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Analysis of Factors Influencing Adoption of Intermediate Farm Tools and Equipment among Farmers in the Semi-Arid Zone of Nigeria

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Abstract: In this study, a number of farmers' characteristics, attributes of the technologies and institutional factors are conceived as influencing adoption of these tools and equipment. The relevant data were collected from secondary and primary sources. The primary data were collected using a questionnaire administered to 120 farmers comprising randomly selected adopters. Percentages, means and t-test were used to analyze certain aspects of the study. Tobit analysis was used to determine factors influencing adoption of IFTE. It was found that farm size and use of biological/chemicals were highly significant determinants of adoption of IFTE. It is concluded that when the recommendations made are implemented, the adoption of IFTE among farmers will increase and consequently, agricultural productivity and production will increase in Nigeria.

Key words: Factors influencing, intermediate farm tools and equipment, adoption, Tobit analysis

INTRODUCTION

Increasing agricultural productivity and production with the adoption of IFTE is a precondition for achieving food security in Nigeria. As long as farmers continue to use traditional tools, the vision of achieving agricultural growth will be a mere illusion in Nigeria. Evidently (Baba, 1985; Panin, 1992; World Bank, 1993), tractors and other imported farm machinery have been distributed to farmers for quite some time in Nigeria. Their adoption, however, has been limited to a very small, privileged percentage of the farming population and has contributed little in boosting production and productivity. This has been compounded in recent time by the astronomical prices of the tractor and other imported farm tools and equipment. Moreover, the enormous increases in petroleum and lubricant prices have accentuated the need to examine alternative less costly farm tools and equipment for agricultural production.

Intermediate Farm Tools and Equipment are terms used to describe any level of farm technologies of very simple design that have been developed systematically above the traditional hand-tools but below the conventional engine-powered technology (Anazodo, 1988). They do not necessarily incorporate high technology precision parts, that is, parts that can be produced only by specialized manufacturers. They may be powered by animal or human energy or engine-powered and their manufacturing requires only locally available raw materials except the engine power in some cases. A list of IFTE, therefore, included ox-ploughs, ox-drawn harrow, ox-ridgers, ox-cultivators, ox-carts, trailers, seed planters, threshers, grinders, decorticators, milling machines and others equipment such as reapers, harvesters, sprayers, storage bins, simple hand tools, etc.

Available statistics (NCAM, 1993), show that between 1975-1987, assorted Intermediate Farm Tools and Equipment (IFTE) amounting to over N684 million were introduced into Nigeria. A lot of work has been done by individuals in Universities, Polytechnics, Research Institutions and Industries, some of which are located in Kaduna State, in developing proto-types of various intermediate farm tools and equipment for the Nigerian farmers (Makanjuola *et al.*, 1991; Odigboh, 1978; Anazodo *et al.*, 1989). Attempts are also being made by some indigenous manufacturers/fabricators to produce and market on commercial scale, various types and sizes of intermediate farm tools and equipment. These efforts have, however, encountered a major obstacle in terms of lack of effective demand for their adoption. Efforts to identify the causes of these problems and promote widespread adoption. of the farm tools and equipment offer considerable promise in overcoming the labour constraints in agriculture. This study was undertaken to determine the level of adoption and factors influencing adoption of intermediate farm tools and equipment in the Northern Guinea Savannah zone of Nigeria. It was also hypothesized that there is a relationship between personal characteristics of the farmers, institutional factors and attributes of the IFTE and level of adoption of IFTE.

MATERIALS AND METHODS

This study was undertaken in Kaduna State of Nigeria Kaduna State was selected for the study for a number of reasons including:

- The state has all the characteristics representative of the Northern Guinea Savannah ecology,
- The state has been promoting the adoption of some IFTE over the past seventy years and has intensified extension activities on the technologies in the last twenty years.

Six Local Government Areas (LGAS), namely: Giwa, Zaria, Sabon-Gari, Soba, Makarfi and Kudan were selected purposively for the study. These L.G. As were selected in consideration of location of relevant Research and Development (R and D) institutions such as the Institute for Agricultural Research (IAR), the National Agricultural Extension and Research Liaison Services (NAERLS), Samaru College of Agriculture, National Animals Production Research Institute (NAPRI) and the existence of several small-scale industries. The Kaduna Agricultural Development Project (KADP) with extension responsibilities commenced its activities in 1975 in the study area. The KADP and the other organizations and small-scale industries have been involved in the production and transfer of IFTE for quite some years now. The IFTE selected for this study were: ox-drawn ploughs, ox-drawn harrow, ox-drawn ridgers, ox-drawn weeders, ox-drawn carts, improved hand weeders, fertilizer/chemical applicators, jab planters and treadle pumps.

Musa (1996), NAERLS (1997) and Fashina (1999) have provided the standard potential outputs (h) of work per hectare per operation for different IFTE. Using these standard outputs, adoption was measured in this study as actual h of use of IFTE divided by potential h. A farmer with less than 1/3 h of usage was regarded as a non-adopter, while those who obtained proportions greater than 1/3 were considered as adopters.

The primary data were collected using a questionnaire designed for the head of households' males or females and generated information on characteristics of respondents, attributes of the IFTE in use and level of adoption. After the questionnaire had been tested and modified, the actual fieldwork was conducted from March to December, 2005 through face-to-face interviews by a selected team of five enumerators after giving them a thorough training. The total sample drawn was 120 from a list of 673 adopters.

The techniques of analysis used in analysing the data were primarily descriptive statistics using frequencies, percentages, cross tabulation and means. A Tobit model was also used to investigate the determinants of IFTE adoption.

In technology adoption studies, limited dependent variable models such as Logit, Probit and Tobit continue to have extensive applications in obtaining information from the non-normal distribution of such data (Adesina and Zinnah, 1993). The ordinary least squares regression is inappropriate when the dependent variable is discontinuous (Feder *et al*., 1985; Pindyck and Rubinfield, 1998). Logit and Probit models are appropriate when the dependent variable is discrete, usually taking two values, 0 or 1. These models are useful if the question is whether to adopt or not, but are not appropriate when it is important to measure the intensity of adoption of a technology. The Tobit model which better handles censored dependent variables (continuous between some lower and possibly upper bound) (Shakya and Flinn, 1985; Pindyck and Rubinfield, 1998) is superior to the Logit and Probit. It measures both the probability of adoption and intensity of use. In this study, the Tobit model was used to achieve the stated objectives.

The probit model for this study was empirically specified (Shakya and Falinn, 1985) as follows:

$$Y^* = \alpha + \beta X + \varepsilon \quad (1)$$

and

$$Y = g(Y^*) \quad (2)$$

Where:
$Y = Y^*$ for $Y^* > 0$
$Y = 0$, otherwise

Y^* is an index reflecting the combine effect of X (farmer specific and technology specific) factors that influence adoption decision.
Y^* is not observable. What is, however, observed is whether the farmer adopts the technology (when $Y^*>0$) or not (when $Y^* = 0$).

Where Y is the area (ha) under improved maize varieties, X is as defined above, α, β are parameters to be estimated and å is a stochastic error term.

The probability of adoption and use intensity can be estimated using the following conditional expectation function:

$$E(Y|Y^*) = Y^*.F(Y^*/\sigma + o.\ f(Y^*/\sigma) \quad (3)$$

$E(Y|Y^*)$ = The expected area (ha) given that the variety is adopted.

Table 1: Descriptive statistics of variables used in the empirical model

Variables	Measurement	Mean	Min	Max
Age	Age of farmer(years).	32.3	23.0	67.00
Farm labour capacity	Number of available farmer labour.	7.0	1.0	15.00
Distant markets	1 if farmer thought IFTE were close to their homes, 0 otherwise.	24.3	05.4	107.00
Years of farming experience	Number of years a farmer has been farming.	13.4	1.0	43.00
Farm size	Farm size (ha).	3.2	0.2	12.00
After- sale service	1 if farmer thought no problem in IFTE after-sale service, 0 otherwise.	0.74	0.0	1.00
Credit	Amount in naira (#).	3200.00	10,000.0	120,000.00
Extension contact	Number of extension visits.	1.60	0.0	5.00
Cost	1 if farmer thought IFTE were not Expensive, 0 otherwise.	0.20	0.0	1.00
Freq. breakdown	1 if farmer thought no problem in IFTE Breakdowns, 0 otherwise.	0.21	0.0	1.00
Energy/skill req.	1 if farmer thought no problem in IFTE energy/skill required. 0 otherwise.	0.15	0.0	1.00
Availability of IFTE	1 if farmer thought no problem with IFTE Availability, 0 otherwise.	0.35	0.0	1.00
Compatibility	1 if farmer thought IFTE was compatible with his practice, 0 otherwise.	0.42	0.0	1.00
Preference for imported ones	1 if farmer had no preference for imported IFTE, 0 otherwise.	0. 53	0.0	1.00

σ = Standard error of estimate (reported as Sigma in Table 4).

Y*/σ = Standardized index.

F(Y*/σ) = Tobit probability of adoption, calculated from the cumulative normal distribution.

f(Y*/σ) = Normal density function when Z = (Y*/σ).

The adoption and use intensity of IFTE (dependent variable) was measured as the proportion of farms cultivated with IFTE. The independent variables measured are as shown in Table 1.

RESULTS AND DISCUSSION

Level of IFTE adoption by Farmers: The level of adoption of the IFTE by the farmers was examined from two major perspectives as follows:

- The number of adopters by types of IFTE and
- The total number of h an IFTE was used in the previous farming season.

The IFTE identified were mostly animal drawn and included the ox-drawn ploughs, ox-drawn harrows, ox-drawn ridgers, ox-drawn weeders, ox-drawn carts, Jab planters, fertilizer applicators, improved hand weeders and treadle pumps (Table 2). The table shows that there were 16 adopters of ox-drawn ploughs, 13 adopters of ox-drawn harrows, 28 adopters of ox-drawn ridgers and 25 adopters of ox-drawn carts.

The ox-drawn ridger recorded the highest number of adopters. The least number of adopters was recorded for the treadle pump, followed by the fertilizer applicator and improved hand weeder in ascending order. The low level of usage of these equipment was expected because only very few farmers were aware of them.

Table 2: A breakdown of the number of adopters by types of IFTE

Types of IFTE	No. of adopters	Sample (%)
Ox-drawn plough	16	7.9
Ox-drawn harrow	13	10.9
Ox-drawn ridger	28	5.3
Ox-drawn weeder	15	62.5
Ox-drawn cart	25	4.9
Jab planter	8	61.5
Fertilizer. Applicator	5	55.6
Improved hand weeder	5	45.5
Treadle pump	5	100.0
Total	120	9.4

The h each IFTE was used on the farm were also investigated and the result is presented in Table 3. The ridger had the highest number of usage (2118 h) followed by the ox-drawn cart (1983 h), treadle pump (156 h). The improved hand weeder recorded the least number of h. The h of use pattern reflected the adoption of a particular equipment and its importance as an Agricultural Labour Saving Device (ALSD). Overall, the level of adoption of the equipment studied was very low.

Empirical results: Table 4 presents the maximum likelihood estimates of coefficients in the Tobit regression equation for IFTE adoption. decision model. The model correctly predicted 87% of the variance in adoption intensity. The age of the head of the household and farm size were found to have positive and significant impact on the probability of adoption. Older farmers may be the elders of the farming communities and for that matter, resource owners (access to land, family labour and, to some extent, informal credit due to their social status). As

Table 3: Adopters and total annual hours of use of IFTE

Types of IFTE	Percentage of total adopters (No.)	Total annual use (h)	Percentage of total (h)
Ox-drawn plough	7.9 (43)	56	1.2
Ox-drawn harrow	10.9 (19)	45	0.8
Ox-drawn ridger	5.3 (291)	2118	44.3
Ox-drawn weeder	62.5 (24)	39	0.8
Ox-drawn cart.	4.9 (258)	1893	39.6
Jab planter	61.5 (13)	32	0.7
Fertilizer applicator	55.6 (9)	43	0.9
Improved hand weeder	45.5 (11)	24	0.5
Treadle pump	100.0 (5)	156	1.2

a result they may have preferential access to new technologies through extension services. This is particularly relevant in situations where the success of any new innovation is seen to be dependent on its acceptance by opinion or community leaders.

These results seem to affirm the important role of resource endowment in observed adoption behavior (Adesina and Zinnah, 1993). Certainly, farmers with large farms are more likely to have more opportunities to learn about new IFTE. They are also likely to have more incentives to adopt new technologies and are more able to bear risks associated with early adoption of improved technology (Makanjuola *et al.*, 1991; Adesina and Zinnah, 1993).

Contrary to expectation, family size (proxy for availability of family labour) had a negative influence on the use intensity of IFTE. This suggests that farmers with small family size use IFTE more intensively. Farming experience has also been shown to have negative impact on adoption of improve practices. Farmers' experience with the use of traditional tools may limit land under cultivation.

Distant markets, availability of after-sale service facilities, compatibility, availability of IFTE, cost, frequent breakdown and energy/skill requirement, preference for imported ones, are some technology-specific characteristics that play significant role in adoption decisions. Farmers, therefore, may continue to use an IFTE that satisfies these qualities. Factors such as extension contact and energy/skill requirement did not have significant effect on the intensity of adoption of IFTE in Kaduna State.

Substituting the average values from Table 1 and the parameter estimates (Table 4) into equation 1 (see statistical tools under methodology) to predict the probability of adoption for an average farmer,

$$Y = 4.039 \Rightarrow Y/\sigma = 2.415$$

From the normal distribution table, the probability of adoption is estimated as: $F(Y/\sigma) = F(2, 415) = 0.9922$.

Table 4: Tobit model estimate for factors influencing the adoption of IFTE

Independent variable	Est. coefficient	SE	t-values
Constant	-0.8720	0.4620	-1.604*
Age (x_1)	0.1091	0.0216	2.502***
Farm labour capacity (x_2)	0.0076	0.0026	-1.102**
Distant markets (x_3)	-0.0268	6.4700	-0.002
Years of farming experience (x_4)	0.1025	3.6412	1.071**
Farm size (x_5)	0.5817	0.1167	4.310***
After- sale service (x_6)	0.5582	0.1507	3.052***
Credit (x_7)	0.0021	0.0103	0.18
Extension contact (x_8)	-0.0134	0.0084	-1.458**
Cost (x_9)	-0.2703	0.1415	-1.382**
Breakdown (x_10)	0.5002	0.1720	-2.170***
Energy/skill req. (x_{11})	0.0026	0.0140	0.131
Availability of IFTE (x_{12})	0.0034	0.0213	0.275
Compatibility (x_{13})	0.0028	0.0104	0.213
Preference for imported ones (x_{14})	0.4381	0.1403	3.184***
Sigma	1.5610	0.0630	11.691

***Coefficients statistically significant at 1%, two-tailed level, **Coefficients statistically significant at 5%, two-tailed level, *Coefficients statistically significant at 10%, two-tailed, Percentage of correct predictions = 76, Log of likelihood function = -380.62

Expected area to be put under improved maize varieties is given by:

$$Å(Y|Y^*) = Y^*.\ F(Y^*/\sigma) + \sigma.\ f(Y^*/\sigma)$$

$Y^* = 4.039$, $F(Y^*/\sigma) = 0.9922$, $\sigma = 1.672$ (sigma in Table 4), $f(Y^*/\sigma) = 0.0216$

$$\Rightarrow Å(Y|Y^*) = 4.0387\ (0.9922) + 1.672\ (0.0216) = 4.043 \text{ ha}$$

QED.

The estimated model predicts that an average farmer with an average age of about 44 years and with the other farmers' characteristics would almost certainly (99% chance) adopt an IFTE. Such a farmer would cultivate about 4 ha of his/her land with IFTE.

The results of this study, to a large extent, corroborate the findings of other empirical analysis of the impact of farmer-specific characteristics and technology-specific attributes of innovation adoption (Makanjuola *et al.*, 1991; Adesina and Zinnah, 1993). It was hypothesized in this study that adoption of an innovation occurs as a function of personal characteristics of the farmer, institutional factors and attributes of the IFTE. The personal characteristics included age of the farmer, years of schooling, years of experience in farming, farm labour and farm size. The institutional variables were amount of credit received biological/chemical inputs usage and extension contact. The attributes of the IFTE were cost, frequent breakdown and energy/skill requirement. The specific hypotheses, however, posited positive contributions of age, farm size, biological/chemical inputs, amount of credit received and contact with extension to adoption of IFTE. On the other hand, negative contributions were hypothesized for farm labour, cost, frequent breakdown and energy/skill requirement. The coefficient of determination (R^2) is 0.4214 which means that 42% of variance in level of adoption of

IFTE was explained by the variables included in the model. Furthermore, the F distribution in a statistical table indicates that the probability of getting an F-ratio equals to or greater than 18.08. Table 4, also shows that the standard error of the estimates was 2.5899. This means that, on the average, the level of adoption deviated from the actual by 2.5889 (Table 4).

As indicated in Table 4, eight out of the fourteen multiple regression coefficients were consistent at various levels in direction with the hypotheses. When considering the contribution of each variable, farm size and biological/chemical inputs made the greatest contribution toward level of adoption of IFTE. Farm size and biological/chemical inputs variables accounted for about 18% of the variability in the level of adoption of IFTE usage. Holding other variables constant, however, farm size made the greatest contribution to level of adoption of IFTE. Dropping this variable from the equation reduced the value of the adjusted coefficient of determination (R^2) from 0.4214 to 0.14. These relatively high magnitudes of farm size and biological/chemical inputs imply that if farmers have large farms and access to biological/chemical inputs, they would be inclined to adopt more IFTE.

The regression coefficient of frequent breakdown, though statistically significant (Table 4) was in the opposite direction (0.6003). It was hypothesized that frequent breakdown of the IFTE would be negatively related to their level of adoption. The positive relationship suggests that frequent breakdowns of the IFTE were not a major factor affecting their level of adoption.

The regression coefficient for age was positive and statistically significant at the 1% level. The positive and significant contribution of age, suggests that adoption of IFTE was higher among older farmers than younger ones. Previous research has, however, established that older people are less receptive to accept farm innovations than younger people. Therefore require IFTE to complement their available manual labour input.

The family labour capacity variable, though, significant at the 1% level, has a negative coefficient, suggesting that level of adoption was lower among small-sized households with large manual labour capacity. Households with large family labour capacity tend to use the availability of manual labour to perform their farm operations rather than bother about adopting IFTE.

Years of farming experience had a positive coefficient and was statistically significant at the 5% level. The hypothesis predicting a positive relationship between years of farming experience and level of adoption of IFTE is therefore supported. This implies that farmers who have spent many years in farming used more IFTE. This was probably that years in farming might have enhanced the farmers' ability to appreciate the benefits of large scale farming associated with the adoption of IFTE. As the years of a person increased on the job, the degree of perceived benefits also increases.

Though contact with extension made significant contribution in the regression analysis, it had a negative coefficient indicating that farmers having contact with extension adopted less IFTE. This suggest that extension contact was not important factor for determining the level of adoption of IFTE. This might be taken to mean that although the farmers had contact with extension, they did not receive information on IFTE. The farmers seemed to have benefited more in other areas of agricultural innovations from extension services than in IFTE usage. The hypothesis that contact with extension would be positively and significantly related with level of adoption of IFTE was, therefore, not supported.

The amount of credit received, made a positive but insignificant (0.0032) contribution to level of adoption of IFTE. The positive coefficient suggests that farmers who received institutional credit used more IFTE than those who did not, thus implying that availability of credit enhances farmers ability to purchase IFTE. The insignificant contribution of credit to level of adoption may be due to the fact that very few farmers (35.8%) benefited from any sort of credit facilities in the study area. In the context of a small-farmer peasant economy as in Nigeria, the shortage of funds is often emphasized as a constraint to the adoption of new technologies. In this study, the amount of credit received per household was taken as a proxy of the availability of liquid funds, which could facilitate the purchase of IFTE.

In general, it can be concluded that the most important variables in the adoption of IFTE were farm size followed by the use of biological/chemical inputs. The least important factors were years of experience in farming, extension contact and energy/skill requirement.

RECOMMENDATIONS AND CONCLUSION

This study shows that IFTE have been introduced to farmers in the Northern Guinea Savannah zone of Nigeria and some farmers have adopted the technology. Overall, however, the level of adoption of the equipment studied was very low.

The ox-drawn ridger recorded the highest number of adopters. The least number of h were recorded for the ox-drawn weeder, jap planter and improved hand weeder in ascending order. Eight out of the fourteen multiple regression coefficients were consistent at various levels in direction with the hypotheses. When considering the contribution of each variable, farm size and biological/chemical inputs made the greatest contribution toward adoption of IFTE.

The findings of this study provide a useful basis for making recommendations for the adoption of IFTE. These recommendations include the following:

- High cost has been identified as crucial problem limiting the adoption of IFTE by farmers. It is recommended that rural saving schemes be established to effectively harness rural resources and provide the credit facilities needed to acquire IFTE by farmers.
- Frequent breakdowns resulting in low demand was also a factor affecting the adoption of IFTE. Because of the high frequencies of IFTE break-down and the difficulties usually encountered in obtaining spare parts for effective maintenance, it is strongly recommends that as the R and Ds develop a proto-type, there is the need to consider timely provisions of adequate spare parts.
- This study shows that incompatibility was a constraint for the rapid adoption of IFTE. In this connection, it is suggested that Government should, with the help of the Universities and Technical Colleges, formulate and implement an engineering strategy aimed at the production of IFTE. Adapted to the farmers' farming systems. A gradual process involving one or two crops should be tackled for a start and blacksmiths and fabricators trained in the production of such tools, covering cultivation, planting, weeding, fertilizers application and suitable to the different farmers farming systems and terrain.

It can be concluded, therefore, that when the recommendations made are implemented, the adoption of IFTE among farmers will increase and consequently, agricultural productivity and production will increase in Nigeria.

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