant Coupling for Charging Small CPES

Research Project:	Design and Fabrication of Wireless Power Transmission through Resonant Coupling for Charging Small CPES
Category:	Hardware
Lead Researcher:	Dr. Evans Ashigwuike
Telephone:	08036335397
Name of Institution:	University of Abuja
State of Location:	Abuja FCT
Institution Type:	Federal University
Year of Award:	2019
Grant Value:	N12,839,883.00
Project Status:	**Completed**
Synopsis:	Developed a new technology for wirelessly charging small CPS (cyber physical systems e.g. wearables using inductive technology which is cheaper.
Specific Innovation & Problems to Solve:	a. Use of inductive technology for charging (current ones are capacitive). b. Low cost
Patent Status:	Pending
Target Market:	Individuals, Businesses, Government, etc.
Limitations:	N/A
Challenges Experienced:	a. Most of the components were sourced from China (logistics constraint, exchange rate issue, etc.) b. No blue-chip manufacturing company or facility in Nigeria i.e. local fabrication laboratory.
Impacts of the Research	a. Collaboration with other researchers on campus. b. Sparked more involvement and interest in other researchers. c. Capacity building for post graduate students in the use of equipment for design, circuit making, etc. d. Increased academic teaching and engineering know-how for students.
Anticipated Barriers to Commercialization:	Access to fabrication facilities or laboratories for mass production Startup Funding for SMEs
Commendations to NCC:	N/A
Recommendations:	a. Need for government to develop SMEs that can fabricate final products and components. b. NCC should improve its monitoring techniques. There should be more routine and random check on grant recipients. c. Need for research projects to be completed on time. d. NCC should consider building capacity for agent-based marketing to aid commercialization of the final product.
Current & Next Steps:	Commercialization

4.6.23 Design and Development of a Prototype High Gain Metamaterial MIMO Antenna Array for wireless Communications Systems and Energy Harvesting in Urban and Rural Areas

Research Project:	Design and Development of a Prototype High Gain Metamaterial MIMO Antenna Array for wireless Communications Systems and Energy Harvesting in Urban and Rural Areas.
Category:	Hardware
Lead Researcher:	Aminu Baba
Telephone:	08038027880
Name of Institution:	Abubakar Tafawa Balewa University
State of Location:	Bauchi
Institution Type:	Federal
Year of Award:	2019
Grant Value:	N11,419,849.14
Project Status:	**Ongoing** (Almost Done)
Synopsis:	The research focuses on developing a special type of antenna that can overcome the challenge of multipath fading from building
Specific Innovation & Problems to Solve:	a. Multipath fading avoidance b. Improved antenna performance c. Portability
Patent Status:	Pending
Target Market:	a. Service Providers
Limitations:	N/A
Challenges Experienced:	a. COVID-19 impacts b. Delays in accessing first tranche c. Access to fabrication facilities (fabrication was done in Malaysia) d. High cost of unit fabrication compared to what is obtainable in other countries. e. Access to components.
Impacts of the Research	a. The research resulted in paper publication on a high impact journal. b. Collaboration with a foreign university: University of Technology, Malaysia for R&D activities, fabrication and logistics support. c. Inspired more research interest in MIMO (smart radio environment for 5G and 6G).
Anticipated Barriers to Commercialization:	a. Funding and Investment. b. Access to scaled fabrication and production. c. Access to Component. d. Adoption and Access to Market.
Commendations to NCC:	N/A
Recommendations:	a. NCC should utilize the zonal offices more for quicker and better engagement with lead researchers as most M&E staff are always at the HQ in Abuja. b. NCC should carry out periodic capacity building exercise on focal areas for lecturers in academia community.
Current & Next Steps:	Testing

4.6.24 Design and Construction of Environmentally Friendly Paper Battery for Mobile Phones and Communication Devices.

Research Project:	Design and Construction of Environmentally Friendly Paper Battery for Mobile Phones and Communication Devices
Category:	Hardware
Lead Researcher:	Dr. Aliyu Umar
Telephone:	07030955044
Name of Institution:	Kano State Polytechnic
State of Location:	Kano
Institution Type:	Polytechnic
Year of Award:	2019
Grant Value:	N10,530,000.00
Project Status:	**Ongoing** (Testing)
Synopsis:	The research involves using new materials (paper) as main composition for development of portable batteries for mobile phones and communication devices. Current tests have shown comparability in charge and discharge power metric and cycle with conventional batteries for mobile devices. Most components were sources locally.
Specific Innovation & Problems to Solve:	Baseline research into new material and technology for charging.
Patent Status:	Pending
Target Market:	Individuals, Businesses, Government, etc.
Limitations:	N/A
Challenges Experienced:	f. ASUU strike effects g. High cost of unit fabrication compared to what is obtainable in other countries. h. Access to funds from NCC to the institution: crossing the first stage is the most difficult.
Impacts of the Research	d. The grant has inspired more researchers to indicate interest telecommunications-based research. About 10 researchers from 3 departments in the institution applied for the 2021 NCC grant cycle. e. More collaboration between researchers and the institution as well as interdisciplinary collaboration across faculties for research purposes. f. Procurement of equipment for research purposes. g. Capacity building for students who are part of the research team.
Anticipated Barriers to Commercialization:	e. Funding and Investment. f. Access to scaled fabrication and production. g. Access to Market.
Commendations to NCC:	N/A
Recommendations:	c. NCC should utilize the zonal offices more for quicker and better engagement with lead researchers as most M&E staff are always at the HQ in Abuja. d. NCC should carry out periodic capacity building exercise on focal areas for lecturers in academia community.
Current & Next Steps:	Testing

4.6.25 Development of Infrastructure for Independent Measurement of Mobile Broadband Penetration in Nigeria

Research Project:	Development of Infrastructure for Independent Measurement of Mobile Broadband Penetration in Nigeria
Category:	Hardware, Software
Lead Researcher:	Dr. Uwana Ekpe
Telephone:	07080125430
Name of Institution:	Akwa Ibom State University
State of Location:	Akwa Ibom
Institution Type:	State University
Year of Award:	2019
Grant Value:	N12,835,000.00
Project Status:	**Ongoing**
Synopsis:	Developed and indigenous but effective technique for independent measurement of broadband penetration. This will expose issues in network and broadband availability.
Specific Innovation & Problems to Solve:	Indigenous measuring device using a specialized chip to assemble a device for broadband penetration measurement
Patent Status:	Pending
Target Market:	a. National Regulatory Agency b. Universal Access and Service Providers
Limitations:	N/A
Challenges Experienced:	a. COVID-19 impacts b. High foreign exchange. c. Delays in funds disbursement from the university to the researcher. d. Bottlenecks in communication flow from NCC to the researcher.
Impacts of the Research	a. Capacity building for students involved in the project. b. Collaboration with research institutions (home and abroad). c. The research has led to the publication of three papers; two were published on the Nigerian journal of technology (NIJOTECH) d. Presented papers at the IEEE Nigerian conference (NIGERCON) in May 2022.
Anticipated Barriers to Commercialization:	a. Access to Raspberry Pi which is the heart of the research b. Access to chips c. Adoption
Commendations to NCC:	N/A
Recommendations:	a. NCC should engage more with researcher in the academia community. b. NCC should consider allowing variation in grant amount to accommodate for inflation effects, etc.
Current & Next Steps:	Prototyping

4.6.26 Spectrum Utilization Assessment for better Cellular Coverage and Connection Quality using Machine Learning.

Research Project:	Spectrum Utilization Assessment for Better Cellular Coverage and Connection Quality using Machine Learning
Category:	Artificial Intelligence
Lead Researcher:	Dr. Eze
Telephone:	+447939976085
Name of Institution:	National Space Research and Development Agency (NASDRA), Jos
State of Location:	Plateau
Institution Type:	Specialized Institution
Year of Award:	2019
Grant Value:	N
Project Status:	**Ongoing** (Almost done)
Synopsis:	Technology for channel leasing prediction aimed at addressing issues such as spectrum under and over Utilization. The developed tool can run on a local personal computer but ideally requires a server. The innovation will help telecommunication industry regulator to discern spectrum sales versus lease scenarios.
Specific Innovation & Problems to Solve:	Possibility of telco inter-usage of spectrum
Patent Status:	Pending
Target Market:	a. National Regulatory Agency b. Service Providers
Limitations:	N/A
Challenges Experienced:	a. Hosting the application (technology compatibility for the product engine). b. Collection and verification of sample data from telcos c. Delays in accessing next tranche.
Impacts of the Research	N/A
Anticipated Barriers to Commercialization:	Adoption
Commendations to NCC:	N/A
Recommendations:	NCC should critically consider research outcomes in formulating policies aimed at encouraging the adoption of these innovations and ultimately the growth of the telecommunications industry.
Current & Next Steps:	Migrating to a server environment (Amazon Web Service -AWS) for scaled testing

4.6.27 Development of all-weather Solar System for Energy Optimization in a Mobile Communication Base-Station

Research Project:	Development of all-weather Solar System for Energy Optimization in a Mobile Communication Base-Station
Category:	Energy
Lead Researcher:	Prof. Greg Onoh
Telephone:	08037265722
Name of Institution:	Enugu State University of Technology (ESUT)
State of Location:	Enugu
Institution Type:	State University
Year of Award:	2020
Grant Value:	N10,147,000.00
Project Status:	**Ongoing** (Almost done)
Synopsis:	Solar system that would work in day and night time.
Specific Innovation & Problems to Solve:	Night operation for solar cells
Patent Status:	Pending
Target Market:	a. Service Providers b. Individuals & Households c. Businesses d. Government e. Security Agencies, etc
Limitations:	N/A
Challenges Experienced:	a. Access to chemicals needed (raw materials) b. Export ban and import issues (customs) for reference chemicals because they can be used to make explosive (experienced 3 failed attempt to import). c. Access to funds (the current tranch model is not favourable for this sort of research project)
Impacts of the Research	a. Increased awareness on the NCC telecommunication-based research grant program and the research focus area within the institution. b. Increased intake/admission of staff and students into engineering. c. Collaboration with other researchers/lecturers
Anticipated Barriers to Commercialization:	a. Funding & Investment b. Access to raw materials. c. Public acceptance and adoption.
Commendations to NCC:	N/A
Recommendations:	
Current & Next Steps:	Project Finalization

4.6.28 Design and Fabrication of Metamaterial Inspired UWB/ MIMO Antenna for 5G sub 6GHz Applications

Research Project	Year	Institution	State	Researcher	Grant Value
Design and Fabrication of Metamaterial Inspired UWB/ MIMO Antenna for 5G sub 6GHz Applications	2020	Taraba State University Jalingo	Taraba	Engr. Dr. Halilu Adamu Jabire 08036570803	N9,911,811.39

NOTES: The lead researcher was unreachable to provide data on this research project.

4.6.29 Weather WAN: A Wide Area Network of Low-Cost IoT-Compliant Weather Stations

Research Project:	WAN: Wide Area Network of Low Cost IoT-Compliant Weather Status
Category:	Internet of Things (IoT)
Lead Researcher:	Dr. Kayode Ayodele
Telephone:	07030705929
Name of Institution:	Obafemi Awolowo University, Ile-Ife
State of Location:	Osun
Institution Type:	Federal University
Year of Award:	2020
Grant Value:	N11,686.500.00
Project Status:	**Ongoing**
Synopsis:	The project involves setting up a network of low power weather stations
Specific Innovation & Problems to Solve:	Use of mega-traditional sensor networks with IoT. This will allow for combination of disparate technologies to get an optimal output.
Patent Status:	Pending
Target Market:	Meteorological Agencies, Weather Research Institutions, Military
Limitations:	N/A
Challenges Experienced:	a. Access to components. b. Exchange rate issues. c. USA export control restrictions. d. Little bottleneck in accessing funds. e. ASUU strike effects.
Impacts of the Research	a. Increased research interest in telecoms innovation. b. Engagement with students and birthing of new researchers (transceiver-based research projects).
Anticipated Barriers to Commercialization:	a. Funding & Investment b. Adoption
Commendations to NCC:	N/A
Recommendations:	a. NCC should consider expanding the program and allow concurrency for researchers once they confirm viability of the Research innovation. b. NCC should strengthen the IP protection process for the program. c. More funding is needed. d. Researchers should be made more accountable.
Current & Next Steps:	Current: Tested basic technology at weather station. Next step: replicate the weather station using second tranch funds

4.6.30 Intelligent and Autonomous Multi-UAVs (Multiple Drones) Swarm Monitoring for Effective Surveillance and Situation Awareness in the Nigerian Telecommunication Industry

Research Project:	Intelligent and Autonomous Multi-UAVs (Multiple Drones) Swarm Monitoring for Effective Surveillance and Situation Awareness in the Nigerian Telecommunication Industry
Category:	UAV - Drone
Lead Researcher:	Mohammed Sagir Yusuf
Telephone:	07083586307
Name of Institution:	Gombe State University
State of Location:	Gombe
Institution Type:	State University
Year of Award:	2020
Grant Value:	N11,668,758.75
Project Status:	**Completed** (presented to NCC)
Synopsis:	The project involves setting up a network of low power weather stations
Specific Innovation & Problems to Solve:	Developed an algorithm for coordinating the drone flight path and conserving energy while on flight. The hardware components had 60% of materials imported and 40% sourced locally.
Patent Status:	Pending
Target Market:	a. Military b. Security Agencies and Law Enforcement Organizations c. Service Providers for monitoring communication equipment and radio planning. d. Business with UAV monitoring needs. e. National Regulatory Agency for compliance and monitoring (e.g. search for network boosters within a geographic location).
Limitations:	N/A
Challenges Experienced:	a. Bottlenecks in funds disbursement process (NCC to institution to researcher). b. Exchange rate issues. c. Inflation effects.
Impacts of the Research	c. Two research paper publication on two high impact journals d. Engagement with students and birthing of new researchers (transceiver-based research projects).
Anticipated Barriers to Commercialization:	a. Funding & Investment b. Adoption c. Government support for awareness creation
Commendations to NCC:	N/A
Recommendations:	e. NCC should consider expanding the program and allow concurrency for researchers once they confirm viability of the Research innovation. f. NCC should strengthen the IP protection process for the program. g. More funding is needed. h. Researchers should be made more accountable.
Current & Next Steps:	Current: Tested basic technology at weather station. Next step: replicate the weather station using second tranche funds

4.6.31 Development of Intelligent Cognitive Smart Engine for Quality of Service Management in 5G Network

Research Project:	Development of Intelligent Cognitive Smart Engine for Quality of Service Management in 5G Network
Category:	AI, Deep Learning
Lead Researcher:	Prof. Godfrey Onyiagha
Telephone:	07035493741
Name of Institution:	Air Force Institute of Technology
State of Location:	Kaduna
Institution Type:	Specialized Institution
Year of Award:	2020
Grant Value:	N
Project Status:	**Ongoing** (Stage 2)
Synopsis:	Exhibited proposal for NCC in 2020 for design and measurement of QOS based on AI. This would enable the study of traffic patterns in Networks and use those patterns to achieve good QOS control in 5G
Specific Innovation & Problems to Solve:	AI, Deep Learning, Stochastic Intelligence
Patent Status:	Pending
Target Market:	a. National Regulatory Agency b. Universal Access and Service Providers
Limitations:	N/A
Challenges Experienced:	a. Availability and stability of research resources poses challenges (some researchers have relocated abroad or travelled abroad for studies). b. Tranche model for Payment is not favourable for this sort of project.
Impacts of the Research	a. Published research papers on a high impact journal b. Training and mentoring of researchers and students in the art of AI in telecommunications (capacity building). c. Setup of small AI and embedded systems lab in the Department within the university. d. Use of lab equipment for other related research.
Anticipated Barriers to Commercialization:	Adoption
Commendations to NCC:	"*The Monitoring and Evaluation team has been good to us and does follow up effectively.*"
Recommendations:	a. NCC need to increase the research fund amount to be compatible with those of other donors like TETFund. b. NCC should consider having bigger presence in institutions via building labs/research centres "powered by NCC" just like TETFund so that it would create awareness of the NCC brand.
Current & Next Steps:	Current stage: Design and modelling AI & systems. Next step: Integrate AI for software to hardware.

4.7 Factors affecting Rate of the Research Innovation Outputs

During the qualitative survey, discussions were held with stakeholders on factors affecting rate of the telecommunications-based research innovation outputs from Nigerian tertiary institutions. Some of the findings include.

a. Access to Funds

This is one of the biggest challenges faced by researchers in the NCC telecommunications-based research innovation program for tertiary institutions. Some of the limiting factors creating the problem of access to funds include:

1. Long turnaround time for funds disbursement from NCC to researchers via their tertiary institution.
2. Unfavourable tranche model especially for hardware-centric projects where incremental fabrications and prototyping is required.

The lack of streamlined access to funds impacts negatively on the speed and quality of delivery of the research projects.

b. Access to Raw Materials and Specialized Components

Some of the raw materials and components required to develop working prototypes are sourced abroad, mostly from countries like China, Malaysia, India and South Africa. This poses the challenge of:

1. Incurring extra costs i.e. import duties (expense).
2. Wastage by adhering to minimum order quantity (MOQ) which is usually higher than the maximum number required by researchers.

The strained access to raw materials and specialized components results in delays in completing the research project.

c. Availability of Fabrication and Assembly Plants

A close observation of the categories of research projects under the NCC research innovation program for tertiary institutions shows a high dominance of hardware-centric projects. These projects require fabrication and assembly of components and parts. Over 90% of the hardware-related research projects fabricate or produce their parts abroad. For instance, all projects requiring electronic circuits had their Printed Circuit Board (PCB) fabricated abroad in China, Malaysia or South Africa due to lack of high-tech embedded systems fabrication plants in Nigeria.

The risks in fabricating prototypes abroad includes:

1. Risk of loss of intellectual property (IP) to countries where the fabrication and assembly process is carried out.
2. Loss of competitive edge on the global scene if the country of production decides to reverse-engineer and advance the innovation.

d. High Foreign Exchange Rate

The USD to Naira exchange rate has shown steady and sometimes sharp increases in the last seven (7) years. The USD to Naira exchange rate rose from an average of $1.00 = N195 in 2015 to $1.00 = N419 in 2022 indicating over 200% increase in USD to Naira exchange rate in 7 years. The figure below shows official exchange rate of USD to Naira from 2014 to 2022.

Figure 23: US Dollar to Naira Exchange rate (2014 to 2022)
Graph source: https://tradingeconomics.com/nigeria/currency;
(data source: Central Bank of Nigeria)

Recent policies by the Central Bank of Nigeria (CBN) has stifled access to foreign exchange and widened the gap between the official exchange rate and the parallel market rate (for instance, although the official rate in August 2022 is $1.00 = N419, the parallel market rate is at $1.00 = N670 i.e. 160% above the official rate). The continuous increase in exchange rate results in:

1. Incurring extra costs in research projects that require purchase of components, raw materials or fabrication abroad.
2. Switching choice of components to lesser quality ones to keep the project within budget.

e. High Inflation Rate

The National Bureau of Statistics (NBS) Consumer Price Index (CPI) and Inflation Report of June 2022 showed that the inflation rate in Nigeria increased to 18.60% (Nigeria's inflation rate averaged 9.01% in 2015) – over 200% increase in the last 7 years.

The figure below shows Nigeria's inflation rate from 2014 to 2022.

Figure 24: Nigeria Inflation Rate (2014 to 2022)
Graph Source: https://tradingeconomics.com/nigeria/inflation-cpi;
Data Source: National Bureau of Statistics (NBS)

The research grant program does not provide room for any variations on the grant amount. This implies that researchers must make do with the research grant amount irrespective of the increasing inflation rate hence straining the financial flexibility of researchers to deliver effectively on the research project.

f. Nigeria's Insecurity Profile

One of the major problems plaguing Nigeria is insecurity which also impacts on the rate of research innovation. Nigeria's insecurity profile in recent years has led to:

1. Export ban (by countries like USA, UK, India, Malaysia etc.) on shipment of specialized chips, components, special batteries and chemicals to Nigeria (mostly military-grade & high-tech communication systems components), largely because they can be used to manufacture explosives.
2. Difficulty by NOTAP in establishing Intellectual Property and Technology Transfer Offices (IPTTO) in the northeast and southeast regions of the country.

g. Communication and Collaboration Gaps

Delays in sending and receiving notifications, lag in project updates, no communication of change of NCC's M&E staff, etc. are frequent communication and collaboration gaps that occur in the research grant program. Most of these happen because the program management and tracking processes are largely done manually & semi-automated in some cases. The table below summarizes the factors affecting the rate of NCC research innovation outputs.

Table 23: Factor affecting rate of NCC Research Innovation Output in Nigerian Tertiary Institutions

SN	Factor	Causes	Impacts and Risks
1.	Access to Funds	a. Bottlenecks in the fund disbursement process from NCC to the institutions and from the institution to the researchers. b. Unfavourable payment tranche model.	a. Longer project delivery time. b. Use of lower substitute components and materials.
2.	Access to Raw Materials and Specialized Components	a. Non-availability of specialized raw materials and components in Nigeria. b. Export ban on some specialized components & raw materials. c. Nigeria's Insecurity profile.	a. Import-dependence for access to specialized raw materials and components. b. Delays in project delivery due to shipping and import logistics
3.	Availability of Fabrication and Assembly Plants	a. Lack of high-quality embedded systems fabrication and assembly plant in Nigeria	a. Increased project delivery cost b. Risk of loss of intellectual property (IP) to countries where the fabrication and assembly process is carried out c. Risk of loss of competitive edge on the global scale if the innovation is reverse engineered by countries where the fabrication and assembly process is carried out.
4.	High Foreign Exchange Rate	a. Economic Instability	a. Increased project delivery cost b. Use of lower substitute components & materials c.
5.	High Inflation Rate	a. Economic Instability	a. Increased project delivery cost b. Use of lower substitute components & materials c.
6.	Communication and Collaboration Gaps	a. Use of semi-automated processes for program management. b. Absence of an online portal platform for applications, tracking and progress management of the research innovation program, c. Frequent staff redeployments in NCC.	a. Delays in sending and receiving notifications. b. Difficulty in tracking correspondence status c. Longer project delivery time.

4.8 Status of Intellectual Property Protection and Registration in Nigeria

Intellectual property registration is handled by the Trademarks, Patents and Designs Registry, Commercial Law Department in the Ministry of Trade and Investment and the process is actively facilitated by the National Office for Technology Acquisition and Promotion (NOTAP). The Patents and Design Act (PDA) Cap. 344 of the law of the Federal Republic of Nigeria (Act of 1970) governs the patenting process in Nigeria.

As at 31st July 2022, a total of 374 patent certification have been facilitated by NOTAP. Cumulatively, NOTAP has assisted in the issuance of 60% of all patents in Nigeria.

4.8.1 Intellectual Property and Technology Transfer Office (IPTTO)

NOTAP is saddled with the responsibility of establishing Intellectual Property and Technology Transfer Offices (IPTTO) in Nigerian tertiary institutions to promote a healthy patenting culture among researchers in Nigeria.

According to NOTAP, "***the IPTTO is designed to develop a robust intellectual Property Rights portfolio through patenting, copyright, technology licensing; to support the Institution's initiative in developing patent culture. The IPTTO also sets into motion the formal system of incentives and reward that encourages individual researcher to be involve in partnerships***".

In an interview session with Mrs. Caroline Anie-Osuagwu, Director of Technology Acquisition and Research Coordination (TARC) department in NOTAP, she revealed that: "***Most innovators and researchers in Nigeria do not take patent seriously"***. She also stressed that: "***Researchers in Nigeria are too quick to publish papers without protecting their intellectual property which eventually leads to IP theft by international companies***".

To encourage patenting of outputs of applied researches in Nigerian tertiary institutions, NOTAP announced in May 2022 that it shall commence ranking of IPTTOs in Nigeria. There **68 IPTTOs** in Nigeria today. NOTAP's commitment to establishing more IPTTOs in Nigeria has been slowed down by the current securities challenges in Nigeria. The figure and table below show the IPTTO distribution across regions in Nigeria.

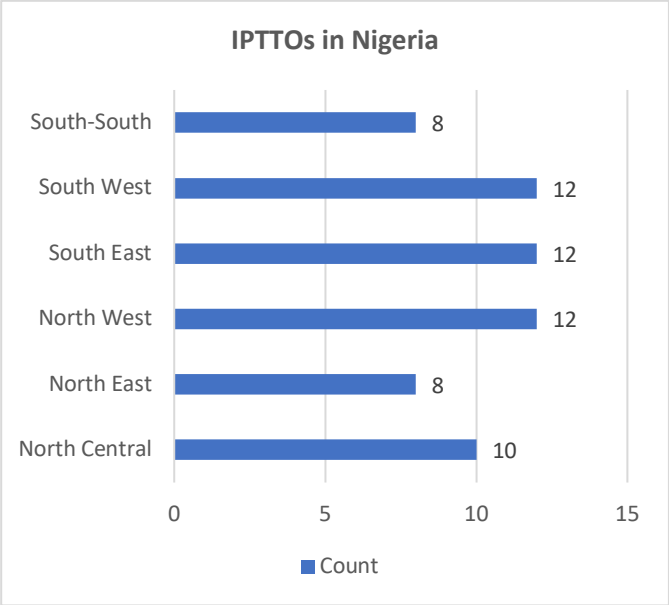


Figure 25: IPTTO Distribution in Nigeria.
Data Source: NOTAP

Table 24: IPTTOs in Nigeria

Region	Count
North Central	10
North East	8
North West	12
South East	12
South West	12
South-South	8
Total	**68**

Benefits of Patent Registration through NOTAP

a. The entire patent registration process is done free of charge.
b. Assistance in packaging relevant documents to facilitate the patent registration process.
c. Continuous follow-up until patent certification is granted.
d. Education of researchers on different aspects of the patent process, requirements, etc.

4.8.2 Statistics of IP Registrations in Nigeria

Data from the Ministry of Trade and investment reveals the following statistics as regard IP registration in Nigeria for the last 5 years.

Table 25: IP Registration Statistics in Nigeria (Last 5 Years)

Category	**Count**
Design Registrations	241
Patents Completed	2,152
Trademark Certifications	6,154
Total IP certification (Last 5 Years)	**8,547**
Source: Ministry of Trade and Investment: Online available at: https://www.iponigeria.com/AboutUs	

4.8.3 Challenges of IP Protection and Registration by Researchers in Nigeria

a. Low awareness on the need and requirements for IP registration.
b. Low incentives for researchers and tertiary institutions.
c. Unattractive IP registration potentials in Nigeria due to low commercialization.

4.9 Analysis and Assessment of Triple Helix Linkages in Nigeria

Nigeria is currently at strength level 2 (i.e. Push-pull) of the Triple Helix framework for the tripartite linkage between academia, government and the industry.

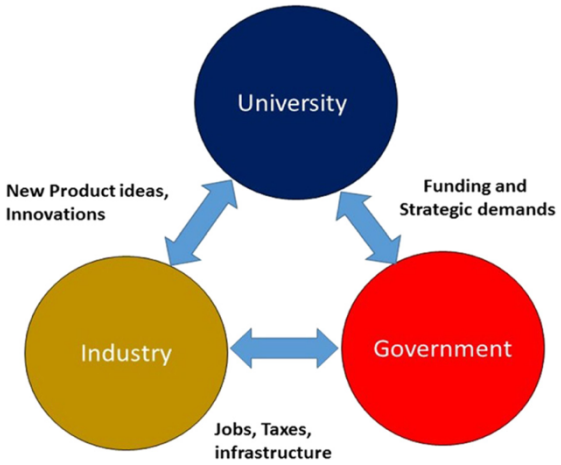


Figure 26: Push-Pull Stage of the Triple Helix Framework

Several barriers still limit the seamless interaction of the 3 parties and the sustained commercialization of research outputs is yet to be achieved. The table below shows the assessment of the tripartite linkage for the NCC research innovation program in Nigerian tertiary institutions based on feedback from engagements with stakeholders.

Table 26: Analysis and Assessment of Triple Helix Linkage in Nigeria

SN	Interaction/Linkage	Current Status & Remarks	Assessment Grade
1.	Government-Academia	**a. Funding & Investments** Several grants have been awarded in the last 5 to 10 years to different researchers in Nigerian tertiary institutions to promote RDI activities. Although more funding is required, past grants shows governments commitment to ensuring continuous research and innovation outputs from the academia community. **b. Strategic RDI Demands** A very mature R&D needs assessment regime currently exists where government grantors are very specific with the research focus areas and desired outputs expected from the research projects.	Above Average

2.	Government-Industry	**a. Infrastructure** Continuous development of physical and telecommunication infrastructure across the country to match or surpass targets set in the National Broadband Plan (NNBP) 2020 – 2025, the National Digital Economy Policy and Strategy (2020 – 2030), among others. **b. Innovation Adoption** This aspect of the linkage is low because most of the research outputs are yet to be commercialized. **c. New Job Creation** This is also low because of low level of commercialization of research and development outputs. **d. Policies & Regulations** Several emerging policies, initiatives and programs have been put in place to promote indigenous innovation in Nigeria. Examples include Nigeria Start-up Bill, Office for Nigeria Digital Innovation (ONDI), NODITS, etc.	Average
3.	Academia-Industry	**a. New Product Ideas** Most of the innovation ideas emanate from individuals & government based on needs assessment; the industry's involvement in influencing research focus areas are still minimal. **b. Innovation** A good number of research innovations are currently ongoing in various tertiary institutions across the country. **c. Early Adoption** A good number of research projects are still ongoing; and there is a Low level of commercialization of completed research projects	Below Average

In an interview with Dr. Mohammed Agbali, Chief Research Officer at NITDA, he noted that: "***Leadership & Management is a key factor to drive R&D in Nigeria. There is also the need for synergy between all parties i.e. government, industry and academia so that we can start reaping the benefits of R&D in Nigeria.***"

4.10 SWOT Analysis of the NCC Telecommunications-based Research Innovation Program

The key strengths, weaknesses, opportunities and threats of the NCC telecommunications-based research innovation program are listed below.

Table 27: SWOT Analysis of NCC Telecommunication-based Research Grant Program

Strengths	h. Funding from NCC (Over N500million has been invested in research grant). i. Applied research regime based on strong research needs-assessment by NCC. j. Integration of several new and emerging technologies (5G, IoT, AI, etc.). k. Knowledge and skillset of Researchers. l. Good Government-Industry linkage. m. Strong Collaboration between researchers in academia community. n. Capacity building vehicle for tertiary institution.
Weaknesses	e. Weak Academia-Industry linkage. f. Collaboration bottlenecks between researchers and NCC g. Funds disbursement bottlenecks (NCC to institution and institution to researcher). h. Low IP protection enforcement.
Opportunities	e. Investment opportunities (local and foreign) in commercialization of research outputs. f. Socioeconomic development post commercialization. g. Export potential for commercialized products and services. h. Multi-sector application of research outputs e.g. telecoms, health, security, regulation, military.
Threats	e. Economic Instability (high inflation and high exchange rates f. Problem of Insecurity. g. IP theft due to early publication of research papers without patenting as well as prototype fabrication abroad. h. Legal risks in research grant practices.

4.11 Comparative Analysis of ICT and Telecommunications-based Research Grant Programmes

The table below shows a comparative analysis of major ICT and telecommunications-based research grant programmes in Nigeria.

Table 28: Comparative Analysis of ICT & Telecommunications-based Research Grant Programmes

Criteria	Grantor Agencies			
	NCC	**TETFund**	**NCS**	**NCDMB**
Programme Name	Telecommunications-based Research Innovation Grant	National Research Fund (NRF) Grant	NCS Innovation Development Fund (NIDF) Grant	Nigerian Content Research and Development Fund (NCR&DF) Grant
Start Year	2013 (Consolidated 2018)	2009	2021	2015
Major Research Areas	Telecommunications	a. Humanities & Social Science b. Science; Technology & Innovation c. Cross-Cutting	a. Information & Communication Technology b. Emerging Technologies	a. Industrial technologies b. Special Materials c. Process Optimization
Maximum Grant Amount	N14 million	N50 million	N5 million	Varies (Not Specific)
Maximum Research Delivery Period	2 years	2 years	1 to 3 years	Varies (Not Specific)
Has an Automation Portal for Progamme Management?	No	Yes	No	No
Major Target Sector for Commercialization	Telecommunication, Homes, Businesses, Security, etc.	Multiple Sectors: Agriculture, Health, ICT, Homes, Businesses, etc.	ICT, Homes,	Oil and Gas; Manufacturing; Process Control.
Key Strengths	R&D on Core Telecommunications & New and Emerging Technologies.	Grant value; Multi-sector R&D; Commercialization.	R&D is mainly on New and Emerging Technologies.	Grant value; Industrial applicability of R&D outputs.
Key Weaknesses	Actual R&D Completion Time; Commercialization.	Socio-economic applicability of the research outputs.	Funding Inadequacy	Non-granularity of Research focus areas.

4.12 Legal Risks Associated with Research Grant Programmes in Nigeria

Sample letters of grant award and agreement documents for R&D grant programmes were studied and reviewed. Interviews with legal experts in intellectual property and competition law were conducted to determine the legal risks in research grant practices in Nigeria.

The following risks were identified:

a. **Intellectual Property (IP) Ownership:** This risk exists if there are no clear-cut definition of IP ownership at the different stages of the research grant program such as: conceptualization, design, prototyping and commercialization.

   In an interview with Barr. Ejike Nwafor of Blue-Ribbon Attorneys, he noted that: "*An Agreement or MOU should serve as the Binding document for all parties; it should also clearly define the roles, responsibilities and powers of each party in the research grant.*"

b. **Intellectual Property (IP) Theft:** This risk can occur if the different IPs (such as design, process, prototype, etc.) are not protected through patenting. All major milestones of the research and development progresses ought to be patented to safeguard the IP. During an interview with Barr. Francis Nworah, an Abuja-based IT/IP and Competition Law Expert, he stressed that: "*IP should be protected at all cost to prevent contests and claims to research copyrights*."

c. **Plagiarism:** This involves presenting someone else's work or ideas as one's own. This risk can expose the grantor and beneficiary institution to litigation by persons or organizations whose works have been plagiarised by researchers under a grant programme.

   Research proposal must be original, and must represent one's own work. Conceptualization, design and prototyping stages if the R&D process are expected to be subjected to plagiarism checks before approval.

d. **Force Majeure:** These are unforeseen circumstances that can prevent lead researchers from completing the R&D project and hence not fulfilling the grant contract terms. These include natural causes (fire, storms, floods), governmental or societal actions (war, invasion, civil unrest, labour strikes), infrastructure failures (transportation, energy), etc. A typical example is the COVID-19 pandemic.

5. Commercialization Outlook

In recent years, there has been several awakenings on the need to commence commercialization of R&D outputs from the academia community. The commercialization process are the last stages of the innovation cycle which involves taking the RDI outputs to market for consumers. Commercialization promotes continuous innovation and competition.

5.1 Technology Readiness Levels (TRL) for Commercialization

The Organization for Economic Cooperation and Development (OECD) defines Technology Readiness Level (TRL) as "***a model used to identify the stage of innovation at which funding is being applied***". OECD defined 9 Technology Readiness Levels which starts from TRL 1 (basic research) and ends at TRL 9 (early deployment of near-commercial technologies). Once TRL 9 has been attained, an innovation is set for full commercialization. The table below shows the different TRLs.

Table 29: Description of Technology Readiness Levels (TRL)

Stage	Description of Activity
TRL 1-3 Basic Research	*Activity driven by a desire to broaden scientific and technical knowledge, and is not explicitly linked to industrial or commercial objectives. It typically includes investigating the underlying foundations of phenomena and observable facts, and typically takes place almost entirely in the academic community.*
TRL 4–5 Development	*Research with a more direct commercial application, driven both by scientific enquiry (with a degree of public good in the outcomes) and commercial opportunity (with research areas driven by expertise in spotting market opportunity), and is seen as an opportunity to build and develop links between industry and academia increasing the likely success and pull through of ideas from the academic community*.
TRL 6–7 Demonstration	*Large-scale pre-commercial demonstration of technologies, designed to test and improve longer term operational reliability, develop and improve full scale designs, establish and reduce operating costs and take the technology to a stage where the technology becomes a potential commercial investment. Work is undertaken by the private sector, typically with some academic involvement.*
TRL 8-9 Early Deployment	*Technologies have been shown to work on a large scale, but are not yet competitive in the market, require a policy and market framework that supports their deployment. Development is undertaken by companies in the private sector.*

Source: OECD (2010); online available at: https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=com/env/epoc/ctpa/cfa(2009)40/final; P6.

The figure below shows a visual depiction of the different TRLs, stages and roles of RDI actors.

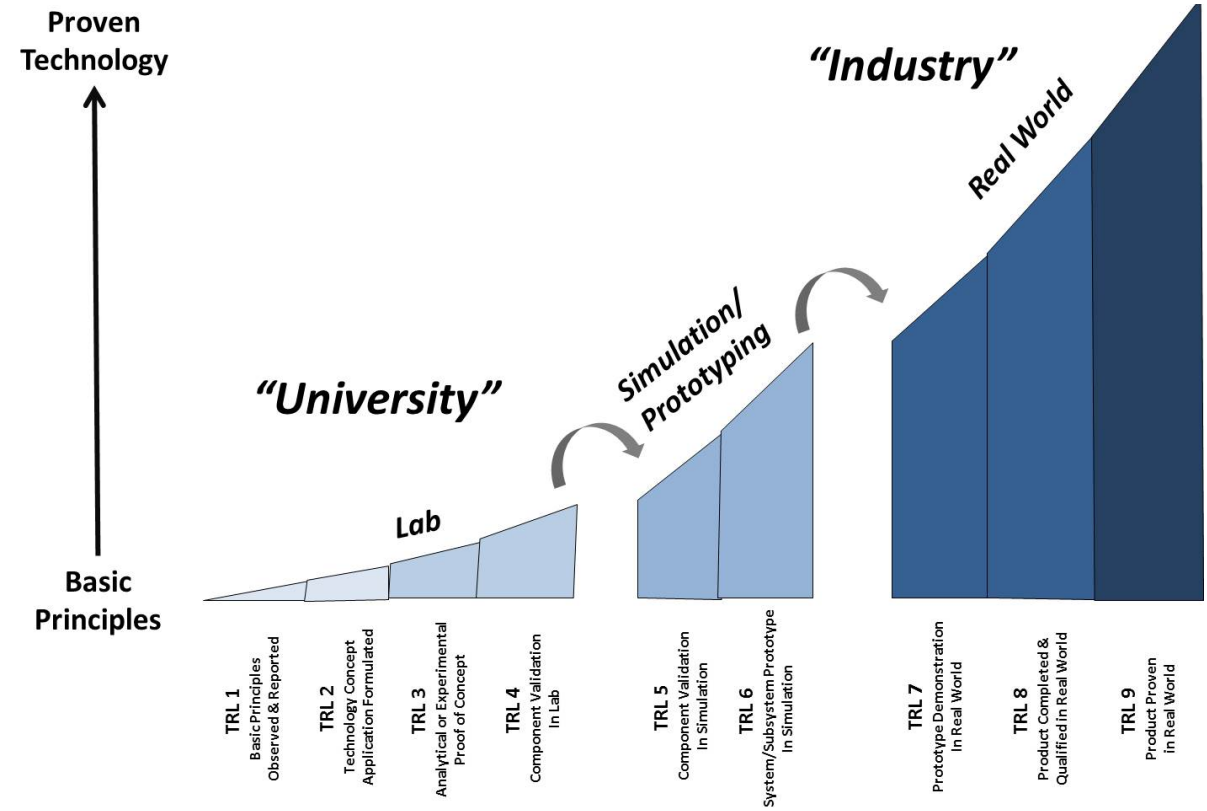


Figure 27: TRL for Commercialization

Image Source: https://alopexoninnovation.com/2013/09/10/innovation-diffusion-from-university-rd/

5.2 Key Enablers for Commercialization

The figure below shows the roles of major actors in the innovation process.

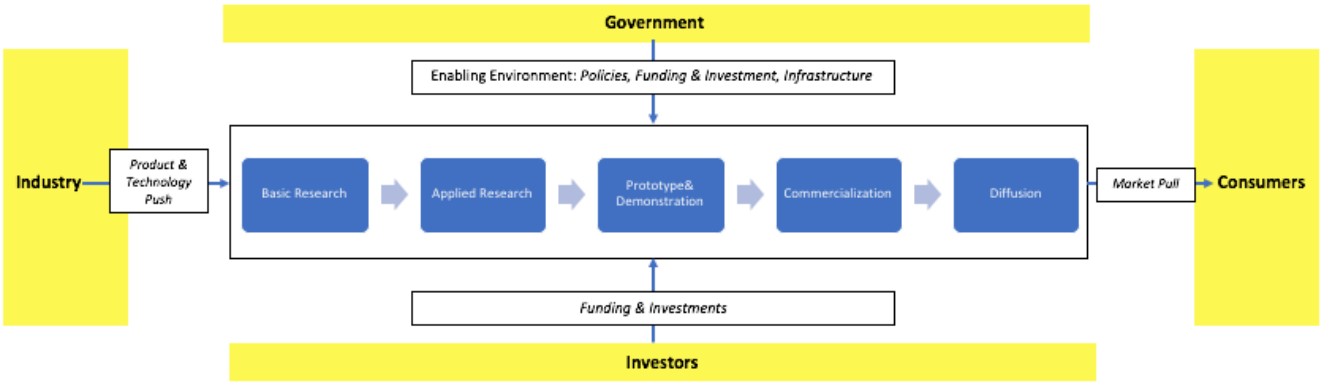


Figure 28: Roles of Innovation chain Actors

The table below enumerates key enablers, actors and actions for commercialization in Nigeria.

Table 30: Enablers, Actors, Activity for Commercialization

SN	Enabler	Actors	Activity
1.	Funding and Investment	a. **Government**: Bank of Industry (BOI), CBN, FMoCDE, FMSTI, etc. b. **Investors**	Funding & investment for product and service commercialization activities e.g. branding, marketing, sales, expos, advertorials, etc.
2.	Policies	a. **Government**: FMSTI, NITDA, NCC, FMoCDE, etc.	Policy interventions aimed at overcoming barriers to commercialization
3.	Infrastructure	**Government**: Federal, state and local governments as well as statutory government MDAs	Provision of adequate physical and telecommunication infrastructure
4.	Scaled Production Facilities	a. **Industry** b. **Government**	Provision of tech-tech fabrication laboratories and factories for scaled
5.	Adoption	a. **Industry** b. **Government**	Early adoption and promotion of innovation outputs;
6.	Awareness	a. **Government** b. **Industry** c. **Civil Society Organizations (CSO),** etc.	Creation of public awareness on existence of innovation outputs

The industry plays a significant in the early adoption and promotion of innovation output with a goal for commercialization. Government acts as facilitators and catalysts for promoting the commercialization process through funding & investment and creating enabling policies.

During an interview with Engr. Yakubu Musa, the acting national coordinator of ONDI in August 2022, he emphasized that: "***there are enabling policies but implementation is a challenge and there is need for more synergy between government, industry and academia to bring out the best in terms of commercializing R&D outputs in Nigeria***".

5.3 Potential Application Areas for NCC Sponsored Researches

The table below categorizes the different NCC sponsored research innovation programs into different potential areas of application.

Table 31: Potential Application areas of NCC sponsored research innovations in tertiary institutions

	Universal Access & Service Providers	Individuals & Households	Physical & Online Businesses	Govt. MDAs	National Regulatory Agency (NRA)	Agriculture	Health	Military, Security Services
Research Projects Numbers:	2, 4, 6, 8, 11, 12, 13, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 30, 31	2, 4, 8, 11, 19, 22, 24, 27	2, 3, 4, 7, 8, 11, 14, 19, 22, 24, 27, 30	2, 4, 6, 7, 8, 11, 19, 22, 24, 27	2, 4, 6, 7, 8, 11, 12, 13, 19, 20, 22, 24, 25, 26, 27, 29, 30, 31	2, 4, 8, 11, 15, 19, 22, 24, 27	2, 4, 7, 8, 11, 16, 19, 21, 22, 24, 27	2, 4, 7, 8, 11, 13, 14, 19, 22, 24, 27, 29, 30
NOTE: The research project numbers above are adopted from the serial numbering on table 5 of chapter 3.2.								

The categorization above will help in selecting research projects for commercialization in terms of strategic partnerships with stakeholders, funding and investment and early adoption.

5.4 Recent Commercialization-Promotion Initiatives

Some of the recent initiatives aimed at promoting commercialization in Nigeria include but are not limited to the following.

a. Science, Technology and Innovation (STI) Expo

The STI expo commenced in 2016 and is an initiative by the Federal ministry of Science, Technology and Innovation (FMSTI) to showcase indigenous innovation, thereby attracting investors to enhance the Nigerian economy. The last STI expo was held in November 2021 and attended by scientists, researchers, inventors, innovators, investors, entrepreneurs, foreign guests and other Nigerians. It was themed: "***Sustainable National Economic Growth Through Science, Technology and Innovation***". The then Honourable Minister of FMSTI, Dr. Ogbonaya Onu noted that: "***Nigeria has made tremendous breakthrough in import reduction, by cumulatively saving N5.03 trillion from 2017 to 2020. (Quote based on the data by the United Nations Harmonised System Code and the National Bureau of Statistics)***".

b. Engagements with Stakeholders for Commercialization

In the last four to five years, several notable engagement sessions of key stakeholders in the Nigerian innovation ecosystem have been held with the goal of finding ways to address barriers for commercialization. Some of these engagements include:

1. **NCC engagement with Academia Community and Telecommunication industry stakeholders**: This started in October 2018 and has become an annual event conducted by NCC to strengthen the linkages between stakeholders. In late July and early August 2022, NCC held round table meetings with representatives from the academia community and the telecommunication industry in Kano (for northern region) and Lagos (for southern region) respectively, to discuss areas of collaborations for commercialization of R&D outputs from its sponsored telecommunications-based research innovations in Nigerian tertiary institutions.
   The round-table engagement session for southern region held in Lagos was titled: "**The Path from Innovative Research to Commercialisation of Viable Prototypes**". During the discussion sessions, Prof. Umar Danbatta, Executive Vice Chairman (EVC) of NCC observed that: "***it is clear that the commission will have to make a commitment to facilitate the contributions from academia, by supporting commercialisation of these prototypes to deepen indigenous technological capabilities, which would support the overall development of the industry***."
2. **NOTAP with Academia, Industry and Other Stakeholders**: In the last two years, NOTAP has been active in engaging with academia and other stakeholders in the Nigerian innovation ecosystem aimed at promoting commercialization of R&D outputs from Nigerian tertiary institutions. From raping up its setup of IPTTOs across tertiary and research institutions in the country to engaging with academia and industry stakeholders, NOTAP has demonstrated its commitment to promoting innovation in Nigeria. It was a one-day forum for patentees in Northern Nigeria to discuss modalities of moving their inventions and innovations to the next level of commercialization. Dr DanAzumi Ibrahim, the Director General of NOTAP, noted that "***the forum will also provide the needed synergy between researchers and funding institutions to create the necessary impetus that would ensure that Research and Development (R&D) outputs from the nation's knowledge centres are moved to the market as products and services***". He revealed that NOTAP's activities had saved Nigeria over N79.6 billion that would have left the nation's borders as capital, through its regulatory role of registration and monitoring of technology transfer agreements.

c. Nigeria's First Digital Fabrication Laboratory (FABLAB 1.0)

This was launched in May 2022 as first of its kind in Nigeria by NITDA as part of efforts for implementation of the National Digital Economy Policy and Strategy (NDEPS).

a. FABLAB 1.0 has state-of-the-art equipment that includes:
b. Printed Circuit Board (PCB) production equipment
c. Computer Numerical Control (CNC) machines
d. 3D printers
e. Servers
f. Graphics processing units (GPUs), and
g. Other digital fabrication tools and equipment.

During in its launch on May 2022, the Mr.Kashifu Abdullahi, Director General of NITDA, noted that: "***The FABLAB maintains an open access policy to allow it serve as a digital innovation accelerator for all innovators and makers. It allows open-production and public access to aid innovation and entrepreneurship activities***".

During a one-day visit (on 10th August 2022) to the FABLAB 1.0 is located at ONDI office in Wuye District, Abuja, we were given a tour of the facility. See photographs below:

Figure 29: FABLAB Digital Fabrication Workflow

Figure 30: FABLAB 3D Printer, ovens etc

Figure 31: FABLAB Testing Workbench

Figure 32: Digital Fabrication Tools

Figure 33: FABLAB State-of-the-art CNC Machine

Figure 34: PCB Scanner

Figure 35: Group photograph taken with Acting National Coordinator of ONDI and other staff at NITDA's National Centre for Artificial Intelligence and Robotics (NCAIR), Wuye, Abuja.

d. NCC & SMEDAN Digital Academy for Entrepreneurs

This initiative is aimed at improving digital skills of entrepreneurs, inventors, innovators and researchers. NCC partnered with SMEDAN in 2021 to establish the Digital Academy for Entrepreneurs. The digital academy is a public-private partnership initiative driven by the NCC, SMEDAN and Sapphital Learning Limited.

e. FMSTI's Push for Strong Regulatory Framework for Commercialization

In 2021, the FMSTI held the second national competitiveness forum with other stakeholders in the Nigerian innovation ecosystem on the need for synergy between stakeholders to improve overall efficiency of innovation in Nigeria. The then Minister of FMSTI, Dr.Ogbonaya Onu stressed that: "***Our programmes, especially for R&D, will focus principally on need-based, demand-driven activities. This will ease the commercialisation of research and development results***."

5.5 Modalities for Adopting an Efficient Research Grant Framework

The expected outcomes of the strategic interactions in the triple helix model stipulates the modalities to consider in setting up an efficient research grant framework. This is enumerated below.

Government-Academia Linkage

a. Funding and Investments
b. Strategic RDI demands
c. Monitoring and Evaluation

Government-Industry Linkage

a. Policies and Regulations
b. Infrastructure
c. Innovation Adoption
d. Job Creation

Industry-Academia Linkage

a. New Product Ideas
b. Innovation
c. Early Adoption

6. Conclusion and Recommendations

6.1 Conclusion

The NCC telecommunications-based research innovation programme has been effective in driving interest among researchers in Nigerian tertiary institutions to engage in and collaborate on various applied research and development activities. The program has also helped in building indigenous capacity within the academia in this regard. A good number of these research projects are nearing the prototype completion stage and have good commercialization potentials for use in telecommunications service provision, homes & businesses, telecoms industry regulatory services, security, agriculture, health, etc.

NCC has also been instrumental in facilitating and strengthening linkages between academia, industry and government through this programme. Bottlenecks in the funds administration process, access to specialized components & raw materials, impacts of the COVID-19 pandemic and high foreign exchange rates have been the biggest barriers faced by lead researchers in the NCC telecommunications-based research grant programme. The commercialization of prototypes, once fully developed, is essential to addressing existing and emerging socio-economic challenges in Nigeria and promotion of investments.

6.2 Recommendations

List of key recommendations include the following:

a. Design, Development and Deployment of a centralized online portal platform for management of the NCC research grants program. This will assist in:
    1. Workflow automation and streamlining of key processes involved in the research grant management process;
    2. Maintenance of electronic repository for easy storage and retrieval of records, reports, etc;
    3. Reduction of communication and collaboration bottlenecks between lead researchers, beneficiary institutions and NCC.
    4. Ease of continuity in program management activities whenever staff redeployments are done.

b. Establishment of a state-of-the art design and fabrication facility/laboratory to facilitate access to digital design and production technologies.

c. Strategic collaboration & partnership between NCC and CBN to facilitate lead researchers' access to FOREX for purchase of specialized components.

d. Strategic collaboration & partnership between NCC and Nigerian Customs Service to facilitate importation of "restricted items" needed by lead researchers in research projects that require such.

e. NCC should consider increasing the maximum grant value owing to the prevailing inflation rates in Nigeria.
f. NCC should consider an upward review of the initial tranches especially for hardware-centric projects that require fabrication at initial stages.
g. Conduct a separate consultancy for Commercialization of the R&D outputs.
h. Creation and promotion of policies that will drive local content adoption in the Nigerian telecommunications industry.
i. NCC should foster academia-industry linkage by encouraging private sector participation (e.g. telecommunications service providers) in telecommunication-based research and development activities.
j. NCC should consider benchmarking innovation outputs with regional and international standards to ensure future-proof R&D outcomes.
k. NCC should consider conducting entrepreneurship development workshops for lead researchers during the research & development phase of their projects.

References

NCC (2021), *"Press Statement: Telecoms Sector, others Take Nigeria out of Recession as Sector Boosts GDP by 12.45%";* online available at: https://ncc.gov.ng/media-centre/news-headlines/960-press-statement-telecoms-sector-others-take-nigeria-out-of-recession-as-sector-boosts-gdp-by-12-45; published on 22nd February, 2021; accessed on 12th April, 2022.

The Nation (2022), *"Telecoms add 12.45% to Nigeria's GDP"*; online available at https://thenationonlineng.net/telecoms-add-12-45-to-nigerias-gdp/; published on 14th January, 2022; author: Toba Adedeji; accessed on 12th April, 2022.

NCC (2022), *"News Release: New Awards to NCC, Danbatta Underscore Significance of Telecom Contribution to GDP"*; online available at https://www.ncc.gov.ng/media-centre/news-headlines/1153-news-release-new-awards-to-ncc-danbatta-underscore-significance-of-telecom-contribution-to-gdp; published on 24th January, 2022; accessed on 12th April, 2022.

NCC (2022), *"Mandate of the NCC"*; online available at: https://www.ncc.gov.ng/the-ncc/mandate; accessed on 15th April, 2022.

NCC (2022), *"News Release: NCC awards N233 million in research grants, professorial chair endowments";* online available at https://www.ncc.gov.ng/media-centre/news-headlines/1195-news-release-ncc-awards-n233-million-in-research-grants-professorial-chair-endowments; published on 8th April, 2022; accessed on 12th April, 2022.

TETFund (2022), *"National Research Fund"*; online available at https://tetfundserver.com/index.php/national-research-fund/; accessed on 20th April, 2022.

TETFund (2020), *"Guidelines for the Completion of the TETFund National Research Fund (NRF) Grant Application Form"*; online available at: https://nrf.tetfund.gov.ng/UserGuides/Proposal_Guidelines.pdf; accessed on 20th June, 2022.

Blueprint (2021), "*TETFund disburses N6.4Bn to researchers*"; online available at: https://www.blueprint.ng/tetfund-disburses-n6-4bn-to-researchers/; published on 11th November, 2021; Author: Uji Abdullahi Iliyasu; accessed on: 25th June, 2022.

Nairametric (2021), "*Education: FG increases TETFund research grants to N8.5 billion*"; online available at: https://nairametrics.com/2021/09/15/education-fg-increases-tetfund-research-grants-to-n8-5-billion/; pubished on 15th September, 2021; Author: William Ukpe; accessed on 25th June, 2022.

NCC(2021), "*2021 Telecommunications - Based Research Innovation from Academics in Nigeria Tertiary Institutions*"; online available at: https://www.ncc.gov.ng/technical-regulation/research/1026-research-grant-2021; accessed on 25th June, 2022.

Capital Post (2022), "*NCC spends N500m on research in Nigerian Universities, other tertiary institutions*"; online available at: https://www.capitalpost.ng/2022/08/ncc-spends-n500m-on-research-in-nigerian-universities-other-tertiary-institutions/; published on 1st August, 2021; Author: Victoria Ojone Samson; Accessed on: 1st August, 2022

AFIT (2022), "*Defence Research and Development Bureautto Sponsor Research Activities in AFIT*"; online available at: https://afit.edu.ng/home/defence-research-and-development-bureau-to-sponsor-research-activities-in-afit/; published in June 2022; accessed on 15th July, 2022.

PTDF (2022), "*PTDF Programs Database*", online available at: https://pid.ptdf.gov.ng/pid/pid/; accessed on 20th July, 2022.

The Nation (2022), "*Fed Govt screens proposals for $20.5m research grant*", online available at: https://thenationonlineng.net/fed-govt-screens-proposals-for-20-5m-research-grant/; published on 5th August, 2022; author: Grace Obike; accessed on: 5th August, 2022.

National Bureau of Statistics (2022), "*CPI and Inflation Report - June 2022*", online available at: https://nigerianstat.gov.ng/elibrary/read/1241197; published in July 2022; accessed on 1st August, 2022.

Trading Economic (2022), "*The Nigerian Naira*", online available at: https://tradingeconomics.com/nigeria/currency; published on:

NOTAP (2022), "*NOTAP to Commence Ranking of IPTTOs to Encourage Demand-driven Research*"; online available at: https://notap.gov.ng/new_dev/notap-to-commence-ranking-of-ipttos-to-encourage-demand-driven-research/; published in May 2022; accessed on 10th July, 2022.

Federal Ministry of Trade and Investment (2022), "*We Can Protect Your Ideas, Inventions, Designs, And Trade Secrets*"; Online available at: https://www.iponigeria.com/AboutUs; Published by Trademarks, Patents And Designs Registry, Commercial Law Department, Ministry of Trade and Investment; published in 2022; accessed on 10th July, 2022.

OECD (2010), "*Environmental and Eco-Innovation: Concepts, Evidence and Policies*"; online available at: https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=com/env/epoc/ctpa/cfa(2009)40/final"; accessed on 12th July 2022.

Aloplex Management Consulting (2013), "*Aloplex on Innovation*", online available at: https://alopexoninnovation.com/2013/09/10/innovation-diffusion-from-university-rd/; accessed on 12th July 2022.

The Guardian (2022), "*NCC rallies academia, others for commercialisation of indigenous technologies*"; online available at: https://guardian.ng/news/ncc-rallies-academia-others-for-commercialisation-of-indigenous-technologies/; author: Adeyemi Adepetun; published on 4th August,2022; accessed on 5th August, 2022.

NCC (2018), "*NCC holds Roundtable Interaction with Academia, Industry and other Stakeholders in Kano*"; online available at: https://ncc.gov.ng/media-centre/news-headlines/437-ncc-holds-roundtable-interaction-with-academia-industry-and-other-stakeholders-in-kano-2; published on 24th October, 2022; accessed on 5th August, 2022.

New Telegraph (2022), "*NOTAP Seeks Commercialization of Local Inventions*"; online available at: https://www.newtelegraphng.com/notap-seeks-commercialisation-of-local-inventions/; published on 5th July 2022; accessed on 15th July 2022.

The Cable (2021), "*NCC partners with SMEDAN to establish digital academy for entrepreneurs*", online available at: https://www.thecable.ng/ncc-partners-with-smedan-to-establish-digital-academy-for-entrepreneurs; published on: 18th December 2021; author: Busola Aro; accessed on 5th August 2021.

Appendix

Appendix A: Interview Questions

1. Key Interview Questions for Lead Researchers in Tertiary Institutions

1. What telecoms-based research area is your research on?
2. What problems will it solve when rolled-out?
3. What are the impacts of your research within your tertiary institution community?
4. What is the status of the project?
5. What challenges did you encounter (or are you encountering) in your implementation?
6. What challenges do you envisage will occur at the commercialization stage of your innovation?
7. How best can innovation outputs be commercialized in Nigeria?
8. What are the bottlenecks in your research with respect to access to funding?
9. In what ways can the fund allocation, disbursement and beneficiary access be improved?
10. Are you collaborating with any other party such as technology research companies, research institutes, industry association, other researchers etc for your research?
11. If yes in SN 10 above, in what ways are you collaborating with them?
12. What other ICT-based research grants are you aware of?
13. In what ways can NCC improve the telecommunications-based research innovations programme?
14. What are the legal risks associated with the current practice of delivery of research grants in Nigeria?
15. How can these legal risks in SN 14 above be addressed?

2. Key Interview Questions for Research Fund Administrators in Tertiary Institutions

1. What are the challenges encountered in research fund administration in your institution?
2. Are there any bottlenecks with accessing grant-funds from NCC?
3. If yes in SN 2 above, what are the challenges?
4. What are the challenges with funds disbursement to lead researchers?
5. Are there similar ICT-based research projects being sponsored by other donors in your institution?
6. If yes in SN 5 above, who are the donors and what are the projects?
7. What are the impacts of the sponsored research within your tertiary institution community?
8. What are the benefits of these grants to your institution and the telecommunications industry?
9. In what ways can NCC improve the telecommunications-based research innovations programme?
10. In what ways can the fund allocation, disbursement and beneficiary access be improved?
11. What are the legal risks associated with the current practice of delivery of research grants in Nigeria?
12. How can these legal risks in SN 11 above be addressed?

3. Key Interview Questions for Departments in NCC

1. Are the innovation outputs meeting the desired objectives of the programme?
2. In what ways can we ensure the commercialization of telecommunications-based research innovations outputs in Nigeria?
3. What are the benefits of telecommunications-based and ICT-based research innovations projects to the industry and Nigeria at large?
4. How can ICT-based research innovations support the digital economy agenda in Nigeria?
5. How can more stakeholders' involvement be encouraged in ICT-based research innovations?
6. What are the legal risks associated with the current practice of delivery of research grants in Nigeria?
7. In what ways can NCC improve the telecommunications-based research innovations programme?

4. Key Interview Questions for Other Stakeholders in the Research Innovations Ecosystem

1. What are the benefits of telecommunications and ICT-based research innovations projects in Nigeria?
2. How can ICT-based research innovations support the Digital economy agenda in Nigeria?
3. In what ways can government and private sector promote and support innovation in Nigeria?
4. In what ways can we ensure commercialization of research innovations outputs in Nigeria?
5. How can more stakeholders' involvement be encouraged in ICT-based research innovations?
6. How can collaboration be promoted in ICT-based research innovations?
7. What are the legal risks associated with the current practice of delivery of research grants in Nigeria?
8. How can these legal risks in SN 7 above be addressed?

Appendix B: List of Research Projects (2015 – 2020)

Institution Name, Research Project, Year of Award and Phase

SN	Institution Name	Research Project	Year	Phase
1.	University of Maiduguri, Borno state	Development & Implementation of Multiple Noise Attenuation Device for Mobile Telephony End Users	2015	Phase 1
2.	Nigerian Air force Institute of Technology, Kaduna State	Design and Construction of a Power Line Communication Modem for Domestic LAN	2018	Phase 2
3.	Elizade University, Ondo State	GSM-Based Smart Energy Meter	2018	Phase 2
4.	Ahmadu Bello University, Zaria, Kaduna State	Development of Wearable E-Band Tracking system	2018	Phase 2
5.	Ahmadu Bello University, Zaria, Kaduna State	Design, Fabrication, Experimental Characterisation of Plastic Optical Fibre cable and the exploitation of its potentials in Nigeria Telecommunications Industry	2018	Phase 2
6.	Covenant University, Ota Ogun State	Development of low–cost GSM System for Rural Areas	2018	Phase 2
7.	Abubakar Tafawa Balewa University, Bauchi State	Design & Construction of customer identification system by their voices in telecoms industry	2018	Phase 2
8.	Enugu State University of Science and Technology, Enugu State	Development of a Home-Grown Electrical Power Charger for cell phones from cooking heat	2018	Phase 2
9.	Obafemi Awolowo University, Ife, Osun State	Development of wireless Communication Based vehicle crash detection and reporting system	2018	Phase 2
10.	University of Port Harcourt, Rivers State	Design and Construction of 1 to 10GHz Anechoic Chamber for 3G,4G and Future 5G antenna measurement	2018	Phase 2
11.	University of Nigeria Nsukka, Enugu State.	Chemically engineered and safe organic-inorganic hybrid perovskites as optical gain media	2018	Phase 3
12.	University of Lagos	Development of a Smart Repeater cell for Rural Broadband penetration in Nigeria	2018	Phase 3
13.	Ahmadu Bello University, Zaria, Kaduna State	Design and Development of Transition Avoidance Wireless Communications system for enhanced spectral Efficiency	2018	Phase 3
14.	Federal University of Technology Akure, Ondo State	Development of a Bi-Directional, Multilingual Speech to Speech translation System Communication	2018	Phase 3
15.	University of Ibadan, Oyo State	Development of secure prototype and framework for data harvester and monitoring system to secure large farmlands	2018	Phase 3
16.	University of Jos, Plateau State	Vital Signs Monitoring Using Sparse Representation Based on Smart Phone Video Camera	2018	Phase 3
17.	Abubakar Tafawa Balewa University, Bauchi State	Implementation of Low-Cost 5Kw Microwave oscillator for 0.9 to 8GHz	2018	Phase 3
18.	Bayero University Kano, Kano State	Design, Simulation and Fabrication of Millimetre Wave (MM-WAVE) Antenna for Next Generation Mobile Communication Networks	2018	Phase 3

19.	Federal University of Technology, Minna, Niger State	Fabrication of intelligent wireless mobile Phone Battery Charger	2018	Phase 3
20.	University of Port Harcourt, Rivers State	Mobile Broadband Mapping of Major Urban Centres in South-South Nigeria	2018	Phase 3
21.	Ahmadu Bello University, Zaria, Kaduna State	Neuroendocrine and metabolic Studies of Mobile Phone Radiation	2018	Phase 3
22.	University of Abuja, FCT	Design and Fabrication of Wireless Power Transmission through Resonant Coupling for Charging Small CPES	2019	Phase 4
23.	Federal University of Technology Akure, Ondo State. (Mobile Network Group)	Subscriber Participating approach to Data and Voice Services Analysis provided by Mobile Network operations.	2019	Phase 4
24.	Abubakar Tafawa Balewa University, Bauchi State	Design and Development of a Prototype High Gain Metamaterial MIMO Antenna Array for wireless Communications Systems and Energy Harvesting in Urban and Rural Areas.	2019	Phase 4
25.	Kano State Polytechnic Kano State (Department of Mechanical Engineering, School of Technology)	Design and Construction of Environmentally Friendly Paper Battery for Mobile Phones and Communication Devices.	2019	Phase 4
26.	Akwa Ibom State University, Akwa Ibom	Development of Infrastructure for Independent Measurement of Mobile Broadband Penetration in Nigeria.	2019	Phase 4
27.	Enugu State University of Science & Technology, Enugu State	Development of all-weather solar system for energy optimization in a mobile communication-based station	2020	Phase 5
28.	Taraba State University, Jalingo, Taraba State	Design and Fabrication of Metamaterial Inspired UWB/ MIMO Antenna for 5G sub 6GHz Applications	2020	Phase 5
29.	Obafemi Awolowo University, Ife, Osun State	Weather WAN: A Wide Area Network of Low-Cost IoT – Compliant Weather Stations	2020	Phase 5
30.	Gombe State University, Gombe, Gombe State	Intelligent and Autonomous Multi-UAVs (Multiple Drones) Swarm Monitoring for Effective Surveillance and Situation Awareness in the Nigerian Telecommunications Industry	2020	Phase 5
31.	Nigerian Air Force Institute of Technology, Kaduna State	Development of Intelligent Cognitive Smart Engine for Quality of Service Management in 5G Network	2020	Phase 5

Summary by Institution Name, Number of Projects, State and Geo-political Zone

SN	Institution Name	Number of Projects	State	Geo-Political Zone
1.	Federal University of Technology, Minna	1	Niger	North Central
2.	University of Abuja	1	FCT	
3.	University of Jos	1	Plateau	
4.	Abubakar Tafawa Balewa University	3	Bauchi	North East
5.	University of Maiduguri	1	Borno	
6.	Gombe State University	1	Gombe	
7.	Taraba State University	1	Taraba	
8.	Ahmadu Bello University	4	Kaduna	North West
9.	Nigerian Air force Institute of Technology, Kaduna	2	Kaduna	
10.	Bayero University Kano	1	Kano	
11.	Kano State Polytechnic	1	Kano	
12.	University of Nigeria Nsukka	1	Enugu	South East
13.	Enugu State University of Science & Technology	2	Enugu	
14.	University of Port Harcourt	2	Rivers	South-South
15.	Akwa Ibom State University	1	Akwa Ibom	
16.	Obafemi Awolowo University	2	Osun	South West
17.	University of Lagos	1	Lagos	
18.	University of Ibadan	1	Oyo	
19.	Covenant University	1	Ogun	
20.	Elizade University	1	Ondo	
21.	Federal University of Technology Akure	2	Ondo	
	Total	**31**		

Appendix C: Survey Questionnaire

Aim and Objectives:
To determine the level and impact of telecommunications-based research innovations in Nigerian tertiary institutions.

Target Respondents: Lead Researchers

SECTION A: Background Information

1. What is the name of your Institution? _____
2. Type of Institution:

   (1) Federal University (2) State University (3) Private University
   (4) College of Education (5) Polytechnic
   (6) Others (Military, Training Centre's, Specialized)

3. State of Location: _____
4. Title of your Research Innovations Project:
   _____
5. What is the Technology Area/Category?
   _____
6. What year was it awarded?
   (1) 2015 (2) 2016 (3)2017 (4)2018 (5)2019 (6)2020
7. What is the current status of the project?
   (1) Ongoing (2) Completed (3) Cancelled

SECTION B: Socio-Economic and Education Attributes of Respondent

8. What is your gender?
   (1) Male (2) Female
9. What is your age bracket in years as at your last birthday?
   (1) Below 18 (2) 18 -20 (3)21 – 25 (4)26 - 30 (5)31 - 35 (6)36 - 40
   (7) 41 - 45 (8) 46 -50 (9)51 – 55 (10)56 - 60 (11)61 - 65 (12) Above 65
10. What is your marital status?
    (1) Single (Never Married) (2) Married (Monogamous) (3) Married (Polygamous)
    (4) Informal/Loose Union (5) Divorced (6) Separated
11. What is your area of discipline/expertise?
    _____
12. What is your highest level of qualification?
    (1) HND (2) Bachelors (3) PgD (4) Masters (5) PhD
13. What is your length of service in years?
    (1) Less than 5 (2) 6 – 10 (3) 11 – 15 (4) 16 – 20 (5) 21 – 25
    (6) 26 – 30 (7) Above 30
14. What is your monthly salary range?
    (1) below N100,000 (2) N100,000 – N199,999 (3)N200,000 – N299,999
    (4) N300,000 – N399,999 (5) N400,000 – N499,999 (6) N500,000 – N599,999
    (7) N600,000 and above

SECTION C: Level (Research Areas and Collaborations) of Telecommunications-based Innovation Research

	Question	YES	NO
15.	Are you collaborating with other individuals who are researchers in the telecommunications industry for your project?		
16.	Are you collaborating with any domestic research institution for your project?		
17.	Are you collaborating with any international research institution for your project?		
18.	Is/Was your research innovation area on any of the new and emerging technologies?		
19.	Has/Did your research inspire you to publish any technical paper?		
20.	Has the intellectual property in the innovation been protected in the course of this research?		
21.	Are you aware of other ICT-based research innovations programmes in Nigerian tertiary institutions being sponsored by indigenous donors?		
22.	Are you aware of other ICT-based research innovations programmes in Nigerian tertiary institutions being sponsored by foreign donors?		

SECTION D: Impacts (Effectiveness and Efficiency) of Telecommunications-based Innovation Research

How do you agree with, share no opinion, or disagree with the following statements within your institution?

SN	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
23.	The research innovation programme has improved collaboration with other researchers and stakeholders in the telecommunications industry					
24.	The research innovation programme is closing the gap between the academia community and the telecommunications industry.					
25.	The research innovations programme is building indigenous capacity in tertiary institutions.					
26.	Funds appropriated are adequate to achieve the research objectives.					
27.	Access to funds is a major bottleneck in conducting the research innovation.					
28.	Access to ICT infrastructure is a major bottleneck in conducting the research innovation.					
29.	The research innovations programme has the potential of creating job opportunities in Nigeria.					
30.	The research innovations programme has the potential of attracting foreign investors.					
31.	The market exists to patronise the research innovations outputs when commercialized.					

SECTION E: Challenges and Recommendations

32. Which of these poses the biggest challenge to your research innovations? (select top 2)
    (1) Poor Basic Infrastructure (2) Inadequate Research Facilities
    (3) Access to Funds (4) Difficulty in finding Collaborators
    (5) Access to Specialized Components and Raw Materials
    (6) Technical-related Issues
    (7) Others (Please specify)

33. What stage of the research innovations fund administration process has the most bottleneck?
    (1) Funds Availability at NCC (2) Funds disbursement from NCC to the institution
    (3) Funds disbursement from the institution to researchers
    (4) Others (Please specify)

34. What do you consider/anticipate as the biggest barrier to commercializing your research output? (select top 2)
    (1) Lack of market information (2) Low market demand
    (3) Branding & Marketing (4) Funding & Investment
    (5) Lack of business expertise (6) Others (Please specify)

35. What are your recommendations with respect to improving the overall telecommunications-based research innovations programme sponsored by NCC?

Contact Us

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