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Adoption Process of Agro-biotechnology Among Researchers in Nigerian Universities and Research Institutes: The Logistics Regression Approach

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Aims: Food insecurity in most developing countries was a result of their low/small scale of operation in farming enterprise resulting to low yields. To increase agricultural productivity, biotechnology has been considered as a strong potential to improve agricultural production. This paper examined the biotechnology adoption scenario in Nigeria from the viewpoint of academic researchers.
Study Design: A purposive sampling technique was adopted and the target population was limited to 100 academic biotechnology researchers.
Methodology: Eighty percent of the researchers came from Universities while 10per centeach was drawn from College of Agriculture and Institute of Agricultural Research respectively. Mean age was 44.5 years; mean teaching/research experience was 7.5 years. Logit model estimates for the study areas showed that the effect of the three independent variables: level of knowledge, level of acceptance and level of transfer of technology were statistically significant at 5% level.
Results: These findings' revealed that knowledge about an innovation is an indicator of the level of adoption. As the awareness of knowledge increases, it is more likely that there will be a corresponding increase in the level of adoption. The acceptance variable has a positive impact on the decision to adopt biotechnology.

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Conclusion: The results of this study indicated that the level of knowledge, acceptance and transfer of technology has direct effect on the level of adoption of biotechnology innovations. Therefore, there is need for policies that will streamline agro-biotechnology programme in a sustainable way for potential users.

Keywords: Starvation; acceptance; deficiency; awareness; agro-biotechnology; scholastic; society.

1. INTRODUCTION

Evidence abounds in past studies and literature that hunger and poverty are closely linked [1- 4]. Hunger is a result of lack of access to food (quality) to satisfy starvation. Poverty on the other hand has been hypothesized as lack of power to produce a desired result. Consequently, most farming households in developing countries lack the power to make enough provisions to meet food needs. Also, it has been documented that most African countries (25 African countries out of 38 worldwide) including Nigeria experience serious food emergencies [5]. The root causes of food shortages included natural disasters such as droughts, civil unrest and endemic diseases such as HIV/AIDS, malaria and tuberculosis. Others include economic constraints such as sharp declines in commodity prices, inefficient/insufficient policies, programmes and investments to increase agricultural productivity.

Past studies revealed that food insecurity in most developing countries was a result of their low/small scale of operation in farming enterprise resulting to low yields [6-8]. The low yield is attributable to low-level farm technology and productivity. In addition, there is predominance of the use of traditional technology, traditional tools and equipment, limited use of improved planting materials and fertilizer consumption. To improve low yields experienced by farmers, biotechnology has been advocated as a way of boosting agricultural production [9-11]. There is a school of thought that said introduction of biotechnology to agricultural production will improve the sector [12-14].

However, due to multitude of problems faced by farmers in developing countries, biotechnology may not completely solve the problem of low yield in agricultural production [9,15,16,17]. The problems of poor agricultural infrastructure, socio-economic barriers, lack of farm management skills and the degradation of natural resources still need to be tackled [1,18]. The challenge of increasing farm-level production in a sustainable manner (environmentally, economically and socially) is a very complex one, requiring an integrated approach, of which agricultural biotechnology is but a component. However, modern biotechnology has the potential to make crop breeding and crop-management systems in developing countries more efficient in generating improved crop varieties and higher yields.

Recent advances in agricultural applications of modern biotechnology showed significant potential to contribute to sustainable gains in agricultural productivity, reducing poverty and enhancing food security in developing countries [9]. Since agricultural biotechnology has been considered as a strong potential to improve agricultural production, the level of its adoption in Nigeria should be accelerated to change this potential to actual gain. Research institutes, Colleges of Agriculture and Universities play a great role in this context because they are the main providers of biotechnology innovations. Therefore this paper examines the process leading to biotechnology adoption scenario in Nigeria and determines the factors influencing the process from the viewpoint of academic researchers.

1.2 Conceptual Framework

Food security refers to the availability of food and one's access to it. A household is considered food secured when its occupants do not live in famine or fear of malnourishment. It has been reported by various authors that agriculture is the primary means by which man has satisfied the requirement for food and nutrition [2]. Due to increased farming for use in biofuels, conversion of agricultural land to residential and industrial development, land use for agricultural purposes is gradually losing its place. Consequently, there is need to fashion a strategy that will maximize the availability of land for agricultural purposes. Researchers around the world have advocated the use of agricultural biotechnology as a strong potential to speed up the movement towards industrialization and securing food in most of the developing countries.

Wolf et al. [19] emphasized that there is a need for a linkage between innovators and industry. It

was argued that it is necessary to evaluate the market needs and the value of new technology. Consequently, there is a need for closer linkage between the researchers/innovators and the users of the innovations. Academic research centers as the home of innovations are also directly involved in the process of adoption of innovations.

1.3 Nigeria and Biotechnology

There is a wide definition of the term "biotechnologies" with different techniques and applications, for this study the term "biotechnologies" was captured by the definition of Convention on Biological Diversity (CBD) that defines biotechnology as: *"any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use"*. Evidence from literature revealed that the Nigerian government believes in the opportunities offered by biotechnology to empower farmers through increased productivity and this led to the creation of National Biotechnology Development Agency (NABDA) [11]. This agency maintains collaboration with a large number of organizations in bringing improved technologies, including biotechnology products, to farmers. NABDA also maintained a close teamwork with a sizeable number of scientists from Nigerian Agricultural Institutes and Universities.

Studies have shown that agricultural scientists in developing countries anticipated great benefits from biotechnology in the coming decades to help meet future needs for food and fibre. For example the commercial adoption of transgenic crops by farmers has been one of the most rapid cases of technology diffusion in the history of agriculture [10,11]. In the last 20years, biotechnology has developed valuable new scientific methodologies and products, which need active financial and organizational support to bring them to fruition. So far, biotechnology has the greatest impact in medicine and public health. There are also a number of fascinating developments that are approaching commercial applications in agriculture [11]. In addition, agricultural biotechnology in Nigeria has not been sufficiently research to appreciate its relevance to poverty and food security. Hence, this paper tends to highlight the benefits of agricultural biotechnology from the viewpoints of academic lecturers. It is hoped that benefits highlighted will contribute significantly to food security issues in Nigeria. In addition too, breakthrough in biotechnology research should be given effective extension delivery by the researchers to the end users (farmers) and understanding the relevance of biotechnology in small farms development. This is a research relevance that needs to be investigated.

1.4 Agricultural Research and Technology Development Programmes

Agricultural research and technology development programmes started in Nigeria before the amalgamation of the Southern and Northern Protectorates into one country, Nigeria, in 1914 [20,21]. It was the initiative of the British colonial masters, with the establishment of a Botanical Station in Lagos in 1893, followed by experimental stations in Ibadan between 1899 and 1912 for improving the cultivation of rubber and cotton and the management of the forest of humid southern Nigeria.

From this modest beginning, the programmes have become expansive covering the establishment and management of anumber of national and international Research Institutes, Agricultural Universities, Faculties of Agriculture, Faculties of Veterinary Medicine and Colleges of Agriculture. These research Institutes are supposed to provide innovations and new technologies to users and help in the process of facilitation and adoption to the end users.

2. METHODOLOGY

2.1 Sampling Procedures and Data Collection

Due to the nature of this research purposive sampling techniques was adopted. This is because; researchers that were involved in biotechnology and adoption extension process were identified. In Nigeria, very few Scientists in Nigerian higher institutions are found out to be involved in biotechnology research. Literatures reviewed have shown the importance of biotechnology in agricultural outputs and growth, thus there is need to identified the value of these researchers in biotechnology research and their adoption processes and how relevance their outputs in the agricultural development of Nigeria.

“The target population was limited to 100 academic biotechnology researchers” in Federal

University of Technology Akure (FUTA), University of Ibadan, Federal College of Agriculture Akure and Moor Plantations, Ibadan. The data collection was done by means of a self-administered questionnaire on identified researchers in Nigerian Universities and research institutes. Information obtained from these identified researchers was from questionnaire distributed and collected from the identified researchers. The questionnaire which was developed by the researchers and their substance were based on the literature review and the local and social situation to ensure validity.

The questions were tailored to match the research context. The validity of the questionnaire was established by a panel of experts and through a pilot test carried at the Federal College of Agriculture, Akure, to determine the validity and reliability of the questionnaire. The reliability was measured by using the Cranach's alpha internal consistency [22,23]. The calculated reliability coefficients for this questionnaire as a whole were equal to 0.716. The confirmed and coherent questionnaire was distributed to the 140 (but 100 data were useful for subsequent analysis) biotechnology experts working as academics in biotechnology fields.

The data obtained were used to accomplish the logistic regression modeling for this study. Data were collected on household size, teaching and research experience, detailed information on various aspects of level of knowledge, amount of fund, level of acceptance and receptiveness, level of cooperation, level of transfer of technology and personal characteristics from the perspective of University and Research Institute biotechnology experts among others

2.2 Estimation Procedure: Logistic Regression Model

Literature reviewed revealed that a rational management faces two sequential decisions regarding technology: whether to adopt a technology or not and whether to retain or abandon the technology once adopted. It is obvious that the second decision is only relevant to those farmers who have previously adopted the technology. Thus, the two decisions are correlated with each other because the probability of technology retention orabandonment is contingent upon the probability of technology adoption [24,25] Consequently, the motivation of the study lies in the assumption that biotechnology innovations have been adopted. Following Walton et al. [26], the study incorporate the sequential decisions into the expected random utility framework [27,28].

Logit and probit are two binary choice models commonly used in analyzing technology adoption or not. For example, Mohamed [29] and Vaessen [30] employed the logit model to examine the relative importance of household factors in determining the probability of accessing different types of technology, while Umoh [31] opted for the probit model for their empirical analyses. Both logit and probit models provide consistent, efficient, and asymptotically normal estimates, and yield very similar prediction results in empirical work. Instead of trying to determine the farmer's choice, this paper utilizes the observed information of adoption process of biotechnology among researchers in Nigerian Universities/and research institutes and researchers characteristics to estimate the probability of the researchers choice conditional on the researchers characteristics using the log it model, owing to the merits possessed by the model such as good approximation to the normal distribution and analytical convenience [32,33].

Description of variables used in the logit model is available in Table 1. The logistic regression has been acknowledged as a new method to obtain more exact estimates on the level of adoption in social sciences [10,27]. The logistic regression is characterized with representing one or more independent variables that determine a dependent variable or outcome. This outcome is measured or recorded via a binary variable; the independent variable(s) on the other hand can be classified as continuous or amix of continuous and categorical.

The goal of logistic regression is to find the best fitting model to describe the relationship between the dichotomous characteristic of interest (dependent variable = response or outcome variable) and a set of independent (predictor or explanatory) variables. Logistic regression generates the coefficients (and its standard errors as well as significance levels) of a formula to predict a *Logit transformation* of the probability of presence of interest:

Table 1. Description of variables used in the log it model

Variable name	Variable type	Variable description
Dependent variable		
level of adoption of biotechnology innovations	Binary	Process done on Adoption of biotechnology innovation (1= Yes, 0=No) by Researchers
Independent variable		
Financial status (X_1)	Continuous	Amount of fund used (measured in Naira)
level of acceptance (X_2)	Continuous	Intensity of acceptance (numbers)
level of knowledge (X_3)	Continuous	Intensity of knowledge (numbers)
level of cooperation (X_4)	Continuous	Intensity of cooperation (numbers)
level of transfer of technology and rate of adoption (X_5)	Continuous	Intensity of technology transfer (numbers)

Source: Field survey, 2012

In this study, a problem with five independent variables namely: level of knowledge, amount of fund, financial status, level of acceptance, level of cooperation, level of transfer of technology and rate of adoption, was analyzed. The level of adoption of biotechnology innovations is taking as the dependent variable.

The logistics regression is amodel as

$$\text{Logit}(pi) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 \quad (1)$$

Where *p* is the probability of presence of the *i*characteristic of interest. The logit transformation is defined as the logged odds:

$$\text{Odds} = \frac{pi}{1\text{-}pi} \quad (2)$$

And therefore the Logits (natural logs of the odds), of the unknown binomial probabilities are modeled as a linear function of the *X*:

$$\text{Log it}(pi)\ \text{Ln}\left[\frac{P_i}{1-P_i}\right] = \beta_0 + \sum_{j=1}^{5}\beta jXj \quad (3)$$

(Retype equation 3 to make the denominator shift from the line) (Equation 3 retyped)

The Log it model assumes that underlying stimulus index *log it*(*p*) is a random variable, which predicts the *i* probability of biotechnology innovation adoption:

Chance of adoption=

$$pi = \frac{1}{1 + \varepsilon^{\text{Logit}(pi)}}{}^{1} = \frac{\varepsilon^{\text{Logit}(pi)}}{1 + \varepsilon^{\text{Logit}(pi)}} \quad (4)$$

The above formulas have been used to calculate the probability of adoption of biotechnology innovations that is to predict the possibility and chances for the innovations to be adopted. Considering the peculiarities of equation (4), Maximum Likelihood Estimate Method was used as estimation technique (Give ref) [27].

3. RESULTS AND DISCUSSIONS

The analyses of demographics of the respondents 'are presented in Table 2. The findings revealed that 55.80per cent of the researchers came from Universities, 21.10per cent from College of Agriculture and 14.10per cent from Institute of Agricultural Research. The mean age of the respondents was 44.5 years, while the mean teaching/research experience was 7.5 years. The analysis also showed that the age distributions of the participants were between 35 and 45 years. Evidence from literatures suggested that age and academic experience were the two major factors that affect the rate of innovations produced by academics [17,34].

However, it has been adduced that a reasonably lengthy years (about 5-8 years) of teaching and working experiences of academic staff has a great influence on their academic innovations [35]. For instance, academic lecturers whose 5-8 years of teaching experience in a academic environment were found out to be more innovative. Comparing this finding with lecturers that had more than 10 years working experience experienced a significant decreases were discovered in their innovations (Jacobson, [43]). The same distribution pattern of working environment, like adequate funding, regular and effective electricity and necessary infrastructures applies to working experience, where those with

less than 10 years of experience were more innovative while a significant decrease was noted among those in the range of 11 to 15 years. This pattern can be attributed to the academic system of promotions and salary increments in most Nigerian Universities. The new young academic staffs are more eager and enthusiastic to create innovations that will give them promotion to become professorial chance of influencing decision and mentoring the younger lecturer*)*. In addition, attaining professorship make most young lecturers to be more they are energetic and driven by future prospects in their work environment. However as they settle down, the level of innovation appears to decline perhaps due to complacency [43].

Given new perspectives for change and growth in subsequent years, the academic members get renewed vigour and work harder. This could explain the trend as seen above. The job designations of the respondents showed that those in lecturer II category had the highest productivity rate of 50 percent while senior lecturer the lowest. Since there were no significant differences among the groups, with respect to academic designations, this cannot be considered as a differentiating factor.

The data analyses on factors influencing adoption processes were carried out using SPSS 17 and LIMDEP 6.0 software and were used to derive estimates for the rate of biotechnology innovation adoption. The results of the tests of model coefficients were presented from Table 3. Table 3 shows the chi-square goodness-of-fit test of the scope of the study and determines that the step is justified. Here the step is defined from the constant-only model to the all-independents model. When the step was to add a variable or variables, the inclusion is justified if the significance of the step is less than .05. Therefore, the likelihood ratio chi-square of 40.078 with a *p*-value of .000 shows that the outcome model fits significantly.

The Logistic regression analysis showed that all coefficients simultaneously are statistically different from zero and the test of significance helped in explaining the decisions on the adoption of biotechnology innovations. The parameter estimates for the model were evaluated at 5% level of significance. Logit model estimates for the study areas (Table 4) showed that the effect of the three independent variables, namely level of knowledge, level of acceptance and level of transfer of technology were statistically significant at 5% level. These results are consistent with a number of theoretical and empirical studies revealing that knowledge of an innovation is the first step in the decision-making process [34,36,37] In similar studies, Harryson et al. [38] and Chong et al. [39] noted that knowledge is an independent variable that determines the level of adoption of an innovation.

The studies reaffirmed that knowledge gained from the Research Institutes/Universities benefits users more and accelerates the level of adoption. The findings of this study are in line with these observations as they showed negative signs and significance of level of knowledge variable. Research Institutes and Universities researchers are of the view that level of knowledge is an important factor in determining the adoption level of innovation by biotechnology users. Knowledge about an innovation is an indicator of the level of

Table 2. Demography variables of the respondents

Institutions	Male	Female	Total (%)
University of Ibadan	18	7	25(24.%)
Obafemi Awolowo University, Ile-Ife	14	6	20
University of Benin	13	7	20
Federal University of Technology Akure	9	6	15(26%)
Federal College of Agriculture, Akure	6	4	10(21%)
Institute of Agricultural Research, Ibadan	5	5	10(14%)
Total	**65**	**35**	**100**
Variables/Academic Status			
Senior Lecturer	15	8	23 (11%)
Lecturer I	20	11	31 (39%)
Lecturer II	30	16	46 (50%)
Age (years) (Mean)	47.2	41.8	44.5
Teaching/Research Experience (years) (Mean)	8	7	7.5

Source: Field Survey, 2012

adoption. As the awareness of knowledge increases, it is more likely that there will be a corresponding increase in the level of adoption. Level of knowledge about biotechnology innovations on the other hand contributes to low adoption rate. The findings indicated that other source affecting the process of adoption of biotechnology innovation is acceptance. The acceptance variable has a positive impact on the decision to adopt biotechnology Innovation (Table 4).

This is in line with the works of Boon and Holmes [40] and Cahill et al. [41] that have noted the importance of trust as one of the indicators affecting adoption based on technology acceptance models. Furthermore, the adoption of new technology is a function of profitability, riskiness, initial capital requirement, complexity and availability [37,42,43,44]. The positive sign and significance of the acceptance variables in this study imply that acceptance is a second major factor according to magnitude of coefficient that will promote adoption of innovation by biotechnology users.

The significant result for transfer of technology in the present study showed that it is another important factor encouraging users of biotechnology to adopt biotechnology innovations. Empirical results of most studies support this finding. This was presented as an important element by Cottrill et al. [45] noting that technology transfer and diffusion of innovations provide the link between technology development and utilization, hence transferring work of technology developers into the hands of end users. The potential of new technologies cannot be fully realized without the successful movement of technology out of a development laboratory and into a user's environment. The national policy includes development innovation in academic biotechnology research, biotechnology industry and transfer of technology.

Table 3. Collection tests of model coefficients

Step		Chi-square	Significant
1	Step	40.078	.000
2	Block	40.015	.010
3	Model	41.010	.015

Source: Field survey, 2012

The dissemination model of technology transfer takes the view that transfer is best accomplished when experts transfer specialized knowledge to a willing receptor [2,35,37]. The findings of this study also support that transfer of technology is a significant predictor. According to National Bureau of Statistics [46] and Central Bank of Nigeria [47] the support given to the innovation or new technology users is in the form of loans, grants and funds. Therefore, it is important for biotechnology users to be familiar with types of assistance and the nature of their utilization [46,47]. The findings illustrate that provision of funds does not have a significant impact on the decisions to adopt biotechnology innovation by users.

However, these findings are contrary to empirical results of previous studies, which found finance as an essential factor affecting adoption decisions [37,48]. This could be due to the fact that grants are given to researchers for innovation purposes but it is not ration upon them to produce suitable and profitable innovations according to users' needs. Researchers may devote their efforts to produce new biotechnology products without considering the price information or the needs and demands of the biotechnology users. The effect of cooperation has been studied in earlier researches, such as [35,49,50,51]. These researchers argued that gaining basic science, applied science, experimental development, measurement and testing, consulting services, funds and grants, are important reasons for cooperation between companies and universities.

Table 4. Analysis of maximum likelihood estimates

Step	Independent variable	Coefficients	Standard error	Significant levels
1	Level of Knowledge X_1	-3.012	0.873	0.000
	Amount of fund X_2	0.458	0.215	0.175
	Level of Acceptance X_3	2.153	0.518	0.002
	Level of Cooperation X_4	0.815	0.614	0.182
	Level of transfer of Technology X_5	1.792	0.815	0.014
	Constant	-7.185	2.152	0.020

Source: Field survey, 2012

However, the findings of the current study differed from earlier report of model as a linear function of the *Xi.* The results showed that the cooperation variable is not a statistically significant factor. This implies that academic centres generally do not believe in the effect of the rate of extension services' in enhancing the level of adoption.

The probability that a company will adopt a biotechnology innovation, for any units are allocated to this study's predictors, is given by

$$\text{Chance of adoption} = pi = \frac{1}{1 + \varepsilon^{\text{Logit}(pi)}}{}_{1} \quad (5)$$

Accordingly, equation (5) will be used to these researchers; the empirical model is used to draw economic justifications for strategies to improve biotechnology innovation in Nigeria. Therefore, the probability of adoption will shows clearly that the percentage change of biotechnology adoption by adopters of such biotech companies when any unit is allocated to the predictors.

4. CONCLUSION

The results of this study indicate that the level of knowledge, acceptance and transfer of technology have direct effect on the level of adoption of biotechnology innovations. Therefore, there is need for policies that will streamline biotechnology programmes in a sustainable way to potential users. Also, policies that will advance agricultural research institutes boost agricultural biotechnology activities, increasing outputs and improving income of agricultural entrepreneur are advocated. Hunger and poverty reduction must be addressed for the country's stability by integrating modern agriculture with traditional food production system and to make sure that food and agricultural varieties, which were not part of the traditional food system, are introduced into the country to expand the food and agricultural product base.

This study has highlighted the benefits of agricultural biotechnology from the viewpoints of academia. These benefits will, however, reach poor farmers only if the innovations are closely linked to the farmers' needs and if a national research system is properly developed. Agricultural biotechnology can increase yields, improve the environment by decreasing the use of chemical inputs, contribute to reducing soil erosion and decrease the need for new land to respond to the increase in food demand. However, it is not wise to raise unreasonable expectations about what agricultural biotechnology can do. Agricultural biotechnologies are not the magic silver bullet that will eliminate food insecurity and poverty. The spread of a message that is unrealistically optimistic would be ethically wrong, economically erroneous and politically counterproductive. Nevertheless, agricultural biotechnology can support efforts aimed at increasing the agricultural production and improving the income of small-scale farmers in Nigeria.

COMPETING INTERESTS

Author has declared no competing interests exists.

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