

THE MANAGEMENT OF RESEARCH AND DEVELOPMENT (R&D) FOR COMMERCIALIZATION IN NIGERIA

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ABSTRACT

Effective management of R&D activities is crucial for wealth creation and national development. But at present the issues of commercialization of R&D outcomes have remained a mirage. Hence, this study aimed at investigating some of the factors that could affect the management of R&D results for commercialization. Three factors namely: implicit (X_1), explicit (X_2) and technology brokering factors (X_3) were examined for their impact on R&D management structure (Y) in Nigeria. A questionnaire was designed and used to collect data for the study. The data were grouped and analyzed using Multiple Regression Method. The result of Multiple Regression of R&D Management Structure (Y) on the three independent variables (X_1 , X_2 and X_3) affecting the management of R&D results for commercialization showed a significant R value of 0.973 and Coefficient of determination of 0.962. The multiple regression model is: $Y = 3.243 + 0.154 X_1 + 0.578 X_2 + 0.085X_3$. The study also identified that a significant relationship exists among implicit factors, explicit factors, technology brokering influences and R&D management structure. The study applied Regression for Categorical Data to ascertain the degree of importance of the factors that made up each variable. Therefore, the study finally suggests that policymakers prioritize appropriate and adequate investment on management of R&D results for commercialization towards building a strong, sound and viable economy.

Keywords: Research and Development, Management, Commercialization, Technology, Development and Economy.

INTRODUCTION

In most countries, the quality and quantity of Research and Development (R&D) results are recognized as pivotal in re-energizing national development and economic well being. In Nigeria, the utilization of research findings remained dormant for years, as the R&D results from our Ivory Towers are shelved in archival records. It is generally an accepted fact that a research result or an invention emanating from R&D has value only when it serves a purpose. This only comes through innovation. An R&D result or invention is only useful when it gets to a market, otherwise, it will remain on the shelf of learned journals. In this sense, an R&D result is purely

an intellectual artifact and shall so remain and be of no service to mankind until it is commercialized. Therefore, only when an invention or R&D result is capitalized, that is to say commercialized, does its importance become manifest by impacting on human life. The power of commercialization of R&D results has been recognized by developed and developing countries such as France, India, Denmark, Brazil, etc. long ago. Each established a national agency for the specific function of the commercialization of R&D results. The most prominent of such institutions are the Agence Nationale de Valorisation de la Recherche (ANVAR) in France, and the National Research and Development Cooperation (NRDC) in India.

In Nigeria, for instance, several factors have been suggested to account for the non-capitalization of R&D results, and these factors are as follows: Lack of awareness on existing R&D outcomes, lack of National Coordination of R&D activities/results thereby leading to duplication/dissipation of efforts, lack of linkages between Industry, University and Research Institutes, inadequate research funding, infrastructural problems, lack of critical mass of personnel and facilities thereby leading to weak institutional provisions, lack of enabling environment thereby leading to professional limitations of the researcher, poor patent culture thereby leading to lack of patent marketing, poor management of Intellectual Property Rights thereby leading to lack of motivation for research, weak Intellectual Property Rights (IPR) laws and enforcement, poor reward system and control, poor technological base prevalent in the country, low level of entrepreneurship, poor technology management, poor targeting of research and market orientation that have resulted in irrelevance of R&D results/inventions, poor quality assurance of local R&D results thereby making it unattractive to domestic industries, apathy of financial institutions towards commercialization of research results as it is considered a high risk venture, lack of confidence by venture capitalists thereby leading to low level of venture capital in financing commercialization, absence of a well-recognized financially strong and viable agency to promote and drive commercialization process, lack of a national policy that protects local products of R&D results and provides a strong marketing strategy, e.t.c. Perhaps, the single most important of these factors was the absence, before 1988, of a formal institutional framework of excellence for the management of commercialization of R&D results emanating from the public sector and private organizations. Despite the fact that there were over fifty (50) resource based research institutions in the country, the outcomes from research activities of these institutions have not been developed to the benefit of the national economy, because the developmental aspect of R&D has not received the right attention in the national development plan.

In a bid to resolve this hiccup, a Ministerial Consultative Committee on the commercialization of R&D results (MCCR), in Nigeria was set up in Uyo, Akwa Ibom State, on 15th August, 1997 to “examine and recommend means to facilitating an efficient and effective conversion of R&D results for industries to expatiate wealth creation in Nigeria”. Consequently, the National Office for Technology Acquisition and Promotion (NOTAP) was directed through the Honourable Minister of Science and Technology (FMST) to serve as a center of excellence during the last

quarter of 1998, and to “assume the implementation of commercialization of all R&D result emanating from Government Funded Projects” In recognition of the new mandate, NOTAP charted a new course and embarked on documentation and commercialization of indigenous novel R&D findings, inventions and innovations in all the Research Institutions, Universities, Polytechnics including Private Laboratories, workshops and novel R&D results in private organizations.

NOTAP is a technology brokerage organization that was established by Degree No. 70 of 1979 to implement the acquisition, promotion and development of technology and at the same time correct certain imperfections in the acquisition of foreign technology into the country. Hence, the management of R&D in the country is being anchored by no other organization (agency) than NOTAP; this is because the success achieved by any nation in exploiting R&D outcomes for growth and development depends on the effectiveness of the National Innovation System. National Innovation System (NIS) is the bedrock of R&D Management structure. It is imperative at this juncture to understand the activities and factors that are involved in the management of R&D. This is to enable the realization of viable and commercializable R&D results, with a view to highlighting R&D management structure which will be our dependent variable in this study. Hence, the management of R&D results for commercialization comprises activities such as:

- Technology brokering which involves the development of good research-industry linkage and adequate collaboration with national and international organizations concerned with the commercialization of R&D results for wealth creation. NCST (1997).
- Providing various support services like, dissemination of technology information to SMEs from patent document as a means of technology transfer to enhance R&D activities, promoting Intellectual Property Rights and innovation system through facilitations and payment of patent registration fees by the Federal Government of Nigeria.
- Establishing/strengthening of brokerage offices and Technology Transfer Offices (TTOs) such as the establishment of Intellectual Property/Technology Transfer Offices (IPTTOs) in major innovation-generating institutions in the country i.e. Universities, Polytechnics and Research Institutions for effective and efficient harnessing of R&D results as well as promoting incentive/reward systems for researchers, inventors and innovators. NCST (2007)
- Developing a compendium management system, which is a database of R&D results from tertiary institutions, public research institutes and private laboratories for coordinating, monitoring and managing of R&D in the country. NCST (1997)
- Producing industrial project profiles on patented indigenous products for investors/entrepreneurial and promoting entrepreneurial culture within the institutions. NCST (2007).

From the foregoing, it pertinent to state that effective management of R&D is crucial to national development. In other to locate the present discussion properly, below are the implied definitions of implicit and explicit factors:

- ❖ *Implicit factors are those factors that inherently affect R&D activities in generation of research results and innovations, namely: Funding, Infrastructure, Equipment, Research Personnel, Technology information, Existing R&D results and Reward system.*
- ❖ *Explicit factors are those factors that should be promotional to the generated R&D results towards commercialization, and they include the following: Linkages, Quality assurance, IPR system, Entrepreneurship, Investments, Investors confidence and Marketing strategy.*

Objective of the Study

The aim of this study is to overcome some of the problems hindering successful management of R&D results for commercialization. The objectives of this study are:

- i. To investigate all the implicit and explicit factors that inhibits the commercialization of R&D outcome.
- ii. To examine how technology brokering will leverage the commercialization of R&D outcomes and other inventions.
- iii. To identify the factors that can affect the management of R&D results for commercialization.
- iv. To test the significance of these factors on the management of R&D results.
- v. To make recommendations based on the findings that could enhance the management of R&D activities in Nigeria.

Research Questions

This write up will attempt to proffer answers to the questions that are pertinent to this study:

- (i) What is the impact of implicit factors on the commercialization of R&D outcome and other inventions?
- (ii) What is the impact of explicit factors on the commercialization of R&D outcome and other inventions?
- (iii) What is the effect of technology brokering activities in leveraging the commercialization of R&D outcome and other inventions?

Research Hypothesis

- (i) Hypothesis I
The factors are significant in the R&D management structure for commercialization or not.
- (ii) Hypothesis II

Each of these factors has significant impact on the R&D management structure for commercialization or not.

LITERATURE REVIEW

It is a known fact that Nigeria is endowed with vast resources: human, agriculture, mineral, to mention just a few, which if optimally harnessed can re-position the nation to be amongst the high-ranking industrialized nations of the world (NOTAP, 2008). Okongwu, (2007) opined that there is no country in the world that is so blessed with more resources than Nigeria. In spite of this, Nigeria, after 50 years of independence is still classified among the third world countries. This is not surprising because development comes through research as rightly put by Waiter (1972) thus: "A society develops economically as its members increase jointly their capacity for dealing with the environment. This capacity for dealing with the environment is dependent on the extent to which they understand (through research) the laws of nature (science), and on the extent to which they put that understanding into practice by devising tools (technology) and on the manner in which work is organised". This statement clearly shows that research is central to development. Research and Development (R&D) in Nigeria has little or nothing to show considering the resource base of the country. The root cause of this failure can be traced to many problems facing research activities in Nigeria.

Challenges of R&D Procurement

Before one can speak of the commercial exploitation of R&D results, such results must of course be available, and capable of being exploited. According to Briggs, (2002) a number of factors affect availability of R&D results, and consequently its role in national development. Among others, include the following:

- (a). Funding of Research,
- (b). Level of Entrepreneurship in the nation,
- (c). Absence of demand-pull approach in project selection,
- (d). Search for technical excellence at the cost of commercial reality,
- (e). Mismatch of objectives and interests of R&D institutes and corporate objectives,
- (f). Technological gaps between R&D institutes and firms,
- (g). Time-lags in transfer,
- (h). Lack or loss of credibility of R&D institutes,
- (i). Lack of sustained follow-up,
- (j). Transformation of overseas educated elite into desk managers of R&D,
- (k). Expectation for too quick results without sustained efforts,
- (l). Lack of an integrated approach,
- (m). Failure of government in providing technology infrastructure,
- (n). Lack of autonomy given to the research institutes and industry, etc.

Problems Facing Promotion of Technology Innovations

A study of Nigeria's Tertiary/Research Institutions by NOTAP (2008) has shown that the greatest constraints to the generation and exploitation of viable innovations in these institutions are:

- a. The non-existence of appropriate incentives/Reward Systems
- b. Poor intellectual property culture
- c. Lack of support structure for taking innovation to the market place i.e. commercialization of innovation
- d. Poor research-industry linkage and
- e. Absence of a system or structure for auditing research and generating wealthy industries and jobs from research activities.

Problems and Constraints of R&D Activities in Nigeria

The problems militating against the growth and effectiveness of R&D activities in Nigeria are multifaceted. They have been highlighted in many publications according to Adewoye (2007) and some of them are highlighted below.

- a. Lack of adequate funding
- b. Poor Power and Utilities Supply
- c. Lack of adequate infrastructure Lack of Private Sector Participation
- d. Inconsistent Government Policies
- e. Unfair Competition by Imported Products
- f. Use of Outdated Technologies for R&D activities
- g. Lack of Accurate and Relevant Data Base
- h. Lack of Research and Development Equipment
- i. Lack of Emphasis on Dual Use of Technologies
- j. Lack of Collaboration with Civil R&D and Industrial Complexes
- k. Lack of enabling environment
- m. Brain Drain.

Technology Brokering

The idea of technology brokering is to span multiple, otherwise disconnected industries, to see how existing technologies could be used to create breakthrough innovations in other markets. Technology brokering requires companies to be strong in two areas (Hargadon, 2003). As Andrew Hargadon, technology brokering's founder, summarized: "Firstly, the company must have the ability to bridge distant communities, usually when a company can move easily across a range of different markets they have a better view of how technologies can be used in new ways. Secondly, technology brokering involves creating new markets and industries based around innovative combinations of existing technology. These two strengths are difficult to have simultaneously because the strong ties the companies have with customers and supplies in one industry prevent the company from moving easily into other markets and experimenting with new ideas" (Hargadon, 2003). Yet, when a company is able to combine these two strengths it can result in being the first to experience technological advances. Technology brokering can teach firms how to effectively shift the focus of traditional R&D teams from trying to invent completely new products to combining previous innovations. New ideas for observation based

research pulls R&D scientists out of the laboratory and places them into direct consumer observation allowing them to diagnose problems with products and identify the needs of the customer more accurately (Hargadon, 2003).

Technology brokering activities are very essential for successful commercialization of R&D results and innovations, since, it is the bedrock onto which commercialization stands. Hence, the following are ways in which technology brokering promotes R&D activities and leverages commercialization:

- a. It justifies time, efforts, funds committed to research,
- b. It spurs industrialization,
- c. It breeds inventiveness,
- d. It creates investment opportunities,
- e. It enhances company technological capability/competitiveness,
- f. It makes research more demand-driven,
- g. It promotes marketing of R&D outcomes, etc (Okongwu, 2007).

Commercialization

Commercialization of technology involves any possible configuration or scheme that allows those who invest in technological innovation (inventors, research systems, private firms and others) to capture some of the economic benefits generated by their innovation. Patent licensing, research grants and contracts, R&D joint ventures, and technical services for a fee, are all examples of commercialization schemes. (Kalaitzandonakes, 1997) However, technology commercialization is a process of moving research results from a research environment to a successfully marketable product. Commercialization is often thought of as an orderly series of steps, i.e. defining a product (or process), building a prototype and testing its feasibility, completing product development and design, starting a production phase and finally passing the manufactured product to the marketing and sales department. This is certainly not a sequential and orderly path, rather it is slow and an expensive business. The ability to commercialize technology; to move a technology from concept to market quickly and efficiently is crucial in the light of changes in the business environment. Included among these new familiar trends is the increasing proliferation of technologies and the speed with which they render the previous technologies obsolete. Empirical evidence is numerous and indicates the ever shortening of life cycles of products and processes.

Major sponsors of research in developing countries are usually the government itself. The government spending on R&D is of the order of about 90% for most of the developing counties. In comparison, the same is around 40% for many developed countries (OECD, 1999). Ironically, R&D institutes in developing counties have not been able to meet the expectations of either the industry or the policy planners.

Commercialization Process

Today's marketplace experiences an intensification and rapid change of competition in the market (Bower, 1993; Aijo, 1996; Cartwright, 2000), fostered by factors such as globalization

Gummesson, (2002), the maturing of domestic markets and rapid technological change. Palmer (2002). These characteristics of today's marketplace have implications for the market players. Firstly, companies are confronted with an intense pressure to advance knowledge and develop new products, technologies and processes to be successful in today's marketplace. Gupta and Wilemon, (2000) stated that "companies cannot become world-class innovators on their own. For continuous innovation, they must develop linkages with other firms and institutions that will spur them on to better performance. Benefits for companies from innovation-oriented collaborations have also been emphasized by other authors, including advantages such as a significant higher number of patents. George and Zahra (2002).

Secondly, as a result of increased national and international competition and cuts in government funding, research institutions are urged more and more to find new ways to generate income (Montgomery, 1992; Australian Research Council, 2001). At universities, the potential funding from student's fees is restricted. Hence, the commercialization of research has become a topic of major interest in the university environment, as it offers an opportunity for increased funding. In addition, the commercialization of research applied to industry problems offers the test of theories, George and Zahra (2002), opportunities for knowledge creation (Cyert and Goodman, 1997), the enhancement of career opportunities and improved facilities (Harmann, 2001)

Thirdly, government has an interest in promoting successful relationships between research institutions and industries, which can be explained by the fact that knowledge based on research is seen as key factor to the future success of society and the economy. Research enables the innovations that have become key drivers of economic performance (OECD, 1991). Hence, governments of many developed countries make major efforts to encourage university-industry research partnerships to stimulate the nation's participation and competitiveness in a global environment (OECD, 1991).

Based on these market conditions, companies and governmental research tasks are increasingly outsourced to specialized research institutions, leading to a raised relevance, increase in number and intensity of contact between these institutions (OECD, 1991), and the government. In accordance with this increase, literatures in this area multiplies rapidly with a large amount of research focusing on technology transfer as well as research commercialization and management on the university's side (Montgomery, 1992; Graff and Heiman, 2002) as well as innovation and research and development (R&D thereafter) management on the industry's side (Desphandé and Farley, 1993; Griffin and Hauser, 1996; Gupta and Wilemon, 2000). Despite the increasing outsourcing of research tasks and interest in the area of research commercialization and cooperation, so far, most authors approach the area from a financial or operational view. Few authors considered the use of marketing principles for the commercialization of research. This is surprising, as marketing is an established field applied for all product and service markets around the world.

Research Gap

From the foregoing, it is pertinent to state that there are many factors hindering successful commercialization of R&D results, thereby leading to ineffective management of R&D activities. Also, that technology brokering factors could promote and leverage commercialization thereby enhancing proper management of R&D activities for commercialization. For the purpose of this study, the factors that hinder commercialization are grouped into implicit and explicit, earlier defined in the course of this study.

RESEARCH METHODOLOGY

The data in this study were collected from (1) National Office for Technology Acquisition and Promotion, Abuja; (2) Raw Materials Research and Development Council, Abuja; (3) Small and Medium Enterprises Development Agency of Nigeria, Abuja; (4) Projects Development Institute, Enugu; (5) Scientific Equipment Development Institute, Enugu; (6) National Biotechnology Development Agency, Abuja and (7) National Institute for Pharmaceutical Research and Development, Abuja. The population under study consists of technical staff involved in R&D activities. This is due to the in depth involvement and experience of these staff in the subject under study. A randomly selected sample of employees was chosen to participate in the study. These individuals render different services in the management of R&D results for commercialization.

A questionnaire was designed and used to collect data for the study involving three independent variables – **implicit factors (X_1)**:- Funding, Infrastructures, Equipments, Research personnel, Technology information, Existing R&D results and Reward system, and these are covered by questions 1 - 7; **explicit factors (X_2)**:- Linkages, Quality assurance, IPR system, Entrepreneurship, Investments, Investors confidence and Marketing strategy, and these are covered by questions 8 - 14; **technology brokering activities (X_3)**:- R&D promotion and marketing, Justification of activities, Industrialization, Inventiveness, Investment opportunities, Capability and Demand, and these are covered by questions 15 – 21; a dependent variable – **R&D management structure (Y)**:- Functional R&D system, Monitoring R&D efforts, R&D Technical review, Human resources, R&D Utility, Research products dispersion and Nigerian Innovative System, and these are covered by questions 22 – 28, in commercialising research outcomes. The questionnaire was a closed type designed on the five point responses format, ranging from strongly agree to strongly disagree.

Respondents were presented with statements to which they are expected to express the degree of their agreement or disagreement. A score of four (4) points was assigned to strongly agree, and 3, 2, 1, 0, respectively to agree, neutral, disagree and strongly disagree.

The questionnaire contained a set of seven statements for each of the three independent variables and the dependent variable. A total of one hundred (100) questionnaires were produced and sent out while ninety three (93) were retrieved and used for the study.

Table 1: Questionnaire spread and response

S/N	ORGANISATION	SPREAD	RESPONSE/COLLECTION
1	NOTAP, ABUJA	20	20
2	RMRDC, ABUJA	20	19
3	SMEDAN, ABUJA	10	9
4	PRODA, ENUGU	10	8
5	SEDI, ENUGU	15	15
6	NBDA, ABUJA	10	9
7	NIPRD, ABUJA	15	13
TOTAL		100	93

However, the choice of the above seven (7) organizations are based on their different approach and role that encompasses the issues involved in R&D management in Nigeria through commercialisation and technology brokering activities.

Method of Analysis

The data collected for this study were presented in tabular form before carrying out a regression analysis of the dependant variable on the independent variables.

Multiple regression model is one in which there are two or more independent variables. The aim is to examine the relationship between R&D management structure in commercialising research outcomes and the factors that are associated with it.

The estimated model describing the relationship between the dependant variable ‘Y’, and a set of three independent variables X_{1i} to X_{3i} can be expressed as:

$$Y_i = B_0 + B_1X_{i1} + B_2X_{i2} + B_3X_{i3} + e_i \quad \text{--- (1)}$$

For $i = 1, 2 \dots n$

Where $n =$ number of observations in both y and x

$Y_i =$ R&D management structure in commercialising research outcomes

$X_{i1} =$ Implicit factors

$X_{i2} =$ Explicit factors

$X_{i3} =$ Technology Brokering activities

$B_0, B_1, B_2, B_3 =$ The unknown parameter being estimated with B_0 the intercept and $B_1, B_2,$ and B_3 giving the regression co-efficient, $e_i =$ normally distributed error term

Text of Significance and Decision Rule

F – test was conducted to test the existence of a significant relationship between the dependent and independent variable. This was done by comparing the Fcal value with the significance F = value obtained using SPSS 15.0 (Statistical Package for Social Sciences).

The null hypothesis (Ho) is accepted if the F-cal Value is less than the significance F value otherwise (Ho) is rejected in favour of the alternative (Ha).

The t – test for multiple regression coefficient.

If the F – test above shows a significant relationship between the dependent and independent variable, we proceed to examine the regression coefficient further and to test more hypotheses about them. The test statistics to be employed here is the t – test. The null hypothesis (Ho) is rejected at 5% level of significance if the P value (probability value) associated with each of the X – variables is less than 0.05 and conclude that the variable has a significant effect on Y.

Coefficient of multiple determination

Finally, the coefficient of multiple determination was considered which measures the proportion of the total variation in the dependent variable Y that is attributable to the dependence of Y on all the independent variable in the regression.

RESULTS AND DISCUSSION

The individual scores of the respondents on their assessment of the three independent variables (X₁ to X₃) and the dependent variable (Y) are presented in table 4. Tables 2. and 3. shows how table 4. was formed by analyzing the scores of respondent 1.

TABLE 2.: Respondent 1 scores for X₁ to X₃

Independent Variables	Groups	Questionnaire Analysis								Total
		Questions	1	2	3	4	5	6	7	
X ₁	1 – 7	Scores	1	0	0	4	3	4	1	13
		Questions	8	9	10	11	12	13	14	
X ₂	8 – 14	Scores	0	4	1	3	4	2	0	14
		Questions	15	16	17	18	19	20	21	
X ₃	15 – 21	Scores	2	4	4	4	4	4	1	23
		Questions								

TABLE .3: Respondent 1 scores to Y

Dependent Variable	Group	Questionnaire Analysis								Total
		Questions	22	23	24	25	26	27	28	
Y	22 – 28	Scores	1	4	4	4	0	1	3	17
		Questions								

Hundred questionnaires were distributed for study. Out of this number, ninety-three were returned and this formed the basis for the analysis. The responses presented are from the session B part of the questionnaire.

Table 4.: Individual Responses

Respondents	X₁	X₂	X₃	Y
1	13	14	23	17
2	13	14	20	9
3	12	13	19	16
4	21	17	23	15
5	18	7	16	14
6	5	9	22	8
7	16	11	19	11
8	11	9	20	7
9	18	20	25	18
10	4	11	20	19
11	15	17	22	21
12	15	13	22	18
13	16	16	27	15
14	12	4	21	3
15	12	14	23	19
16	7	15	22	10
17	7	13	22	8
18	10	16	21	17
19	12	14	27	17
20	9	7	11	10
21	8	4	22	6
22	18	17	21	18
23	14	16	22	16
24	14	16	21	12
25	14	11	22	13
26	11	11	20	9
27	17	11	15	15
28	13	9	26	14
29	8	11	21	13
30	8	21	28	16
31	10	11	21	13
32	7	6	25	7
33	16	14	28	10
34	13	13	19	14
35	13	11	26	12
36	6	4	17	3
37	6	10	22	10

38	13	17	21	13
39	9	15	19	18
40	15	10	18	12
41	7	13	16	14
42	14	12	26	16
43	15	11	27	17
44	5	5	24	17
45	16	17	14	13
46	7	9	21	14
47	11	14	18	15
48	13	14	23	16
49	18	17	27	21
50	18	20	23	25
51	15	19	26	26
52	18	14	23	17
53	15	13	24	20
54	13	15	25	11
55	20	13	22	19
56	19	15	24	20
57	19	12	22	11
58	10	13	21	18
59	8	12	21	16
60	21	11	28	20
61	5	13	24	17
62	13	13	25	5
63	20	23	23	17
64	13	21	20	21
65	9	13	21	16
66	13	16	18	24
67	12	16	21	16
68	16	17	27	20
69	12	22	18	23
70	20	18	25	21
71	15	22	24	14
72	17	15	18	20
73	19	15	20	16
74	19	18	18	17
75	7	14	20	14
76	22	21	20	19

77	22	18	17	18
78	14	12	15	16
79	20	12	18	20
80	5	6	27	9
81	11	10	25	17
82	9	13	20	12
83	21	19	20	20
84	21	19	13	18
85	23	15	19	17
86	12	18	23	17
87	19	17	19	16
88	18	16	21	14
89	19	16	21	16
90	21	14	19	17
91	20	16	18	12
92	18	13	19	16
93	13	11	23	13

DATA ANALYSIS

Regression Analysis

The Regression of R&D Management Structure (Y) on the three independent variables (X₁, X₂ and X₃) affecting the management of R&D results for commercialization.

Table .5 comprising of Model Summary, ANOVA and Coefficients - Results of multiple regression analysis carried out using SPSS (Statistical Package for Social Sciences):

Model Summary

a)

Multiple R	R Square	Std. Error of the Estimate
0.973	0.962	3.027

Dependent Variable: Y1

Predictors: X1, X2, X3

ANOVA(b)

b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1830.283	3	610.094	19.187	.000(a)
	Residual	2829.933	89	31.797		
	Total	4660.216	92			

a Predictors: (Constant), X3, X2, X1

b Dependent Variable: Y1

Coefficients(a)

c)

Model		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	3.243	2.723	1.191	0.237
	X1	0.154	0.090	1.715	0.090
	X2	0.578	0.105	5.489	0.000
	X3	0.085	0.109	0.784	0.435

a Dependent Variable: Y1

The results from table 5.a, b, and c, can be used to explain the degree of dependence of management of R&D Structure (Y) on the independent variables in the test of hypothesis as well as the test of individual contribution of these independent variables in the t – test.

Test of Hypothesis

H₀: The combined effect of X₁, X₂ and X₃ on Y is not significant

Test of Hypothesis I

To test the significance of the inclusion of all the independent variables in the model, the hypothesis is formulated:

H₀: b₁ = b₂ = b₃ = b₄ = 0

TEST STATISTICS

The test statistic for the hypothesis is the F-test shown in the ANOVA Table 5.a. From the table, we have F_{cal} = 19.187 with significances F of 0.000 and F_{tabulated} = 2.70.

Hence, F_{cal} = 19.187 > 2.70 = F_{tab}

Decision Rule

We reject H₀ (=accept H_A) at 5% level of Significance if significance F is less than 0.05 and F_{cal} = 19.187 > 2.70 = F_{tab}.

From table 5.b and c, the significance F value of 0.000 is less than 0.05. Thus, we reject H₀ (= accept H_A) at 5% level of significance. This means that the combined effect of X₁, X₂ and X₃ on Y is significant at 5% level. Thus, we can model Y on X₁, X₂ and X₃.

The multiple regression model is:

$$Y = 3.243 + 0.154 X_1 + 0.578 X_2 + 0.085X_3$$

The above equation can always be used to estimate Y for any given values of X₁, X₂ and X₃.

Also, the R value of 0.973 indicates that there is strong positive relationship between the Xs and Y, more so, R² value of 0.962 shows that about 96.2% of the variations in Y are explained by variations in the Xs.

Furthermore, the fact that the combined effect of X₁, X₂ and X₃ on Y is significant does not mean that all the three X-variables affect Y. To investigate the marginal or individual effect of the X-variables, the t- test was carried out.

Test of Hypothesis II

To Test the Significance of each of the independent variables in the model. We formulate the following hypotheses.

$$H_{01}: b_1 = 0$$

Implicit factors have no significant effect on R&D Management Structure for commercialization.

$$H_{02}: b_2 = 0$$

Explicit factors have no significant effect on R&D Management structure for commercialization.

$$H_{03}: b_3 = 0$$

Technology brokering influence has no significant effect on R&D management structure for commercialization.

Test Statistics

The test statistics for the above stated hypothesis is the t-test as shown in the computer printout (table 5.). The t-cal (that is tstat) and probability values (P-value) are shown in the print-out. However, from the table, $t\text{-tab} = 1.9730$.

Decision Rule

We reject H_0 at 5% level of Significance if the P-value associated with each of the X variable is less than 0.05 and conclude that the variable has a significant effect on Y.

Thus from the table 5, we discover that P-value of 0.000 associated with X_2 is less than 0.05 and $t\text{-cal} = 5.489 > 1.9730 = t\text{-tab}$.

Hence, the marginal effect of X_2 on Y is significant at 5%. The P- values of 0.090, 0.4350 associated with X_1 and X_3 respectively are more than 0.05 and the t-cal values of 1.715, 0.784 associated with X_1 and X_3 respectively are less than t-tab, thus we conclude that the marginal effect of X_1 and X_3 on Y are not significant in the model at 5%.

The result of the t-test has shown that the variable explicit factors have a significant impact on R&D management structure for commercialization. The variable has a marginal effect, represented by its Coefficient (see table 5.) on Y. The marginal effect of the independent variable shows the increase in the dependent variable Y, when that independent variable is increased by one unit while holding other variables constant.

In order to determine the type of linear relationship existing among the dependent and independent variables, a correlation test was conducted. It would be observed from this result that explicit factors has a strong positive linear relationship with R&D management structure followed by implicit factors and then technology brokering, each having a correlation value of 0.609, 0.419 and 0.077 respectively.

CATREG - Regression for Categorical Data (Optimal Scaling) of the factors that made up each variable

Regression for Categorical Data conducted on independent variables (X_1 , X_2 and X_3) and dependent variable (Y) to ascertain the degree of importance of the factors that made up a variable.

Table 6.: Regression for Categorical Data on X₁ (implicit factors)

Implicit factors	Correlation	
	Zero-Order	Importance
q1	0.663	0.179
q2	0.734	0.213
q3	0.658	0.177
q4	0.709	0.214
q5	0.123	0.025
q6	0.015	0.003
q7	0.652	0.189

Dependent Variable: X₁

For Implicit Factors (X₁), the degree of importance from highest to lowest is as follows: q4 = Research personnel, q2 = Infrastructures, q7 = Reward system, q1 = Funding, q3 = Equipments, q5 = Technology information and q6 = Existing R&D results with values of 0.214, 0.213, 0.189, 0.179, 0.177, 0.025 and 0.003 respectively. The values indicate that attention should be given to the factors starting first with Research personnel (0.214) down to Existing R&D results (0.003).

Table 7.: Regression for Categorical Data on X₂ (Explicit factors)

Explicit factors	Correlation	
	Zero-Order	Importance
q8	0.718	0.222
q9	0.678	0.199
q10	0.538	0.138
q11	0.650	0.193
q12	0.109	0.031
q13	0.471	0.102
q14	0.468	0.115

Dependent Variable: X₂

For Explicit Factors (X₂), the degree of importance from highest to lowest is as follows: q8 = Linkages, q9 = Quality assurance, q11 = Entrepreneurship, q10 = IPR system, q14 = Marketing strategy, q13 = Investors confidence and q12 = Investments with values of 0.222, 0.199, 0.193, 0.115, 0.138, 0.102 and 0.031 respectively. The values indicate that attention should be given to the factors starting first with Linkages (0.222) down to Investment (0.031).

Table 8.: Regression for Categorical Data on X₃ (Technology brokering)

	Correlation	
Technology brokering	Zero-Order	Importance
q15	0.513	0.120
q16	0.648	0.172
q17	0.765	0.164
q18	0.778	0.145
q19	0.766	0.139
q20	0.712	0.131
q21	0.568	0.128

Dependent Variable: X₃

For Technology Brokering (X₃), the degree of importance from highest to lowest is as follows: q16 = Justification of activities, q17 = Industrialization, q18 = Inventiveness, q19 = Investment opportunities, q20 = Capability, q21 = Demand and q15 = R&D promotion and marketing with values of 0.172, 0.164, 0.145, 0.139, 0.131, 0.128 and 0.120 respectively. The values indicate that attention should be given to the factors starting first with Justification of activities (0.172) down to R&D promotion and marketing (0.120).

Table 9.: Regression for Categorical Data on Y (R&D Management Structure)

	Correlation	
R&D Mgt. Structure	Zero-Order	Importance
q22	0.585	0.124
q23	0.706	0.174
q24	0.695	0.153
q25	0.662	0.137
q26	0.583	0.125
q27	0.598	0.129
q28	0.668	0.158

Dependent Variable: Y

For R&D Management Structure (Y), the degree of importance from highest to lowest is as follows: q23 = Monitoring R&D efforts, q28 = Nigerian Innovative System (NIS), q24 = R&D Technical review, q25 = Human resources, q27 = Research products dispersion, q26 = R&D Utility and q22 = Functional R&D system with values of 0.174, 0.158, 0.153, 0.137, 0.129, 0.125 and 0.124 respectively. The values indicate that attention should be given to the factors starting first with Monitoring R&D efforts (0.174) down to Functional R&D system (0.124)..

CONCLUSION

The effective management of R&D activities is crucial for wealth creation and national development. It is therefore important that efforts should be made aimed at encouraging successful management of R&D outcomes for commercialization.

To this end, this study tried to investigate some factors that affect the management of R&D outcomes for commercialization. Three factors namely: implicit, explicit and technology brokering were examined for their impact on R&D management structure in Nigeria.

A regression analysis of these factors on R&D management structure shows a combined significant effect at 5% level of significance. However, the T-test carried out showed that explicit factors were the factor that tested significant in the model at 5% level of significance. The factor also had a strong positive correlation with R&D management structure. Since, the findings of this study show that a significant relationship exists among implicit factors, explicit factors, technology brokering and R&D management structure, it is obvious that greater attention should be paid to these factors or their negligence may be detrimental to the expected commercialization of R&D outcomes and other inventions.

It is imperative that at the onset and within the course of the commercialization process, that measures should be taken towards leveraging commercialization of R&D outcomes and other inventions, as this will go a long way in enhancing the management of R&D results for commercialization in Nigeria.

RECOMMENDATION

With regards to the objective, scope, and findings of this study, it is recommended that the National Innovative System (NIS) should:

- (i) Make policies to encourage technology brokering activities in all research and related research institutes.
- (ii) Ensure that it brings together the right mix of quality technical resources to R&D activities.
- (iii) Provide an enabling environment conducive for innovative efforts in research and related research institutes.

It is also recommended that further studies be carried out in order to compare or generalize the findings of this work.

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