

**Research paper****Bio economy Adoption Process of Agro-biotechnology Among Researchers in Nigerian Universities/Research Institutes: The Logistics Regression Approach**

By

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Ikeji-Arakeji.**Abstract**

Food insecurity in most developing countries was as a result of their low/small scale of operation in farming enterprise resulting to low yields. To increase agricultural productivity agro-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. A purposive sampling technique was adopted and the target population was limited to 100 academic biotechnology researchers. Eighty percent of the researchers came from the Universities, 10 percent each from College of Agriculture and Institute of Agricultural Research respectively. Mean age was 44.5 years, teaching/research experience mean 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. Findings' revealing 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. The results of the findings of this study indicated 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 agro-biotechnology programme in a sustainable way to potential users.

**Keywords:** Starvation, Deficiency, Awareness, Agro-biotechnology, Scholastic**Introduction**

Evidenced abounds in past studies and literature that hunger and poverty are closely linked (Apata, *et al*, 2011; ANAP, 2006; Oyeranti and Olayiwola, 2005; Okunmadewa, 2002). Hunger is as a result of lack of access to food (quality) to satisfy starvation. Poverty on the other hand has been hypothesised 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 (World Bank, 2008). 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 as a result of their low/small scale of operation in farming enterprise resulting to low yields (Oksana, 2005; Alayande and Alayande, 2004; Olayide *et al*, 1980). The low yield is attributable to low-level farm technology and productivity. In addition to the predominance of the use of traditional manual 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 (Zilberman *et al*, 2010; Adeogun *et al*, 2008; Magaji, 2007). There is a school of thought that said introduction of biotechnology to agricultural production will improve the sector (Hussain *et al*, 2003; Santaniello, 2002, Flavel, 1999).

However, due to a multitude of problems faced by farmers in developing countries biotechnology may not solve the problem of low yield in agricultural production advocated by another school of thought (Zilberman *et al*, 2010; Manyong *et al*, 2003; Huang *et al*, 2003). 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 (Apata, *et al*, 2011; Olayemi, 1980). The challenge of increasing farm-level production in a sustainable manner (environmentally, economically and socially) is a very complex one, requiring an integrated holistic approach, of which agricultural biotechnology is but a component. However, modern biotechnology (hereafter referred to as “agricultural 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 show a significant potential to contribute to sustainable gains in agricultural productivity, reducing poverty and enhancing food security in developing countries (Zilberman *et al*, 2010). Since Agro-biotechnology has been considered as a strong potential to improve agricultural production, therefore the level of adoption of agricultural biotechnology in Nigeria should be accelerated to change this potential to actual improve. Research institutes, Colleges of Agriculture and Universities centres play a great role in this context because they are the main providers of biotechnology. Therefore this paper examines the biotechnology adoption scenario in Nigeria from the viewpoint of academic researchers.

### 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 certified by various author that agriculture is the primary means by which man has satisfied the requirement for food and nutrition (ANAP, 2006). Due to increased farming for use in bio fuels, 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 maximise the availability of land for agricultural purposes. Researchers around the world have advocated the use of Agro-biotechnology as a strong potential to speed up the movement towards industrialization and securing food in most of the developing countries.

Wolf *et al* (2000) emphasised that there is a need for a linkage between innovators and industry. The paper argued that it is necessary to evaluate the market needs and the value a new technology. For this to happen, there is a need for a closer linkage between the researchers/innovators and the users of the innovations. Academic research centres as the producers of the innovations are also directly involved in the process of adoption of innovations. This is the conceptual construct of this study; to have an insight on the adoption process of biotechnology and factors influencing this process in Nigeria from the academics' point of view.

### Nigeria and Biotechnology:

There is a wide array 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". Evidenced from literature revealed that the Nigerian Government believes in the opportunities offered by biotechnology to empower our farmers through increased productivity and as such led the government in the creation of a National Biotechnology Development Agency (NABDA) (Magaji, 2007). This agency maintains collaboration with a large number of organizations in bringing improved technologies, including biotechnology products, to our farmers. NABDA 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 by farmers of transgenic crops has been one of the most rapid cases of technology diffusion in the history of agriculture (Adeosun *et al*, 2008; Magaji, 2007). 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. However, there are a number of fascinating developments that are approaching commercial applications in agriculture (Magaji, 2007). This is a research relevance that needs to be investigated.

#### **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 (Akinyosoye, 2006, Idachaba, 2000). The initiative was by 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 and the programmes cover the establishment and management of number of national and international Research institutes, Agricultural Universities, Faculties of Agriculture, Faculties of Veterinary Medicine and Colleges of Agriculture. These research Institutes are suppose to provide innovation and new technology to users and help in the process of facilitation and adoption to the ultimate users.

#### **Methodology**

##### **Sampling Procedures and Data Collection.**

Due to the nature of this research purposive sampling techniques was adopted. The target population was limited to 38 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, which was developed by the researchers. The questions and their substance were build up based on the literature review and the local and social situation to ensure validity. The assumed 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. A pilot test was carried out to determine the validity and reliability of the questionnaire. The reliability was measured by using the Cranach's alpha internal consistency (Ary, *et al*, 2006, Lessinger, 1999). The calculated reliability coefficients for this questionnaire as a whole were equal to .716. The confirmed and coherent

questionnaire was distributed to the 40 (but 38 data were useful for subsequent analysis) biotechnology experts working as academics in biotechnology fields.

The obtained data was used to accomplish the logistic regression modelling 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/Research Institute biotechnology experts among others

# **Estimation Procedure: Logistic regression Model**

The logistic regression has been acknowledged as a new method to obtain more exact estimates on the level of adoption in social sciences (Adeogun *et al*, 2008). The logistic regression is characterized with representing one or more independent variables that determine a dependent variable or outcome. This outcome is measured or recoded via a binary variable; the independent variable(s) on the other hand can be classified as Continuous, Mixed 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 and significance levels) of a formula to predict a *Logit transformation* of the probability of presence of interest:

Therefore the present study tends to analyse a problem with five independent variables namely: level of knowledge, amount of found, level of acceptance, level of cooperation, level of transfer of technology and rate of adoption, respectively. The level of adoption of biotechnology innovations is taking as the dependent variable.

The logistics regression is model as

$$\text{Logit}(p_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \quad (1)$$

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

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

and therefore the Logits ( natural logs of the odds), of the unknown binomial probabilities are modelled as a linear function of the  $X$ :

$$\text{Logit}(p_i) \text{ Ln} \left[ \frac{p_i}{1 - p_i} \right] = \beta_0 + \sum_{j=1}^5 \beta_j X_j \quad (3)$$

The Logit model assumes that underlying stimulus index  $\text{logit}(p)$  is a random variable, which predicts the  $i$  probability of biotechnology innovation adoption:

$$\text{Chance of adoption} = p_i = \frac{1}{1 + e^{-\text{Logit}(p_i)}} = \frac{e^{\text{Logit}(p_i)}}{1 + e^{\text{Logit}(p_i)}} \quad (4)$$

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.

## Results and Discussions

The analyses of demographics of the respondents' were presented from Table 1. The findings revealed that 55 percent of the researchers came from the Universities, 21 percent from college of Agriculture and 14 percent from institute of agricultural research (Table 1). The mean age of the respondents was 44.5 years, while teaching/research experience mean was captured as 7.5 years. The analysis also showed that the age of the participants were between 35 to 45 years. Evidence from literatures suggested that Age and academic experience were the two factors that affect the rate of innovations produced by academics (Farid, *et al*, 2010, Hilker and Hamilton, 1994).

The same pattern applies for 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. The new academic staffs are more eager and enthusiastic. They are energetic and driven by future prospects in their work environment. Later on as documented by past studies however as they settle down, the number of innovation appear to decide, perhaps due to complacency.

Given new perspectives for change and growth in subsequent years, the academic members get renewed vigor and work harder. This could explain the trend as seen above. The final part of the data on demography dealt with job designations of the respondents. The participants were categorized into three groups: Senior lecturers, Lecturer I and lecturer II. It was observed 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.

**Table 1: Demography Variables of the Respondents**

| <b>Institutions</b>                        | <b>Male</b> | <b>Female</b> | <b>Total (%)</b> |
|--------------------------------------------|-------------|---------------|------------------|
| 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%)         |
| <b>Total</b>                               | <b>65</b>   | <b>35</b>     | <b>100</b>       |
|                                            |             |               |                  |
| <b>Variables/Academic Status</b>           |             |               |                  |
| Senior Lecturer                            | 15          | 8             | 23 (11%)         |
| Lecturer I                                 | 20          | 11            | 31 (39%)         |
| Lecturer II                                | 30          | 16            | 46 (50%)         |
|                                            |             |               |                  |
| <b>Age (years) (Mean)</b>                  | 47.2        | 41.8          | 44.5             |
|                                            |             |               |                  |
| <b>Teaching/Research Experience (Mean)</b> | 8           | 7             | 7.5              |

The data analyses on factors influencing adoption processes were carried using SPSS 17 and LIMDEP 6.0 software and were used to derive estimates for rate of biotechnology innovation adoption. The results of the compilation tests of model coefficients were presented from Table 2. Table 2 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 as here 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 outcome model as a whole fits significantly.

**Table 2: 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: Computer Results, 2011

Table 3 presents the most important and applicable results for this study. 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 3) 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 (Farid, 2010, Rogers and Shoemaker, 1971 and Rogers 1995). Also, the works of Harryson *et al.* (2007) and Chong *et al.* (2009) were of the opinion 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 the validations given above as they show the negative signs and significance of level of knowledge variable. Research Institutes/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 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 indicate that another 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 3).

**Table 3: 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: Computer Results, 2011

This is in line with the works of Boon and Holmes (1991) and Cahill *et al.* (1990) empirical studies that have noted the importance of trust as one of the indicators affecting adoption based on technology acceptance models. The literature further indicates that the adoption of new technology is a function of profitability, riskiness, initial capital requirement, complexity and availability (Rogers, 1995, Byerlee and Polanco, 1986 and Feder, 1982). 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 research shows that this is the third important factor encouraging users of biotechnology to adopt biotechnology innovations. Empirical results of most studies support this finding. This is presented as an important element by Cottrill *et al.* (1989) whereas they confirm 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 lab and into a user's environment. The national policy includes development innovation in academic biotechnology research, biotechnology industry and transfer of technology (ToT).

The dissemination model of technology transfer takes the view that transfer is best accomplished when experts transfer specialized knowledge to a willing receptor (Farid *et al.*, 2010, ANAP, 2006, Rogers, 1995). As expected, findings of present research support that transfer of technology is a significant predictor. Based on data available from websites of National Bureau of Statistics (NBS, 2011) and Central Bank of Nigeria (CBN, 2011) 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 (NBS, 2011 and CBN, 2011). 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 (Rogers, 1995 and Panatanali, 1987). 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 Veugelers and Cassimanb, (2005), Schartinger *et al.* (2002), Schibany *et al.* (1999), Rosenberg and Nelson, (1994) and Mansfield, (1991) and Farid, (2010). These researchers argue 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.

However, the findings of the current study do not support that of the earlier mentioned studies are modelled as a linear function of the  $X_i$

The results show 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 estimated model is used to predict probability of adoption of biotechnology innovations created by Nigerian Universities for biotechnology users, the results show 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 estimated model is used to predict probability of adoption of biotechnology innovations created by Nigerian Universities for biotechnology industry from the perspective of university biotechnology experts:

$$\text{Logit}(pi) \ln \left[ \frac{pi}{1-pi} \right] = \quad (5)$$

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

$$\text{Chance of adoption} = pi = \frac{1}{1 + e^{-\text{Logit}(pi)}} \quad (6)$$

According to these researchers, the empirical model is used to draw economic justifications for strategies to improve biotechnology innovation in Nigeria. The probability of adoption shows clearly that the percentage change of biotechnology adoption by companies when any unit is allocated to the predictors.

## Conclusion

The results of the findings of this study indicated 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 agro-biotechnology programme in a sustainable way to potential users. Also policies that will advance agricultural research institutes to help boost agricultural biotechnology activities, increasing outputs and improving income of agricultural entrepreneur is 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 view points of academic. These benefits will, however, will 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, cooperate in 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. Having highlighted the benefits of Agricultural biotechnology, there is thus the need to examine an agricultural biotechnology and agricultural productivity.

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