DETERMINANTS OF IMPROVED MAIZE ADOPTION IN NIGERIA: ARE THEY THE SAME FOR POOR AND WELL ENDOWED HOUSEHOLDS?

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ABSTRACT

This paper examined the effects of wealth on households adoption of improved maize varieties in the dry savanna zone of Nigeria. A multi-stage sampling technique was employed to select 350 maize producing households, and data were collected on household characteristics, productive assets, adoption status and maize production operations in the 2005/2006 production season using survey questionnaire. Data were analysed using descriptive statistics, principal component analysis and the tobit regression technique. Results showed that 62% of the households were poorly endowed and 38% well endowed. There were significant differences in the household characteristics of the two wealth groups. A larger proportion of the well-endowed households belonged to associations, had larger farm sizes, adopted more and cultivated larger areas to improved maize. About 68% of the households (56% poor- and 44% well-endowed) were adopters of improved maize varieties while 32% (75% poor- and 25% well-endowed) were non-adopters and variations existed in the adoption behaviour of poor- and well- endowed households. Extension contact, seed availability, yield potential and wealth determined the probability of adoption of improved maize among the poorly endowed, while membership of association, seed availability and resistance to pests/diseases were determinants for the well endowed. Hence, the availability of high yielding seed cuts across the two wealth groups as common determinants of improved maize adoption by the two wealth groups. Farmers' membership of association, farm size, seed availability, yield potential, and wealth significantly influenced the intensity of use of improved maize after adoption by the poorly endowed households, while extension contact, farm size, and labour had similar influence on the well-endowed. Thus, apart from wealth, developmental programmes that provide access to extension service, encourage social networking among farmers, promote effective seed delivery system and enhanced breeding programmes targeted at developing high yielding maize varieties, will promote improved maize adoption among rural households. These findings have implications for targeting new technologies to specific wealth groups for improved livelihood of

farming households.

Key words: Wealth, Adoption, Improved maize, Household, Dry savanna, Nigeria.

Introduction

Technological change entails the creation and possession of rights to wealth and plays a significant role in any developing nation's economy (Olayemi and Ikpi, 1995). Governments and policy makers have therefore emphasized the development, promotion and dissemination of new agricultural technologies for food security and improved standard of living of the people through wealth creation. However, the introduction of many technologies have only been partially successful as measured by observed rates of adoption (Feder et al., 1985; Nwosu, 1995).

The importance of maize as the dominant income and wealth generating food staple throughout many west and central African countries has been increasing steadily during the last two decades. In Nigeria, maize, which is largely cultivated in the dry savanna zones with yields varying between 2 – 6 tons per ha, is one of the two major crops in about 40% of the area under agricultural production, and accounts for 43% of maize grown in West Africa (Philip 2001, Kamara et al., 2006). It has also risen to a commercial crop on which many agro-based industries depend for raw materials. Thus, its productivity performance will play a critical role in the food security and wealth creating opportunities of the nation. The yield-increasing technological changes available for maize production include improved varieties and modern inputs (Byerlee and Heisey, 1997). It is estimated that gains in maize production due to improved materials are sufficient to feed 40 million people annually. However, the generation and diffusion of new and appropriate maize technologies are essential for achieving rapid increases in maize productivity. Farm households that adopt the resulting technologies can benefit directly from higher yields and incomes as well as improved living standard. In most developing countries including Nigeria, failure to adopt recommended practices have been found to contribute significantly to the yield gap (Manu-Aduening and Boa-Amponsem, 1999).

Various studies document the adoption of new technologies, with variations and low rates of adoption (less than 50%) recorded across agroecological zones (Fernandez-Cornejo and McBride 2000; Chianu et al., 2007). Factors adduced to these variations include farm size, risk and uncertainty, extension contact, human capital, labour availability, credit, property rights and complementary input availability (Falusi, 1976; Feder et al., 1985); access to information (Gartrell et al., 1979 and Argarwal, 1983); physical, socio-economic, cultural and political environments (Erenstein and Cadana, 1997; Alene et al., 2007); asset holdings, unequal distribution of resources, vulnerability, institutional and cultural factors (Meinzen-Dick et al., 2004; Langyintou and Mungoma, 2008). There is therefore need to understand the factors affecting technology adoption in specific locations.

Also, most adoption studies fail to assess the relationship of wealth and adoption, mainly because of the problem associated with using income as a proxy for wealth (CIMMYT, 1993). In a review of 17 articles on wealth ranking, Phiri et al. (2004) indicated that none assessed the use of a new technology by the different wealth groups. Nonetheless, the understanding of the wealth segments into which the farming population could be categorized is an important component of the approaches required to target the adoption of technologies for enhanced productivity. According to Olarinde et al. (2007), risks and uncertainties affect farmers' attitude towards innovations and their adoption behaviour and have to be analysed along wealth status. For instance, low-wealth farmers are often reluctant to adopt technologies because they need stable income particularly when returns to adoption are unclear or will only bear fruits in future. In studies where wealth groups are defined, researchers use arbitrary proxies based on their own definitions of wealth and wealth groups (for example high-, medium- and low- income groups). Such studies have shown that the impact of these technologies have been unequally distributed among different segments of the population.

According to Pachico et al. (2000), and Evenson and Gollin (2003), improved agricultural technology has benefited both producers and consumers in developing countries over the last several decades but by-passed many areas with large numbers of the rural poor. On the other hand, evidence from Datt and Ravallion (1998) show that technological change has benefitted the poor, as an improvement in crop yields reduced the proportion of people living on less than US$1 per day. Poor farmers have different needs, problems and resources compared to the well-off and less ability to adopt new technologies (Grandin, 1988). Thus, recognizing the need to reach the poor in marginal environments, the International Agricultural Research community reoriented many of its programmes towards poverty reduction (CGIAR, 2000). A recent study by Langyintou and Mungoma (2008) found that the factors influencing the adoption and use intensity of improved maize varieties differ between the poor- and well- endowed households in Zambia. Hence, an evaluation of the effects of households' wealth on the adoption of new agricultural technologies in other locations becomes imperative.

In addition, methodological variations have been found in the measurement of individual and household wealth in the developed and developing economies. Bound et al. (2001) employed selected assets to compute household wealth in developed economies by quantifying the economic resources of households without directly asking household members about their incomes and expenditures or the total value of their assets. Most of the assets that were counted in the index were commodities purchased with cash in modern markets such as water heater, fridge and freezer. Traditional forms of wealth, including cattle, land and the control of human labor through kinship systems, peculiar to developing countries economies, are either not included in the index at all or constitute a small minority of the indicator variables used to form the index (Filmer and Pritchett, 2001). Other studies have employed similar approaches to quantify variations in household wealth in developing countries. This leads to a situation in which some people may appear to be wealthy when their traditional holdings are considered, yet appear to be poor according to their score on the wealth index. Langyintou and Mungoma (2008) conducted a study within the African context to address this problem, but even then, results varied in different locations depending on the local ecology and culture.

The foregoing raises pertinent questions of concern: What are the traditional productive assets that could be used to classify households into wealth groups? Are there differentials in household characteristics and wealth indices of improved maize producers? How do the adopters and non-adopters of improved maize technology compare in terms of wealth and other demographic factors? What are the determinants of the probability of adoption and intensity of use of improved maize technology among wealth groups? This paper therefore contributes to the literature on technology adoption by examining household wealth effects in a developing country context. Specifically, the paper evaluates how the poor and the well-off react to the adoption of improved maize technology in the dry savannas of Nigeria. This assessment would provide information to researchers and policy makers for research priority setting, technology targeting, and information dissemination efforts.

Methodology

Survey location and data collection

The study was conducted in two states (Kano and Katsina) located in the dry savanna zone of Nigeria. Based on the land area cultivated to maize and its high output, one district was selected in each of the states: Rano in Kano state and Malumfashi in Katsina state. Ten high maize producing communities were purposively selected in each district with the assistance of the district heads. Considering the number of households per community, between 16 and 20 household heads were randomly selected in Rano while between 15 and 22 household heads were selected in Malumfashi. A total of 175 respondents were selected in each district for the study. Data were collected using survey questionnaire targeted at maize farmers for the 2005/2006 production season. Data were collected on household characteristics and assets, and the adoption and production of improved maize varieties. Secondary data were obtained from district Agricultural Development Programmes (ADPs) on maize production systems.

Data analysis

Data were analysed using descriptive statistics, principal component analysis (PCA) and the Tobit regression model. Principal Component Analysis (PCA) was used to analyse household's wealth index and their impact factors, while the maximum likelihood Tobit regression model (ML) was employed to analyse the determinants of adoption and intensity of use of improved maize varieties. The tests of differences between means and proportions was used to compare variables within wealth and adopter groups.

Computation of wealth index

The wealth index (WI) is a composite measure of the cumulative living standard of a household. Following Langyintuo (2008), this study calculated WI using data on households' ownership of selected assets, such as labour force (human capital), total farm size and area cultivated to improved maize (natural capital), motor cycle, draft animals, radio, bicycle and television (physical capital), access to credit or cash (financial capital), and membership of association (social capital).

Each household asset for which information was collected was assigned a weight or factor score generated through PCA. The assigned weights were then used to construct an overall 'wealth index', applying the formula:

$$W_j = \sum_{i=1}^{k}[b_i(a_{ji} - x_i)]/s_i \qquad (1)$$

where: Wj is a standardized wealth index for each household; bi the weights assigned to the (k) variables on the first principal component; aji the value of each household on each of the k variables; xi the mean of each of the k variables; and si the standard deviations. These standardized scores were then used to create the break points that define wealth categories as Poor- or well- endowed. A negative index (-Wj) means that, relative to the communities' measure of wealth, the household is poorly endowed and hence worse-off while a positive figure (Wj) signifies that the household is well-off or well endowed. In this study, the sample mean index of zero is used. Households with zero mean and above are categorized as well endowed while those below are poorly endowed. The impact factor, which indicates the relative adjustment of the wealth index by acquiring corresponding assets, is computed by dividing the score by the standard deviation.

Specification of the Tobit regression model

The Tobit regression model simultaneously estimates the likelihood of the decision to adopt and the extent (i.e., intensity) of adoption. The approach has been applied in studies of adoption of conservation tillage (Norris and Batie, 1987; Gould, Saupe, and Klemme, 1989) and adoption of alternative crop varieties (Adesina and Zinnah, 1993). This study employed the Tobit model to analyse the effect of wealth and other household factors on the adoption and intensity of use of improved maize technology on farm households in northern Nigeria. The model assumes that a farm household's decision to adopt a given technology, yi, in a given period derives from the maximization of expected utility (income/food security) and satisfy

yi = max (yi*,0) .... (2)

Where, yi = observed dependent variable for the ith household, and y*, the non-observable latent variable (the expected utility). The dependent variable employed in this study is the proportion of land in hectares (between 0 and 1) cultivated to improved maize varieties. Hence, the use of the two-limit Tobit model (Maddala, 1983). However, the utility derivable from the technology depends on a vector of explanatory variables, Xi, which represents households wealth and demographic factors. Based on adoption literature, farm and farmer specific characteristics (such as age, education, household and farm size), institutional factors (e.g. extension, credit, and markets), and technology specific characteristics (e.g. seed availability, yield, and disease/pest resistance) were used as explanatory variables in the adoption model. Thus, the probability that a household will adopt improved maize with a profit or food security objective is a function of the vector of explanatory variables, Xi; the unknown parameters, □i; and the error term, □i, assumed to be independently N (0, σ2) distributed, conditional on the Xi's. The model can be expressed in terms of a latent variable as:

yi* = βXi + µi ....(3)

This is explicitly expressed as: yi = β0 + β1X1i + β2X2i + ... + βNXN + µi (i = 1,2,..N),
Where yi contains either zeros for non-adopters or a positive area under an improved variety. To take account of all the information in yi properly, the tobit estimation method uses maximum likelihood to combine the probit and regression components by the log likelihood function. Since µi, is a function of the independent variables, an attempt to estimate equation (3) using Ordinary Least Squares will result in biased and inconsistent estimates (McDonald and Moffitt, 1980; Maddala, 1983). The use of maximum likelihood estimation guarantees that the parameter estimates will be asymptotically efficient for the appropriate statistical tests to be performed (Gujarati, 2006). In a Tobit equation, the marginal effects are used to calculate elasticities, and each marginal effect includes both the influence of the explanatory variable on the probability of adoption as well as on the intensity of adoption. As Gould, Saupe, and Klemme (1989) observed, the total (marginal) effect takes into consideration that a change in an explanatory variable will affect simultaneously the number of adopters and the extent of adoption by both current and new adopters. Unlike traditional regression coefficients, the Tobit coefficients cannot be interpreted directly as estimates of the magnitude of the marginal effects of changes in the explanatory variables on the expected value of the dependent variable. The Tobit estimates in this study were obtained using the version 10 Stata software for econometric analysis.

Description and measurement of variables for the Tobit regression model

Dependent variable (yi): This is a continuous variable for the ith farmer which is measured by the proportion of land cultivated to improved maize.

Expected signs of independent variables

Farm and farmer characteristics

Age of the ith farmer measured in years affects his mental attitude to new ideas and may influence adoption in one of several ways. Generally, there is no agreement on the sign of this variable in the adoption literature as the direction of the effect is location and/or technology specific (Adesina and Zinnah, 1993).

Education is a measure of the ability to assess new technology. It is measured as a dummy, and scored 1 if household head studied beyond high school and 0 otherwise.It is expected to have a positive impact on technology adoption.

Labour force is the number of persons that work on the farm and it is hypothesized to positively influence adoption (Akinola, 1987).

Institutional factors

Membership of associations and cooperatives enhance the interaction and cross-fertilization of ideas among farmers. It is measured as a dichotomous variable with respondents' membership attracting one and non-membership, zero. A positive sign is hypothesized for this variable.

Extension service provides farmers with information on the importance and application of new innovations through counselling and demonstrations by extension agents on a regular basis. It is measured as a dummy with respondents contact scored 1 and non-contact, zero and the expected sign on the coefficient is positive.

Distance to input and output markets: The greater the distance between the input buying station and the respondents' farm, the higher the acquisition cost. This variable is measured in kilometers (km) and expected to have a negative influence on farmers' adoption behaviour.

Wealth: Assets owned by households determine largely their wealth status and ability to take risks associated with adoption of innovations for production activities (Freeman et al., 2004). The wealth index computed from households' capital assets (human, physical, natural, financial and social) is a measure of the wealth variable.

Technology specific characteristics

The adoption of a technology is promoted by its availability, since it is obvious that the technology will not be used unless made available in the right quantity, form and time. Farmers usually compare the attributes of modern and traditional varieties, and tend to adopt modern varieties only when they are perceived as having better characteristics. The coefficients of these variables are measured as dichotomous (yes or no) and hypothesized to have positive signs.

Results and discussion

Household assets and impact

The major physical capital assets owned by households in the study area are radio, bicycle, motor cycle, draft animals, and television in order of predominance. More than 80% of the households own radio and bicycle, while about 57%, 28% and 21% respectively owned motor cycle, draft animals and television. Respondents indicated that the radio is the most common medium through which information is received about their farm activities. The results of PCA that was run on 10 selected asset indicators are shown in Table 1.

Table 1 : Selected household asset indicators and their impact

Variable	Scoring	Standard deviation	Impact*
Human capital			
Labour force (No.)	0.005	0.214	0.023
Natural capital			
Total farm size (ha)	0.186	0.114	1.628
Area cultivated to improved maize (ha)	0.193	0.088	2.201
Physical capital (No.)			
Motor cycle	0.201	0.128	1.577
Draft animals	0.188	0.155	1.212
Radio	0.193	0.108	1.514
Bicycle	0.120	0.155	0.772
Television	0.191	0.126	1.790
*Financial capital***			
Access to credit or cash	-0.003	0.431	-0.007
*Social capital***			
Membership of association	0.217	0.163	1.330

* The impact factor is computed as the score divided by the standard deviation

** Variable measured as dummy: 1 if household owns the asset and zero otherwise

There were variations in the distribution of households physical asset between the two wealth groups. Bicycle, draft animals, television, motor cycle and radio had the largest impact, in decreasing order of importance. Thus, as household wealth status increases, the first item of investment in the study area is bicycle to ease the movement of inputs (e.g. labour, seed, fertilizer) and outputs from the farmstead to the farm and market center. According to the households, this is capable of reducing the cost of transportation and increasing their net farm income. The second item is draft animals which respondents claim are usually used to work the farm, provide food for their consumption, and serve as income generating avenues to meet other household needs like their health and children education. The radio is the third asset of interest. It provides information on weather conditions, planting dates, input and output locations, and proper agronomic practices, which improves farmers' management skills, prevent avoidable risks and assures sustainable farm production. The motor cycle ranks fourth, as it is a faster means of transporting farm inputs and output to and from the market (particularly due to bad road network). The television ranks fifth and provides both audio and visual extension service information about farm practices and new research findings. Hence, a household's ownership of a combination of these assets classifies the household within the wealth categories of either poorly endowed or well endowed. These results are consistent with household's choice of asset accumulation as wealth increases (Langyintuo et al., 2005).

Fig. 1 depicts the probability distribution of households by wealth group in the study area based on the overall standardized composite wealth index computed from the varying levels of different assets owned by them.

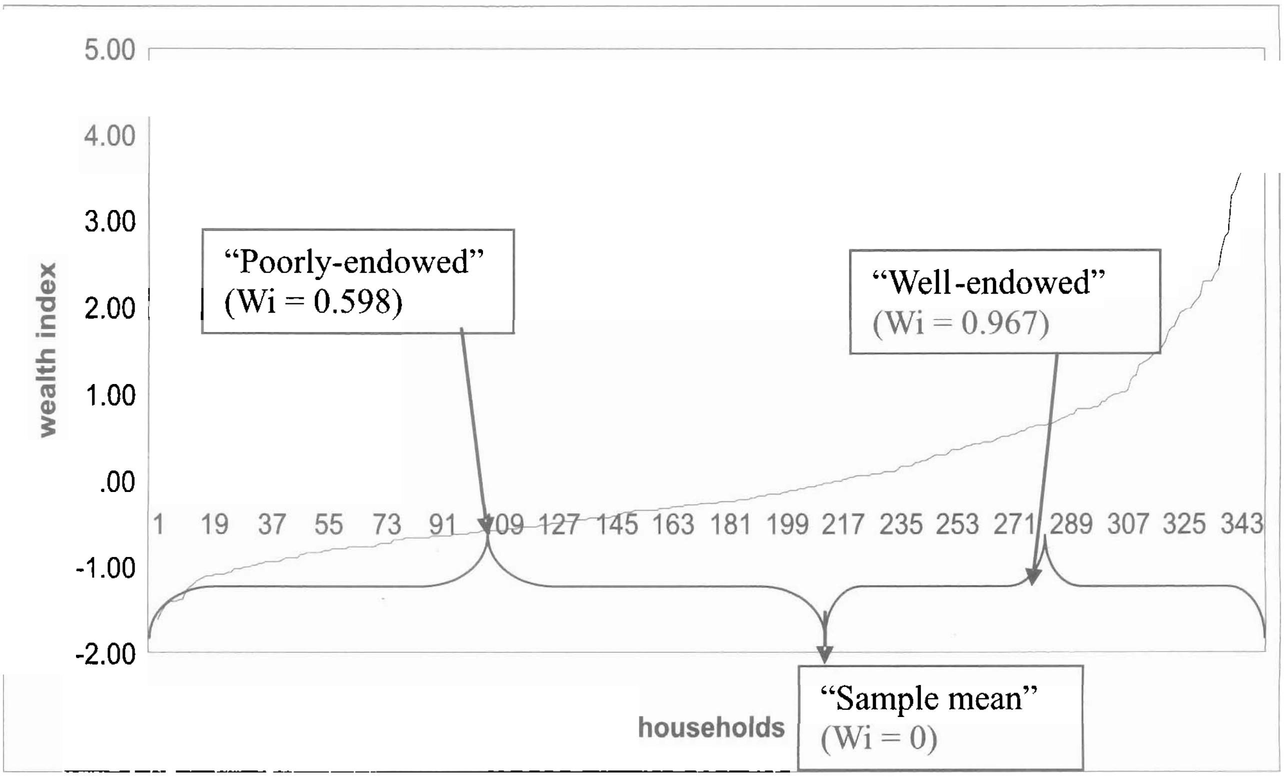

Fig. 1: Probability distribution of households by wealth groups using the wealth index

The average wealth index of the maize producing households below the mean index was -0.599, while those above was +0.967. The distribution of households within the wealth categories showed that there was a decreasing trend in the number of households that belong to each wealth category as the wealth index increased. With a sample mean index of zero, 62% of the households were categorized as poorly-endowed, while 38% were well-endowed. This result is consistent with previous studies (Langyintuo and Mungoma, 2008) and shows that majority of the maize producers in the study area are poor. Thus, any development programme targeted at the poor would better the livelihoods of the people.

Household demographic characteristics and wealth group

The distribution of selected household demographic characteristics according to wealth groups is shown in Table 2.

Table 2: Distribution of household demographic characteristics by wealth group

Variable	Whole sample (n=350)	Wealth group		Significance /t/
		Poorly endowed (n=218)	Well endowed (n=132)	
Demographic characteristics				
Age (years)	47.30 (0.62)	46.67 (0.75)	48.36 (1.07)	1.32
Education (years)	0.99 (0.01)	0.99 (0.01)	0.99 (0.01)	0.11
Credit	0.25 (0.02)	0.25 (0.03)	0.25 (0.04)	0.05
Membership of association	0.65 (0.03)	0.61 (0.03)	0.72 (0.04)	2.18**
Extension contact	0.74 (0.09)	0.68 (0.09)	0.85 (0.16)	0.97
Farm size (ha)	6.31 (0.23)	5.02 (0.22)	8.99 (0.45)	8.98*
Household size (No.)	12.91 (0.25)	13.20 (0.33)	12.45 (0.39)	1.45
Area cultivated to improved maize (ha)	2.19 (0.14)	1.32 (0.08)	3.65 (0.31)	9.13*
Farm distance (km)	4.59 (0.14)	4.66 (0.15)	4.47 (0.26)	0.70
Yield potential	0.77 (0.02)	0.78 (0.03)	0.76 (0.04)	0.38
Pests and diseases	0.04 (0.01)	0.05 (0.01)	0.02 (0.01)	1.11
Seed availability	0.37 (0.03)	0.42 (0.03)	0.30 (0.04)	2.38*
Labour force (man - days)	1.73 (0.05)	1.71 (0.06)	1.78 (0.10)	0.69
Adoption of improved maize (No.)	0.68 (0.03)	0.62 (0.03)	0.79 (0.04)	3.33*
Physical assets				
Bicycle	1.66 (0.08)	1.37 (0.07)	2.13 (0.15)	5.12*
Motor cycle	0.84 (0.06)	0.46 (0.04)	1.47 (0.11)	10.21*
Television	0.32 (0.04)	0.074 (0.02)	0.72 (0.09)	8.59*
Radio	2.13 (0.09)	1.60 (0.07)	2.99 (0.17)	8.65*
Draft animals	0.79 (0.09)	0.24 (0.05)	1.71 (0.20)	8.66*
Cattle	1.55 (0.29)	0.66 (0.22)	3.00 (0.67)	3.94*
Bulls	1.21 (0.17)	0.55 (0.10)	2.29 (0.39)	5.32*
Goats	10.79 (0.57)	9.54 (0.50)	12.84 (1.24)	2.85*
Sheep	6.07 (0.40)	4.13 (0.34)	9.25 (0.84)	6.50*
Local chickens	13.29 (0.99)	12.08 (1.11)	15.26 (1.91)	1.55
Wealth index (wi)	0.01 (0.05)	0.60 (0.02)	0.97 (0.08)	21.93*

() figures in parentheses are standard errors, *, ** indicate significance at 1% and 5% respectively.

There were significant differences between the characteristics of the well- and poor- endowed. A larger percentage of the well endowed households (72%) belonged to associations, and had larger farm sizes averaging about 9 hectares that are located at shorter distances of 4.5km to the market center than the poor endowed. More households (79% as against 62% of the poor endowed) adopted improved maize varieties, and cultivated larger areas of about 3.7ha to improved maize (as against 1.3ha for the poor endowed). However, more of the poor endowed perceived seed availability as an important characteristics of any new improved variety. Though not significant, the positive coefficient of credit shows that both the poor and well- endowed households had almost equal access to credit. This was attributed to the targeting of credit facilities to poor households by the Government and Non-Governmental programmes (such as Sassakawa Global 2000 and Government Starter Pack) in some of the communities during the period under study.

Characteristics of adopters and non-adopters of improved maize varieties

The categorization by wealth group of sampled households into adopters and non-adopters of improved maize and their characteristics are shown in Tables 3 and 4.

Table 3 : Demographic characteristics of households by adopters and non -adopters of improved maize varieties

Variable	Whole sample (n=350)	Adopters (n=239)	Non-adopters (n=111)	t-test
Age (years)	47.30 (0.620)	46.41 (0.724)	49.22 (1.166)	2.11**
Education (years)	0.99 (0.006)	0.98 (0.008)	0.99 (0.009)	0.57
Credit	0.25 (0.023)	0.27 (0.029)	0.21 (0.039)	1.22
Membership of association	0.65 (0.026)	0.74 (0.028)	0.45 (0.047)	5.50*
Extension contact	0.74 (0.085)	0.92 (0.121)	0.37 (0.046)	3.04*
Farm size (ha)	6.31 (0.231)	6.76 (0.285)	5.35 (0.380)	2.90*
Household size (No.)	12.91 (0.251)	12.77 (0.302)	13.22 (0.453)	0.82
Area cultivated to improved maize (ha)	2.19 (0.137)	2.40 (0.164)	1.72 (0.246)	2.31**
Farm distance (km)	4.59 (0.136)	4.56 (0.133)	4.65 (0.319)	0.30
High yield potential	0.77 (0.023)	0.78 (0.027)	0.75 (0.041)	0.63
Diseases/pests resistance	0.04 (0.010)	0.03 (0.011)	0.05 (0.022)	1.14
Availability of seed	0.37 (0.026)	0.39 (0.032)	0.35 (0.046)	0.60
Labour force (man-days)	1.73 (0.053)	1.71 (0.062)	1.78 (0.101)	0.59

() figures in parentheses indicate standard error, *,** Significant at 1% and 5% respectively.

About 68.3% of the sampled households were adopters of improved maize while 31.7% were non-adopters. Significant differences were found between the two categories for age, membership of association, extension contact, farm size, and area cultivated to maize. The farm size and area cultivated to improved maize by adopters were larger than for non-adopters, suggesting that adopters focused on area expansion as well as getting established in social networks that could enhance their knowledge base on good agronomic practices for increased production. A larger proportion of adopters also belonged to associations such as farmers' union and cooperative societies and had more frequent interractions with extension agents. These suggest better access to extension advice on appropriate agronomic practices and stronger linkages with input and output markets. On the other hand, non-adopters were significantly older than the adopters. This supports the findings of Polson and Spencer (1991) that older farmers are less likely to adopt new ideas as they gain more confidence in their traditional ways and methods of farming.

Table 4: Demographic characteristics of adopters and non -adopters of im proved maize varieties by wealth groups

Variable	Poorly endowed			Well endowed		
	Adopters (n=135)	Non-adopters (n=83)	t-test	Adopters (n=104)	Non-adopters (n=28)	t-test
Age	45.869 (0.889)	47.976 (1.347)	1.367	47.135 (1.199)	52.893 (2.224)	2.228**
Education	0.985 (0.010)	0.988 (0.012)	0.170	0.985 (0.011)	1.000 (0.000)	0.735
Credit	0.289 (0.039)	0.181 (0.042)	1.802	0.240 (0.042)	0.286 (0.087)	0.488
Membership of association	0.719 (0.039)	0.422 (0.719)	4.536*	0.769 (0.042)	0.536 (0.096)	2.480**
Extension contact	0.889 (0.144)	0.337 (0.052)	2.936*	0.952 (0.206)	0.464 (0.096)	1.215
Farm size	5.324 (0.278)	4.528 (0.345)	1.788	9.101 (0.501)	8.581 (1.052)	0.462
Household size	13.259 (0.414)	13.096 (0.529)	0.242	12.144 (0.433)	13.571 (0.892)	1.497
Proportion o f land cultivated to improved maize	0.339 (0.031)	0.330 (0.043)	0.178	0.360 (0.030)	0.259 (0.044)	1.568
Area planted to improved maize	1.392 (0.086)	1.201 (0.140)	1.235	3.735 (0.319)	3.326 (0.844)	0.541
Distance to market	4.648 (0.168)	4.687 (0.300)	0.121	4.447 (0.215)	4.536 (0.911)	0.142
Wealth index	-0.525 (0.027)	-0.720 (0.040)	4.186*	1.021 (0.091)	0.768 (0.199)	1.245
High yield potential	0.770 (0.036)	0.783 (0.046)	0.218	0.788 (0.040)	0.643 (0.092)	1.599
Diseases/pests resistance	0.044 (0.018)	0.048 (0.024)	0.128	0.010 (0.010)	0.071 (0.050)	1. 962
Seed availability	0.422 (0.043)	0.422 (0.055)	0.008	0.337 (0.047)	0.143 (0.067)	2.009**
Labour force	1.691 (0.072)	1.729 (0.111)	0.303	1.742 (0.106)	1.928 (0.229)	0.787

( ) Figures in parentheses indicate standard error; *,**Significant at 1% and 5% respectively.

The classification of household wealth groups into adopters and non-adopters showed that membership of association, frequency of extension contact, and wealth index were significantly different between adopters and non-adopters within the poor endowed wealth group, with adopters having a larger proportion (Table 4). For instance, a higher percentage of the adopters within the poorly endowed group belonged to associations, had more extension contact, and were wealthier than the non-adopters. This corroborates the claim that extension agents identify farmers who are innovators, pay them frequent visits, and spend more time with them (Philip, 2001). On the other hand, age, membership of association and seed availability significantly varied between adopters and non-adopters in the well-endowed category. However, while non-adopters were older in age on the average than adopters, a larger proportion of adopters belonged to associations, and considered seed availability as important for adoption. These factors are therefore relevant for consideration in the adoption of maize varieties among wealth groups in the study area.

Determinants of the probability and intensity of adoption of improved maize varieties by wealth group

The elasticities of the Tobit regression estimates presented in Tables 5 and 6 take into account that a change in an explanatory variable will simultaneously affect the number of adopters and the proportion of hectarage under adoption of improved maize technology. The estimates of the probability of adoption are shown in Table 5.

The log likelihood ratio and sigma estimates show that the amount of variation explained by the model is significantly different from zero. Membership of association and wealth index significantly and positively influenced the probability of adoption of improved maize by the poorly endowed, while farm size and perception of yield potential have significant but negative effects. Hence, a one-percent increase in the number of farmers joining associations (such as farmers' union and cooperative societies), would lead to an increase in the expected proportion of maize areas cultivated to improved maize varieties by 0.112%. This corroborates the findings of the adopter-perception model employed by Gould et al. (1989) and Chianu et al. (2007) that the perceived attributes of innovations condition adoption behaviour. In addition, a one-percent improvement in the wealth status of poorly endowed farm households would increase the probability of adoption of improved maize varieties by 0.39%. On the other hand, a one-percent increase from the mean farm size (harvested hectares) by poorly endowed farmers leads to a decrease in the expected proportion of maize area cultivated to improved maize by 0.058%. This may be as a result of poor farmers' inability to access and afford complementary inputs (such as land, labour, fertilizer and pesticides etc.) required to cultivate additional land to improved maize. It may also be associated with farmers' risk averse behaviour and their negative perception of the yield potential of improved maize. This reduces the proportion of adopting farmers by 0.123%, as corroborated by Erenstein and Cadena (1997), and Fernandez-Cornejo and and McBride (2000). These findings imply that membership of association, farm size, perception of yield potential, and wealth are the major factors determining the adoption of improved maize varities by poorly endowed farm households. They are therefore important for consideration by development programmes or policy strategies targeted at the adoption of improved maize among rural households in the study area.

Table 5 : Determinants of households' probability of adoption of improved maize varie ties by wealth group

Variable	Whole sample (n=350)	Wealth group Poorly endowed (n=218)	Well endowed (n=132)
Age	-0.02 (0.002)	0.02 (0.002)	-0.001 (0.002)
Education	-0.107 (0.159)	-0.337 (0.227)	0.130 (0.182)
Membership of Association	0.084** (0.044)	0.112** (0.056)	0.012 (0.060)
Extension contact	-0.003 (0.014)	0.006 (0.020)	-0.019 (0.016)
Farm size	-0.029* (0.006)	-0.058*(0.009)	-0.014*(0.006)
Distance to market	-0.019* (0.008)	-0.018 (0.012)	-0.017***(0.009)
Wealth index	0.109* (0.030)	0.390*(0.092)	0.043 (0.037)
Yield potential	-0.081 (0.053)	-0.123***(0.070)	-0.029 (0.066)
Pests and diseases	-0.117 (0.115)	-0.166 (0.140)	0.121 (0.206)
Seed availability	0.061 (0.043)	0.010 (0.056)	0.145**(0.058)
Labour force	-0.035***(0.021)	-0.023 (0.030)	-0.052**(0.024)
Constant	0.768*(0.200)	1.298*(0.303)	0.529*(0.225)
Pseudo R^2	0.132	0.177	0.522
Sigma	0.350* (0.015)	0.377*(0.020)	0.250*(0.018)
Log likelihood	-146.442	-114.969	-10.156
LR chi^2 (10)	44.38*	49.27*	22.20**

( ) Figures in parentheses indicate standard error,
*,**,***Significant at 1%, 5% and 10% respectively.

For the well endowed, farm size, seed availability, labour force, and distance to input and output markets significantly influence the probability of adoption of improved maize. Apart from seed availability which had a positive coefficient, other variables recorded negative effects. Hence, a one-percent increase in farmers' perception of the availability of improved seed would lead to a 0.145% increase in the proportion of well endowed farmers that would adopt improved maize. On the other hand, every unit increase in farm size has the probability of reducing the number of adopters that are well endowed by 0.014 units. This may be associated with the negative interactive effects of other productive factors such as inability to access adequate and appropriate labour, and bad road linkages to the long distance input and output markets. Thus, in promoting the adoption of improved maize varieties among well endowed households, these factors are important for consideration. It is important to note that wealth has no effect on the probability of adoption of improved maize by the well endowed. However, for the whole sample of both poor- and well- endowed, membership of associations, farm size, distance to input and output markets, labour force, and wealth status significantly influenced the probability of farmers adopting improved maize. Thus, for development programmes aimed at both the poor- and well- endowed households (irrespective of wealth status), these factors have to be taken into account in promoting the adoption of improved maize varieties in the study area.

These findings have economic implications for development programmes aimed at promoting and targeting new technologies to specific wealth categories or to rural farm households for improved livelihood of the farming households. The results also suggest that it is not wealth alone that determines the probability of adoption of improved maize varieties by poor farmers. Thus, if the wealth status of poor households cannot be increased in the short run, their livelihood could be improved through access to other factors such as encouraging farmers to join associations to improve their social networks, improving yield potentials of the technology, and providing opportunities to larger farm areas through appropriate land reforms.

Factors determining the intensity of adoption by wealth group

Based on the second stage Tobit regression estimates, the elasticities of marginal effects are shown in Table 6.

Table 6: Determinants of households' intensity of adoption of improved maize varieties by wealth group

Variable	***Marginal effects*** *(δy/δx)*		
		Wealth group	
	Whole sample (n=350)	Poorly endowed (n=218)	Well endowed (n=132)
Age	-0.025 (0.271)	0.031 (0.382)	-0.200 (0.311)
Education+	-0.335 (0.500)	-1.104 (0.752)	0.385 (0.537)
Membership of association+	0.173***(0.091)	0.225** (0.115)	0.027 (0.131)
Extension contact+	-0.007 (0.031)	0.014 (0.045)	-0.448 (0.039)
Farm size	-0.582* (0.120)	-0.966* (0.180)	-0.392**(0.158)
Distance to market	-0.276* (0.123)	-0.279 (0.185)	-0.237***(0.124)
Wealth index	-0.058* (0.017)	-0.777* (0.199)	0.096 (0.083)
Yield potential+	-0.200 (0.132)	-0.318***(0.182)	-0.069 (0.157)
Pests and diseases+	-0.014 (0.014)	-0.025 (0.021)	0.007 (0.012)
Seed availability+	0.074 (0.052)	0.014 (0.078)	0.130**(0.053)
Labour force	-0.196***(0.118)	-0.129 (0.171)	-0.295**(0.135)

( ) Figures in parentheses indicate standard error,

*,**,***Significant at 1%, 5% and 10% respectively

(+) dy/dx is for discrete change of dummy variable from 0 to 1.

The regressors are all inelastic because the significance levels of the elasticities are identical to those of the original coefficients. This supports the findings of Baum (2006) and Langyintuo (2008). Thus, for the whole sample comprising the two wealth groups, membership of association, farm size, labour force, distance to input and output markets, and wealth status significantly influenced the intensity of farmers use of the technology (i.e. area cultivated to improved maize) after deciding to adopt the technology. While membership of association had a positive influence, other variables recorded a negative effect. Hence, for every additional farmer who joins a social network (farmers association or cooperative society), the area cultivated to improved maize increases by 0.173 units. On the other hand, increasing farm size, labour force, and distance to markets by one unit would lead to a corresponding reduction of 0.582, 0.196 and 0.276 units, respectively in the amount of land area cultivated to improved maize after adoption. However, while wealth status positively influenced the probability of farmers' adoption of improved maize, a negative influence was established between wealth status and the area cultivated to the improved maize after adoption. This could be associated with the overwhelming negative effects by the majority of farmers who are poorly endowed. For a one-unit improvement in the wealth status of farmers in the study area, the intensity of cultivation of improved maize reduces marginally by 0.058 units. This implies that though wealth can promote the adoption of improved maize, it is not a sufficient factor to bring about the cultivation of large areas to improved maize.

For the poorly endowed, membership of association empowers them to increase the area cultivated to improved maize after adoption, suggesting that this category of farmers should be encouraged to join cooperative and farmer associations in the locality. However, increasing the farm size by one unit would lead to a reduction in the intensity of use of the technology by 0.966 units, showing that the poorly endowed cannot cope with large farms on adoption of improved maize. This may be attributed to the need for credit facilities to purchase other associated inputs such as fertilizers and agrochemicals required to enhance production of the high yielding maize varieties. Similarly, farmers' perception of high yield potential of the improved maize reduces the intensity of adoption by 0.318 units. However, a one-unit improvement in the wealth status of poorly endowed households results in a high reduction of the area cultivated to improved maize variety by 0.777 units. This shows that rather than increase the proportion of land cultivated to improved maize as their wealth status improves, poorly endowed households reduce their crop area. This corroborates the findings of Zeller et al. (2006) that with an improvement in wealth status, farmers tend to move away from farming to other non-farm economic activities as a means of livelihood. This thereby curtails their efforts at increasing their farm size. Respondents adduced a similar reason to the estimated reduction of 0.4 units in the intensity of use of improved maize technology, for every unit increase in farm size by the well endowed. This further shows that wealth cannot be thought of as accounting for the cultivation of large land area to improved maize. Distance to input and output markets, and labour force also had significant but negative influences on the area cultivated to improved maize after adoption by the well endowed. These may be attributed to bad road network to market centres which prevents easy transportation of inputs into and outputs from the farm. In addition, respondents claim that most young enterprising members in the survey location have migrated to urban centres for white collar jobs due to inaccessibility to productive resources and low farm yields, while those left behind engaged in non-farm activities (e.g. motor cycle business - adache), believed to be more lucrative. This view is corroborated by Dinechin (2009). However, availability of youth labour would only increase with a dynamic rural economy in both the farm and non-farm sectors. The consistency in the results obtained confirms the effectiveness and accuracy of the wealth ranking approach employed in this study in determining the wealth groups of households.

Summary and conclusion

Using data collected from 350 maize producing households in two districts in the dry savanna zone of Nigeria, this paper investigated the impact of wealth on the probability and intensity of adoption of improved maize by farm households. Principal component analysis (PCA) was employed to rank the productive assets of the households into two major wealth categories: poor- and well- endowed. About 62% and 38% of the households were respectively grouped as poor- and well-endowed, suggesting that majority of the maize producers in the study area are poor.

Based on the traditional forms of productive assets in the survey locations, PCA results showed that five assets (bicycle, draft animals, television, motor cycle and radio) with the largest impact, account for the major items of investment as household wealth increases. Significant differences existed between the characteristics of the two wealth groups, with a larger proportion of the well endowed belonging to associations, adopting more and cultivating larger areas to improved maize. About 68% of the sampled households (56% poor- and 44% well- endowed) were adopters of improved maize while 32% (75% poor- and 25% well- endowed) were non-adopters. Membership of association, perception of yield potential, and seed availability were significantly different between the adopters and non-adopters in the two wealth groups, suggesting that the more the number of households in farmers' associations and cooperative societies, the higher the rate of adoption of improved maize, which subsequently increases the wealth status. In addition, breeding programmes should be targeted at developing high yielding maize varieties, while adequate seed delivery system should be in place to get relevant inputs to the farmers.

The adoption behaviour of the poor- and well-endowed also varied. Frequency of extension contact, seed availability, yield potential, and wealth significantly and positively influenced the probability of adoption of improved maize among the poorly endowed, while farmers' age, membership of association, yield potential, seed availability and resistance to pests/ diseases were significant among the well endowed. These suggest that improving the asset base of farmers enhances the adoption status of improved maize. It also suggests that apart from wealth, other factors are capable of increasing the adoption of improved maize varieties by farmers. For instance, adequate seed delivery system and breeding programmes targeted at developing high yielding maize varieties would promote the adoption and effective use of improved maize by the farming households.
These findings have implications for development programmes aimed at promoting and targeting new technologies to specific wealth categories. This is capable of boosting crop output, strengthening the food security situation, and improving the livelihoods of the farming households, through a large spill-over effect on other farm households.

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