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Impact of cooperative membership on farmers' uptake of technological innovations in Southwest Nigeria

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The underutilization of agriculture in Nigeria with attendant low yield per hectare is generally attributed to lack of innovation to cope with the challenges of climate change and land degradation. In this study, using information from 326 farmers in Southwest Nigeria, we examined the relative impact of cooperative membership compared with the effects of other socioeconomic factors on farmers' adoption of technological innovations. Cooperative membership has a high impact compared to other socioeconomic factors such as land access, gender, and educational status. It is recommended that intervention programs in the agricultural sector should focus more attention on strengthening and expanding farmers' cooperatives for better diffusion and use intensity of innovations and better linking social capital with extension agencies, banks, markets, and agricultural value chains.

Keywords: innovations; farmers' cooperatives; rural agriculture; social capital; Nigeria

Introduction

The primary motivation for farmers' adoption of technological innovations is the improved financial benefits accrued by means of enhanced productivity. There are two main perspectives from which adoption of technological innovations can be assessed. The first focuses on the factors influencing the decision of farmers to adopt particular technologies, and the second relates to the trends and spread of use in the aftermath of adoption (Feder and Umali 1993). Sometimes, adopted technologies are abandoned after years of experimentations, for various reasons ranging from hazards to economic constraints (Marenya and Barrett 2007). Researchers have examined the impact of economic constraints and other socioeconomic characteristics (Reardon and Vosti 1997; White, Labarta, and Leguia 2005; Marenya and Barrett 2007; Langyintuo and Mungoma 2008), technology characteristics (Adesina and Zinna 1995; Adesina and Baidu-Forson 1995), information and knowledge about innovations (Daberkow and McBride 2003; Spielman et al. 2008), and ownership and risk (Greiner, Patterson, and Miller 2009; Meuwissen, Huirnea, and Hardakera 2001) on farmers' adoption behaviors.

In comparison, little scholarly attention has been devoted to the impact of social capital on farmers' adoption of technological innovation, and the effect of social capital on other adoption factors. There is, in particular, a dearth of data on adoption factors and behaviors in West Africa. In this study, we examine the factors influencing farmers' adoption of technological innovations in Southwest Nigeria, with particular attention to socioeconomic characteristics and the role of cooperative membership as a form of social capital.

Agricultural production, cooperatives, and innovation in Nigeria

Nigeria, with a population of about 150 million people, is the most populous country in Africa, and more than 50% of the population live in rural areas. The total land area is 911,000 sq.km, and about 80% of this is available for various agricultural purposes, including arable land, permanent crops, pastures, and irrigated land (FAO 2013).

Although Nigeria is the world's largest producer of cassava, yam, and cowpea, it is still a food-deficit nation and a net importer, and more than 80% of rural dwellers live below the poverty line. Agricultural land is severely underutilized, with less than 50% of land cultivated as of 2009, and less than 7% of irrigable land irrigated (IFAD 2009a).

One of the factors associated with the prevalence and continued increase in rural poverty and food poverty is the state and quality of farming practices. Recent surveys

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indicate that about 44% of male farmers and 72% of female farmers cultivate less than 1 hectare per household, and that only about 34 million of 83 million hectares – 40.96% of agricultural land – is currently being cultivated. About 90% of Nigeria's food is produced by small-scale farmers cultivating small pieces of land (IFAD 2009a, 2009b). Moreover, for the less than 50% of agricultural land currently being cultivated, yield per hectare is low compared to other developing countries such as Brazil and Thailand, owing to the following main factors: (i) prevalence of rain-fed agriculture; (ii) impact of environmental degradation; and (iii) continued use of crude implements and methods (FAO 2005; Anete and Amusa 2010; Oni 2011).

Lack of adequate access to land is one of the major obstacles experienced by small-scale farmers in Nigeria. The land tenure system in Nigeria, by which individuals gain access to land for agricultural, residential, and commercial purposes, varies across the country, but the communal system of land ownership, by which control and allocation are vested in groups and kinship, is the most prevalent among most ethnic groups. Under this system, large parcels of land are owned by clans and extended families and shared among members of the group. Chiefs and village heads, with proportionately larger holdings on account of their status, also play important roles in the control of access to land (Onyebinama 2004; Philip et al. 2009). In 1978, and with updates and modifications in 1990, the military government promulgated the Land Use Act in a bid to correct some of the weaknesses and difficulties inherent in the communal system of land ownership. This law transferred the ownership and control of land to the states and local governments, under the leadership of executive governors and chairmen, respectively.

These land reforms do not seem to have had a significant impact on farmers' access to agricultural land. Recently, the federal Minister of Agriculture remarked that 'Nigeria has an estimated 84 million hectares of arable land. Yet today we only cultivate 40 percent of this land, and only 10 percent of it optimally' (Adesina 2014, 2). However, past policy interventions of Nigerian governments ensured better access to large areas of land for farmers in farm settlements. For example, in the defunct Western Nigeria in the 1960s, under the farm settlement program modeled after the Israeli Moshavim, each settler was given about 50 acres of land for cultivation, later reduced to 25 acres to accommodate new settlers (Okuneye 1984; Oyatoye 1984). These past interventions were severely limited by the fact that only a small fraction of rural farmers benefited, and there have been no new farm settlements established in more than 20 years in Southwest Nigeria.

In addition to the challenge of land access, agricultural production in Nigeria faces two other major challenges. One is the problem associated with non-availability, or severe restrictions, of agricultural credit which enables farmers to access and apply various inputs for improved production and profit. The other concerns the various difficulties encountered with the availability, cost, and relevance of the appropriate technology necessary for improved yield.

The history of government interventions in agricultural production in Nigeria has been characterized by a focus on those two important elements highlighted: provision of credit and promotion of technological innovations. Traditionally, small-scale farmers, especially in the rural areas, have mostly relied on informal means of financing, including loans from family members and friends who lend to farmers more as a social obligation (Badiru 2010).

In spite of the grand ambitions on paper, budgetary allocations and administration of funds have not measured up to aspirations. A study on budgetary allocations between 1990 and 2002 indicates that the percentage of total national budget allocated to agriculture was 1.28% in 1999 and typically fluctuated between 1.7% and 4.9% (Eze et al. 2010).

While the lack of financial support from government is significant, one report identified the low use of modern technology as the main direct cause of low agricultural productivity in Nigeria (World Bank 2006). Other investigators have found that, whereas it was much more efficient for Nigerian farmers to employ modern technology in the cultivation of cassava, plantain and yam, very few farmers have access to such facilities, mainly due to lack of funds and the ready availability of cheap and simple traditional tools. As a result, farmers are reduced to subsistence levels (Tre and Lowenberg-Deboer 2005; Nkakini et al. 2006).

The role of social capital in the development and diffusion of innovations has been explored by several investigators, and it is one of the fundamental parameters considered by experts in a discussion of the speed and rate of adoption (Rogers 1995; Valente 1996; Deroian 2002). It is acknowledged that, in addition to the engineering process and the role of markets, social capital, with its unique emphasis on relational rather than technical tools, constitutes a crucial, if intangible, ingredient in the success of innovations (Landry, Amara, and Lamari 2002). Social capital can take the form of trust, norms, and networks, and it is in these contexts that the role of cooperative societies can be examined with regard to the adoption of innovations (Novkovic 2008).

Cooperatives, by design, fundamentally rely on social capital as well as generate it (Valentinov 2004). Various investigations have shown that membership and participation in a cooperative increase the uptake of technological innovations. Among other things, it was suggested that information and knowledge about innovations spread more quickly within a cooperative compared with individual farmers, and this enhances confidence about innovative practices and helps facilitate a more efficient implementation and application. Also, there is better access to credit for members of cooperatives, compared with their low-income individual counterparts, and availability of funds has a positive correlation with a higher rate of the adoption of innovations (Deji 2005; Nwakwo, Peters, and Bolkemann 2009).

Nigerian government policies have been dominated by significant control and injection of credit into agricultural banks and other microcredit institutions. Invariably, funds deplete and the cooperatives, because of their weak structure and operation, are unable or unwilling to repay loans (Agbo and Chidebelu 2010). There has recently been greater recognition of the need for reform of cooperatives, in terms of greater autonomy and more effective business models relevant to the challenges and opportunities of the twenty-first century. In the current national Agricultural Transformation Agenda (ATA), the federal government has stated that the cooperative policy and the entire agricultural sector will be driven by entrepreneurial capacity and an agribusiness paradigm, and farmers' cooperatives will be at the heart of market reforms (Adesina 2014)

Cooperatives employ several means for the diffusion of innovations. Among others, technical and commercial information can be provided by means of periodic bulletins distributed among members. Talks, meetings, field demonstrations, and educational courses are also arranged for members to learn new production techniques, and cooperatives often appoint some members in their ranks to specialist teams whose responsibility is to explore and design improved methods and subsequently provide feedback and relevant advice for members (Manrique et al. 2002).

Some types of technologies, including most land management innovations, are better suited in their design and applications to groups of farmers than individual households, and here the role of cooperatives is even more significant. For example, a Family Drip Irrigation System, originally developed in Israel, requires the participation of 100 farmers working in a cooperative, and has been applied with some success both in Israel and some African countries (MASHAV 2002). The economy of scale for technological innovations is such that farmer groups, rather than individual farmers, reap the optimum benefits from adoption, are better positioned to share and mitigate risks, and deal more effectively with limitations that may arise from the amount of funds required to procure, apply, and maintain innovations.

The main hypothesis of this paper is that the barriers to access and adoption of innovations are reduced through cooperative membership. We argue that information about, access to, and benefits from innovations are more easily available in cooperatives. Moreover, extension workers tend to operate more efficiently with groups of farmers, rather than individual holders, and cooperatives sometimes contribute funds to buy equipment and seedlings for group use (Adeogun, Olawoye, and Akinbile 2010).

Hypotheses

The main question in this investigation was considered in two main aspects: one, what is the likelihood that farmers in cooperatives will adopt innovations more than their individual household counterparts? Two, which other factors influence the adoption of innovations, and what are the impacts of innovation adoption on cooperative and non-cooperative farmers. The null hypotheses of this research question are set out as follows:

> *Hypothesis 1*: Cooperative farmers are not more likely to adopt innovations than non-cooperative farmers.

Here the term 'cooperative farmers' is taken to include members of multi-purpose cooperatives and other types of cooperatives, as well as members of farm settlements. 'Non-cooperative farmers' refers to individual small-scale holders – similar to the scale of holdings for cooperative farmers – who cultivate their farms and produce their goods without direct support from any cooperative.

> *Hypothesis 2*: Cooperative membership does not influence the adoption of innovation more than personal attributes.

Here, the focus is on the significance of cooperative membership – when compared with personal attributes and other socioeconomic factors – in the adoption of innovations. Attributes and factors considered include age, gender, marital status, and educational level. These variables have been identified in the literature as factors exerting a significant influence on decisions to adopt and the level of adoption, and the objective is to examine whether or not they exert a greater influence on adoption decisions than membership of cooperatives. This is done by examining whether or not, say within the same age group, more cooperative farmers adopt innovations than non-cooperative ones.

> *Hypothesis 3*: Cooperative farmers do not have better access to land than non-cooperative farmers.

This hypothesis considers and compares the amount of land available to both groups to assess the advantage one category of farmers has over the other. It will also consider the impact of land access on adoption and intensity of innovation.

> *Hypothesis 4*: Cooperative farmers do not benefit more from the adoption of innovations than non-cooperative farmers.

This is an assessment of the relative impacts of the adoption of innovations, rather than a consideration of the likelihood of adoption. This examines how much each category of farmers benefits from adopting similar types of innovations, and this impact is measured by a consideration of differences in productivity, farm sales, and profits.

The survey

A pilot study was conducted in 2012 at Ido Local Government area in Ibadan, Oyo State, in Southwest Nigeria. About 45 cooperative and non-cooperative farmers were interviewed. The cooperative used, now known as Cassava Growers Association, was founded in 1978 and has more than 100 active members and many more on the members' register. The results of the pilot study were used to modify and fine-tune the questionnaire and overall research strategy for the main investigation.

For the main investigation, a multistage sampling procedure was used, against the following general criteria: (a) availability of land; (b) intensity of agricultural production; (c) history of direct government intervention, especially with regard to establishment of farm settlements; and (d) the presence of active farmer groups and cooperatives.

Thus, with regard to the set criteria, Southwest Nigeria was selected out of the six geopolitical zones in Nigeria on account of its geographical and historical significance in the agricultural history of Nigeria. As stated earlier, Southwest Nigeria was a pioneer in innovative agriculture, large-scale organization of farmers into cooperative groups in the 1950s and 1960s, establishment of farm settlements modeled after the Israeli Moshavim, and the establishment of agriculture as the main source of external revenue before the discovery and commercial production of crude oil. Within Southwest Nigeria, Oyo State was chosen out of the six states.

In addition to being the political headquarters of the old Western region, Oyo State is currently the leading producer of cassava in Nigeria, Nigeria being the largest producer of cassava in the world. Oyo State is also one of the major producers of maize in the country. This research focuses on high-yielding cassava and maize varieties, among six other innovations. These are two of the main staple crops in Nigeria. In Oyo State, there are 33 local governments, although the majority of the local governments are in high-density areas of principal cities and could not be selected for the purpose of this field survey. Thus, against the set criteria above, four local governments were selected: Oyo West, Afijio, Ido, and Egbeda local governments. These are four of the major local government areas by land area, and Afijio and Ido local governments in particular are hosts to two farm settlements. Across the four local governments, 25 communities were visited, and 331 farmers interviewed. Of these, 326 questionnaires were found valid for the purpose of analysis.

Using the criteria set out above, information was elicited from farmers using structured and semi-structured interview schedules. In the villages and farm settlements, roughly every third household was contacted, and all the sections of the settlements, with respect to geographical spread, were reached. For cooperative members outside of the farm settlement structure, arrangements were made through key contact persons in each community/village, and these gatekeepers helped to contact their members, and sometimes gather them in designated locations where the interview was carried out. Also, to ensure that issues around gender are adequately examined in this study, the investigation was designed such that roughly every third respondent was a woman. The target of 'every third woman' was used because there were some difficulties in gaining access to female farmers, especially married women who were often discouraged from giving interviews by their husbands. Also, in the survey area, there appear to be more men engaged in the cultivation of crops, with more women engaged in post-harvest processing and other value-added activities.

Methods of analysis

Uptake of technological innovation is the main dependent variable in this investigation, and was measured by *rate of adoption,* and *duration of use.* In total, six innovations were examined in this study: tractor combines, high-yield maize, high-yield cassava, pesticides, fertilizers, and irrigation technology. To measure the rate of adoption, respondents were asked if they used the listed innovations, and to access the duration of use, information was elicited using four timeframes: last 2 years, 3–5 years, 5–10 years, and more than 10 years.

For the independent variables, cooperative membership was measured using farmers' response to the relevant question in the interview schedule. In addition, socioeconomic factors considered are age group, marital status, level of education, and non-farm income.

Descriptive statistics were used to obtain the frequency distributions and cross-tabulation analyses of the variables, and to explore some associations between them.

Using SPSS version 18, multiple regression analyses were undertaken to evaluate the combined effects of the independent variables (cooperative membership and socioeconomic characteristics) on the predictor variable (on use intensity of technological innovations). Standardized *Beta* coefficients were used to obtain the combined effects of the independent variables on the dependent variable (Bryman and Cramer 2009).

The equation for the multiple regression model is given as follows:

$$y_i = \beta_1 x_{i1} + \cdots + \beta_p x_{ip} + \varepsilon_i = x_T^i \beta + \varepsilon_i,$$
$$i = 1, \ldots, n,$$

where y_i represents the uptake of technological innovations (the dependent variable), x_i are the independent variables or regressors, β is a p-dimensional parameter vector, and ε_i is the error or disturbance term which captures all the other factors influencing the dependent variable other than the regressors.

Analysis of variance was used to assess the overall significance of the model used using $p < .05$ as criteria of significance. In addition, we obtain the adjusted R^2 value to find the contribution of our model to the overall variance in technological uptake.

One of the main weaknesses associated with the ordinary least-square method used in linear regression analysis is the presence of endogenous regressors leading to inconsistency in parameter estimations. In this study, this problem was taken into consideration in the analysis of factors influencing the adoption of technological innovations, for some endogenous regressors identified. Thus, the approach of instrumental variables, based on a two-stage least-square method (2SLS), was used to analyze the variables for uptake of innovations. As outlined in the foregoing, the problem of endogenous regressors was deemed less significant on use intensities, since respondents in that case were already adopters.

An instrumental variable was chosen such that it did not directly influence the dependent variable, but has an effect on one or the other regressor. Therefore, the first condition of selecting an instrumental variable was that it must be exogenous (uncorrelated with the error). The second condition was that there must be at least the same number of instrumental variables as there are regressors (explanatory variable). This condition is known as 'just identified'.

Thus, in this study, the dependent variable is *adoption of innovation*, one of the independent variables is *land cultivated*, and *land source* is selected as an instrumental variable, since it can have an impact on *land cultivated*, but no direct impact on *innovation adoption*.

It is acknowledged that while regression analyses show relationships between variables, they do not demonstrate causality. However, with respect to the question of whether innovation uptake is caused by cooperative membership, or vice versa, the logical justification for the assumption in this study is that cooperative membership can strengthen the factors involved in the stages that come before adoption of innovation, including information and awareness. In other words, whereas cooperation can influence awareness of innovations, innovation uptake does not logically lead to awareness of the innovation. However, other avenues for information and other forms of social capital exist outside cooperatives. A comparative analysis of the social capital of cooperative and non-cooperative farmers is a priority for future research.

According to this procedure, seven instrumental variables were selected – land source, land rent, marital status, network innovation access, awareness method, farm sale, and transport means, along with six regressors – age group, gender, education level, cooperative membership, land cultivated, and farm income. Thus, as required, the model is over-identified with the number of instruments (seven) greater than the number of regressors (six).

The 2SLS *Instrumental Variable* estimator is defined by the equations:

$$\beta_{\mathrm{IV}} = \left(X'P_zX\right)^{-1}X'P_{zy} \\ = (X'X)^{-1}X'_y,$$

where $P_z = Z(Z'Z)^{-1}Z'$ and $X = P_zX = Z(Z'Z)^{-1}Z'X$.

Results and discussion

Summary of independent variables: frequency distributions

From the summaries in Table 1, we observed that 45.4% of respondents were cooperative members, 70.2 are male, and 62.6% had at least primary educational qualification. Also, most of the farmers (71.8%) were 60 years old or less, and the majority (51.5%) had no access to non-farm income.

Rate of adoption

Data on farmers' usage of the listed innovations were analyzed using frequency distributions. Results of the findings are shown in Table 2.

The rate of adoption is defined as the percentage of farmers who adopted the innovation in the year of observation, from the reference year in which the innovation was first introduced. Majority of the innovations under investigation were introduced about 25 years ago, some longer, but the majority of the farmers have been engaged in farming within the past 25 years, so 1987 is taken as the approximate year of reference of the introduction of innovation, and the year 2012 as the year of observation.

The results (Table 2) indicate that the highest adoption rates are for pesticides and fertilizers, at 88.3% and 85.6%, respectively. Adoption of tractor and high-yield cassava is also considerable, above 60%, but adoption of high-yield maize is a little lower. Of all the innovations examined, adoption of irrigation is very low at 6.7%.

The speed of adoption is measured as the ratio of adoption rates and the number of years, taken as 25, since the introduction of the innovations. This provides further information on the spread and popularity of the innovations since the time of the first introduction. The figures for adoption speed, in Table 2, indicate that the highest speed of adoption is for pesticides at 3.5%/year. Also, the average speed is 2.5%/year for all the innovations investigated, and the speed is especially low for adoption of irrigation, at 0.3%. Subsequent analyses will focus on the impact of socioeconomic factors on the rate and speed of adoption,

Table 1. Frequency distributions.

Variable	Frequency	Percentage
Cooperative membership		
Non-members	178	54.6
Members	148	45.4
Total	326	100
Type of cooperative		
None	154	47.2
Multipurpose service cooperative	106	32.5
Specialist/single production cooperative	4	1.2
Farm settlement	58	17.8
Missing	4	1.2
Total	326	100
Gender		
Male	229	70.2
Female	97	29.8
Total	326	100
Level of education		
No formal education	122	37.4
Primary education	100	30.7
Some secondary education	36	11
Completed secondary education	36	11
Post-secondary education	16	4.9
Degree/postgraduate education	14	4.3
Missing	2	0.6
Total	326	100
Age group (*years*)		
17–25	8	2.5
26–34	37	11.3
35–44	82	25.2
45–60	104	31.9
60+	95	29.1
Total	326	100
Monthly non-farm income (*Naira*)		
None	168	51.5
Less than 10,000	80	24.5
11,000–20,000	38	11.7
21,000–30,000	21	6.4
31,000–50,000	8	2.5
51,000 or more	8	2.5
Missing	3	0.9
Total	326	100
Monthly farm income (*Naira*)		
Less than N15,000	209	64.1
16,000–30,000	60	18.4
31,000–50,000	35	10.7
51,000–70,000	6	1.8
70,000–100,000	1	0.3
100,000 or more	5	1.5
Missing	10	3.1
Total	326	100

Source: Field survey conducted by the authors (August/September 2012).

and how membership of cooperatives affects these socioeconomic indices, as well as directly influences the adoption of innovations.

Cooperative membership and adoption of innovations

The results of the cross-tabulation and chi-square tests on the impact of cooperative membership on adoption are summarized in Table 3. The chi-square values are high for all innovations but irrigation. With significance levels of .000 for high-yield maize, pesticides, fertilizers, and tractors and .001 for cassava, the chi-square values are 29.158, 10.686, 18.209, 27.285, and 26.280 for maize, cassava, pesticides, fertilizers, and tractors, respectively. This leads to the rejection of the null hypothesis, affirming the suggestion that cooperative farmers are more likely to adopt the listed innovations than their non-cooperative counterparts. The null hypothesis for irrigation is confirmed, although we cannot read much into this figure as the adoption data obtained for irrigation is very low (Table 3), with a mere 6.7% of respondents as adopters. The implications of these results are discussed in greater detail in the next section, in the context of other socioeconomic variables.

Cooperative membership and socioeconomic factors

A 2SLS was used to analyze the impact of cooperative membership and some socioeconomic factors on adoption of technological innovations. This approach was preferred to a multiple regression analysis in order to mitigate the potential impact of endogenous variables. Thus, the following instrumental variables were chosen – land source, land rent, marital status, network innovation access, awareness method, farm sale, and transport means – along with the following predictors – age group, gender, education level, cooperative membership, land cultivated, and farm income. For the purpose of the following analysis, we focus on the following six innovations: fertilizers, pesticides, high-yield maize, high-yield cassava, irrigation, and tractor. The results of the analysis are summarized in Table 4.

A key feature of the analysis is the inclusion of access to land, measured in terms of land cultivated by individual farmers. Previous adoption studies for low-income farmers have focused majorly on assessment of farm and non-farm income as indices of farmers' economic capabilities. However, access to land, often acquired by means of communal leases and family inheritance, can play an important role as a measure of farmers' economic capability. In addition, in the particular context of innovation uptake and the potential benefits of higher yield and up-scaling and expansion of farm activities, land access can be even more important, in terms of its positive impact on the economic conditions of farmers.

Income levels

The results in Table 4 indicate that farmers' income levels, measured in terms of farm income, generally have some influence on the adoption of innovations, especially pesticides, high-yield cassava and irrigation. This is in agreement with the findings of several researchers who have reported a linear relationship between wealth/access to

Table 2. Use of innovations.

Innovations	Frequency	Usage	Non-usage	Missing	Rates (% usage)	Adoption speed
Tractor	326	216	104	6	66.3	2.7
HY maize	326	187	134	5	57.4	2.3
HY cassava	326	213	108	5	65.3	2.6
Pesticides	326	288	34	4	88.3	3.5
Fertilizers	326	279	43	4	85.6	3.4
Irrigation	326	22	295	9	6.7	0.3
Average					61.6	2.5

HY, high yield.

Table 3. Cooperative membership and adoption of innovations.

Variable	Non-cooperative members	Cooperative members	Total
Adoption of HY maize			
Non-adopters	96	38	134
Adopters	77	110	187
Total	173	148	321
Adoption of HY cassava			
Non-adopters	72	36	108
Adopters	101	112	213
Total	173	148	321
Adoption of pesticides			
Non-adopters	30	4	34
Adopters	143	145	288
Total	173	149	322
Adoption of fertilizers			
Non-adopters	39	4	43
Adopters	134	145	279
Total	173	149	322
Adoption of tractors			
Non-adopters	77	27	104
Adopters	94	122	216
Total	171	149	320
Adoption of irrigation			
Non-adopters	159	136	295
Adopters	10	12	22
Total	169	148	317
Pearson chi-square	Value	df	Asymp. sig. (two-sided)
High-yield maize	29.158	1	.000
High-yield Cassava	10.686	1	.001
Pesticides	18.209	1	.000
Fertilizers	27.285	1	.000
Tractors	26.280	1	.000
Irrigation	0.586	1	.444

income and adoption of innovation (Feleke and Zegeye 2006; Odoemenem and Obinne 2010), although a few investigators have also indicated non-linearity arising from risk avoidance on the part of otherwise financially able farmers (Languituo and Mungoma 2008). The results of the regression analysis here appear to indicate that income does not have a significant impact on adoption of fertilizers. It seems that the majority of the farmers who have access in terms of information about procurement have used fertilizers at one point or another, with little differences observed regarding their financial capabilities. Information on adoption does not, however, reflect details regarding intensity of use, or adequate application in terms of quantity. Typically, relatively more wealthy farmers apply fertilizers, in adequate quantities, to a greater proportion of their farm lands than farmers with lower access to income.

Gender and marital status

In this study, we have used the individual farmer, rather than the household, as the unit of observation. This is to

Table 4. Instrumental variables analysis of adoption factors.

Variable	Std. error	Beta coeff.	*T*-value	*P*-value		
Fertilizer						
(Constant)	0.687		1.714	.088		
Age group	0.012	−0.562	−1.285	.200		
Gender	0.235	0.080	0.211	.833		
Level of education	0.001	0.055	0.071	.943		
Membership of cooperative	0.228	0.438	1.109	.268		
Land cultivated	0.001	0.143	0.531	.596		
Farm income	0.000	0.036	0.224	.823		
Pesticides						
(Constant)	1.056		2.401	0.017		
Age group	0.018	−1.550	−2.211	.028		
Gender	0.362	−0.395	−0.652	.515		
Level of education	0.002	−0.836	−0.680	.497		
Membership of cooperative	0.350	0.907	1.431	.154		
Land cultivated	0.001	0.240	0.555	.579		
Farm income	0.001	0.079	0.307	.759		
High-yield maize						
(Constant)	1.118		−0.020	.984		
Age group	0.019	0.275	0.668	.505		
Gender	0.397	−0.101	−0.267	.790		
Level of education	0.002	0.721	0.984	.326		
Membership of cooperative	0.352	0.077	0.212	.832		
Land cultivated	0.001	0.035	0.126	.900		
Monthly farm income	0.001	−0.121	−0.823	.412		
High-yield cassava						
(Constant)	0.531		0.293	.770		
Age group	0.014	0.145	0.458	.647		
Level of education	0.001	−0.175	−0.496	0.620		
Membership of cooperative	0.253	0.352	1.307	.192		
Land cultivated	0.001	0.045	0.182	.856		
Farm income	0.001	0.185	1.384	.168		
Tractor combines						
(Constant)	1.210		0.428	.669		
Age group	0.021	−0.005	−0.011	.992		
Gender	0.413	−0.180	−0.426	.671		
Level of education	0.003	−0.380	−0.450	.653		
Membership of cooperative	0.392	0.319	0.733	.464		
Land cultivated	0.001	0.679	2.183	.030		
Farm income	0.001	−0.173	−0.981	.327		
Irrigation						
(Constant)	0.593		0.507	0.612		
Age group	0.011	−0.368	−0.824	.411		
Gender	0.195	0.017	0.047	.963		
Level of education	0.001	−0.550	−0.761	.447		
Membership of cooperative	0.194	0.145	0.374	.709		
Land cultivated	0.001	0.050	0.193	.847		
Farm income	0.000	0.377	2.367	.019		
Model statistics						
	Fertilizer	Pesticides	HY Maize	HY Cassava	Tractors	Irrigation
Sample size	326	326	326	326	326	326
Significance	0.001	0.018	0.000	0.014	0.002	0.136
Adjusted R^2	0.071	0.039	0.096	0.039	0.063	0.016

mitigate the weakness of the model that uses the household, as it leads to the loss of important data regarding the adoption behavior of female farmers in male-headed households (Chipande 1987; Doss and Morris 2001). Our results indicate that the impact of marital status is marginal or negative for most innovations, but the influence of gender is quite significant, especially for fertilizer, pesticide, and tractor combines. As expected, the impact of gender on adoption of tractor combines is especially high, underlying the peculiarly physical nature of applying and maintaining the innovation, which accounts for comparatively higher male adopters. This positive contribution of gender to adoption has also been found to be indirectly associated with secured land rights, favoring male farmers (Tanui et al. 2012).

Age

The impact of age on adoption appears to be comparatively small for all innovations examined, and negative for all but high-yield maize and high-yield cassava. Some studies have found a positive correlation between age and adoption of innovations, on account of, say, farmers' enhanced entrepreneurial experience with increasing age, which in turn positively influences adoption of innovation (Langyintuo and Mungoma 2008; Tanui et al. 2012). However, as Table 4 suggests, older farmers are, in general, less likely to adopt innovations than their younger counterparts, although the impact is considerably lower than other variables. This has been attributed in part to the psychological and physical changes associated with increasing age, which usually lead to reduction of involvement with others and decline of physical energy (Odoemenem and Obinne 2010). In general, it appears that younger farmers, because they are more physically and socially active, are more likely to obtain new information and gain access to innovations than their older counterparts. This is particularly relevant in the context of farmers resident in villages and communities farther from major cities, as found in this study.

Level of education

Adoption studies have, in general, found a positive correlation between education and uptake of innovations (Marra, Pannell, and Ghadim 2003; Ani, Ogundika, and Ifah 2004; Feleke and Zegeye 2006). This investigation indicates that the impact of education is positive for fertilizer and high-yield maize. This is corroborated by the findings of Sidibe (2005), who explored the impact of education in a wider context, not merely of formal qualifications, but also of specialized training accessed by farmers. Other findings affirmed that more educated farmers are more likely to adopt more complex and knowledge intensive innovations (Odomenem and Obinne 2010). Thus, the negative impact of level of education on adoption of tractor combines in this study is unexpected, but the rest of the data appear to indicate that the impacts of other factors are more decisive regarding the adoption of tractor combines. Similarly, the negative contribution of irrigation is unexpected, considering that irrigation technology is more knowledge intensive than most other innovations, and should be positively correlated with educational level, but this result should be understood in the context of the fact that only 6.7% of the respondents, representing 22 of the 326 farmers, indicated they have employed irrigation technology at one point or another. This is by far the lowest adoption rate among all the six innovations considered, so the data for irrigation appear to be inadequate for any conclusion to be drawn on the results of the regression model.

Land access

The impact of land size has been found in this study to be positive throughout the model. It is significant for fertilizers and pesticides, and tractor combines. This is consistent with the findings of Sidibe (2005) which showed, in a study of adoption of conservation techniques, that the impact of farm size sometimes differs according to the innovations. In our model, it would appear that, the need to control weeds, for example, is higher among farmers with relatively larger acreages of land, and for this direct manual weeding is more expensive and time-consuming. For adoption of tractors, the contribution of farm land size is the biggest contributor in our model. This, again, is expected against the backdrop of the fact that manual clearing and cultivation of larger areas of land are more tedious, more expensive and time-consuming, and quite often impracticable.

Cooperative membership

Cooperative membership is the main independent variable explored in this study, and our model shows that it is the single biggest contributor across the whole range of innovations examined. Taking the innovations individually, cooperative membership is often the highest or the second highest contributor to adoption. This is in agreement with the findings of other investigators who affirmed a positive correlation between cooperative/organizational membership and technological uptake (Deji 2005; Sidibe 2005; Nwakwo, Peters, and Bolkemann 2009; Odomenem and Obinne 2010). The peculiar nature of cooperative impact is highlighted by its direct influence on other factors of adoption, including awareness, access to credit and opportunities for technical/more in-depth training via external agencies like extension workers (Laroque, Pierre-Kalala, and Gaboury 2001; Sidibe 2005). External finance agencies, including governments, prefer to deal with groups rather than individual farmers in the disbursement of loans and distribution of subsidized inputs. Conversely, it has also been suggested that certain socioeconomic factors, including age, gender and education, can have significant impacts on how much benefits members can gain from cooperatives, especially with regard to opportunities for social learning and development of management skills (Hartley and Johnson 2014). Furthermore, the cooperative society is a more auspicious platform for quick dissemination of information about innovations among farmers, and it is also more efficient for extension workers and

Table 5. Cooperative membership vs. land cultivated.

Variable	Less than 5 acres	5–10 acres	11–20 acres	More than 20 acres	Total
Cooperative membership					
Non-members	98	61	13	4	177
Members	49	40	14	46	149
Total	147	101	27	50	325
Type of cooperative					
Multipurpose service cooperative	49	33	8	16	106
Specialist/single production cooperative	2	1	1	0	4
Farm settlement	12	10	6	30	58
Total	65	46	15	46	168
Pearson chi-square	Value	df	Asymp. Sig. (two-sided)		
Cooperative membership	54.147	3	.000		
Type of cooperative	35.422	12	.000		

technology sellers to link up with and train groups of farmers rather than individuals.

The implication of the findings discussed above is that we reject our second null hypothesis. As the data show, when compared with other socioeconomic variables, cooperative membership appears to exert the most significant impact on the adoption of technological innovations. As observed, the extent of the cooperative impact can also be measured by the potential positive impact it can have on other variables, as discussed in the foregoing. The cooperative structure relies on, generates, and strengthens social capital. Thus, the educated cooperative farmer is likely to benefit more from information and technical training arranged or facilitated under the auspices of the cooperative, and the illiterate cooperative farmer can mitigate his disadvantage by regular contact with other farmers in meetings, training, and field demonstrations. Also, the older farmer can cope better with physical disadvantage by enjoying bulk procurement of inputs from the cooperative, and long journeys to the city to procure inputs become less necessary. Conversely, the younger cooperative farmer can benefit more than their non-cooperative counterpart from the wealth of experience of older members of the cooperative. The cooperative society thus becomes a platform in which the socioeconomic characteristics of individual farmers can be strengthened and consolidated.

Whereas the impacts of cooperative membership on other socioeconomic variables can be more readily explained, and have been the subject of several investigations, the role of cooperative membership in land access is not so obvious, and is examined in greater detail in the following section.

Cooperative membership and access to land

In the foregoing analyses, it is observed that access to land exerts a quite significant influence on adoption of innovations, more so than direct farm and non-farm income. The results in Table 5 lead to the rejection of our third null hypothesis, which in turn confirms that cooperative farmers indeed have better access to larger areas of land for cultivation than non-cooperative members. This is partly because communal lands are more easily accessed by farmer groups, in general, than individual farmers because community owners and leaders prefer to deal with groups rather than individuals.

For example, 30.9% of cooperative farmers have access to more than 20 acres of land, compared with a very low 0.022% for non-cooperative farmers. The value of the chi-square is quite high at 54.147, with .000 significance. The table also provides further details about the comparative advantage among the different types of cooperatives with regard to land access. Of the 46 farmers with more than 20 acres of land, farm settlers represent 65.2% or 30 farmers. Among the 248 farmers who had access to 10 acres or less, 154 of them, or 64%, were non-cooperative members. This indicates that, whereas cooperative membership appears to significantly influence access to larger areas of land, this influence is negligible with respect to access to small areas of land. Then, the third null hypothesis is thus rejected with a caveat.

Land access is an important consideration in the discussion of adoption of innovation as it provides the essential opportunity for up-scaling and continued use of the adopted innovation. Some innovations, like tractor and irrigation technology, require a certain minimum requirement regarding the area of cultivated land for practical sense and optimum benefit of the innovations. For all other innovations, the availability of land is directly linked with increasing productivity. The more land cultivated, the more the overall farm yield increases.

Cooperative membership and benefit of innovations

The foregoing analyses have focused on the factors influencing farmers' adoption of technological innovations. It is also important to examine the extent to which the innovations are indeed beneficial to farmers. This is difficult to measure directly, due to potential contributions of various factors, including the changing cost of farm inputs and labor, seasonal changes in prices of agricultural outputs, cost of transportation, and access to markets. However, the results of cross-tabulation and chi-square tests in Table 6 provide relevant information from which we can make informed estimates on the benefit of adopted innovations and cooperative membership. The principal unit of measure employed here is average monthly farm sales.

The results indicate that cooperative membership is positively correlated with farm sales, and the Pearson chi-square coefficient obtained at 25.545, at a significance of .000. In essence, cooperative members are about 25 times more likely to make better sales than their non-cooperative counterparts. Regarding the impacts of individual innovations on farm sales, only high-yield maize and irrigation are found to have a positive correlation at acceptable significance levels, of .001 and .045, respectively. The Pearson chi-square co-efficient is 21.658 for high-yield maize and 12.859 for irrigation. The chi-square coefficients for the other four innovations are comparatively low, and at unacceptable significance levels more than .05, leading to the rejection of the null hypotheses.

It would appear that the adoption of innovations, especially the four identified above, does not necessarily bring direct benefit to farmers in terms of increased sales and associated profits. It must be observed, however, that

Table 6. Cooperative membership, adoption and farm sales.

	Monthly farm produce sales							
Variable	Less than 20,000	21,000–40,000	41,000–60,000	61,000–80,000	81,000–120,000	121,000–160,000	More than 160,000	Total
Cooperative membership								
Non-members	120	31	11	4	6	2	0	174
Members	67	43	18	10	4	0	5	147
Total	187	74	29	14	10	2	5	321
High-yield maize								
Non-adopters	96	24	6	4	3	1	0	134
Adopters	87	50	23	10	7	1	5	183
Total	183	74	29	14	10	2	5	317
High-yield cassava								
Non-adopters	72	19	10	4	3	0	0	108
Adopters	111	55	19	10	7	2	5	209
Total	183	74	29	14	10	2	5	317
Pesticides								
Non-adopters	23	5	2	1	1	0	0	32
Adopters	162	69	26	13	9	2	5	286
Total	185	74	28	14	10	2	5	318
Fertilizers								
Non-adopters	31	9	1	1	0	0	0	42
Adopters	154	65	27	13	10	2	5	276
Total	185	74	28	14	10	2	5	318
Tractors								
Non-adopters	62	22	8	6	3	1	1	103
Adopters	122	52	20	8	7	1	4	214
Total	184	74	28	14	10	2	5	317
Irrigation								
Non-adopters	171	69	25	14	9	1	4	293
Adopters	8	5	4	0	1	1	1	20
Total	179	74	29	14	10	2	5	313
Pearson chi-square	Value	df	Asymp. sig. (two-sided)					
Cooperative membership	26.545	6	.000					
High-yield maize	21.658	6	.001					
High-yield cassava	8.469	6	.206					
Pesticides	3.220	6	.781					
Fertilizers	7.408	6	.285					
Tractors	1.924	6	.927					
Irrigation	12.859	6	.045					

sales in itself is not necessarily a measure of productivity. Often, because of the predominately seasonal nature of cultivation and harvest, the same quantity of goods, say a ton of cassava, can sell for a fifth or less of its price at harvest time, leading to heavy losses. Typically, farmers deal with these significant drops in market value by means of storage, and value addition by means of processing and other strategies. Also, farmers can work in groups to sell in bulk to big processing and food companies, or coordinate together to negotiate better prices.

With regard to storage, it is observed that maize, one of the two innovations found to be positively correlated with farm sales in Table 5, is better suited for storage than cassava, which cannot be stored for long in its raw state. On the other hand, maize can be left for longer on the farm and harvested dry, and with minimal preservation held in storage for months. It can also be processed into various types of food products. This implies that farmers can benefit more from increased productivity achieved with adopted innovations, rather than suffer losses when they are forced to sell raw at harvest time. The same applies for irrigation which was also found to be positively correlated with increased farm sales. Adoption of irrigation technology, although it requires significant capital investment, enables farmers to plant in the dry season, when the demand and the market value of goods are higher than the rainy season. This ensures that farmers are able to make more profit from their farm products, and with greater profits, there are more incentives for continued adoption and up-scaling of farm production.

One of the key inferences from the foregoing discussion is the unique role of the cooperative in facilitating more beneficial adoption of agricultural innovations. This affirms our hypothesis, and is consistent with the findings of other investigators (Wollni and Zeller 2006), that cooperative membership plays a significant role in mitigating the barriers to continued adoption of innovation by facilitating optimum benefit and better profit for adopters. Simply put, it appears that the same-adopted innovation can, beyond the general expectation of increased productivity for all adopters, bring more profit for the cooperative farmer than his non-cooperative counterpart.

There are three main reasons that can explain this: (i) the economy of scale, an important factor for most innovations, works better with a farmers' cooperative than individual farmers. This is already mentioned regarding the irrigation technology which requires a minimum of 100 farmers to work (MASHAV 2002). It is also true in terms of cost of procurement, such that bulk purchase of inputs ensures reduced cost for individual cooperative members; (ii) there is potential for more efficient and effective marketing strategies with cooperative or farmer groups. They can network and collaborate better with food companies, guaranteeing regular supplies of raw farm produce, and the cooperative is also better positioned in terms of its bargaining and negotiating powers; (iii) cooperatives are better equipped to facilitate value addition by means of processing and modern storage techniques for their members. This is especially important in the context of farm produce like cassava, which cannot be stored in its raw state, but can be significantly enhanced in market value by processing, as well as stored in their processed states. The required capital for this can be pooled from members' contributions or loans secured from finance agencies, and the risk and maintenance costs of facilities, as with the profits, are shared by all members.

Conclusion

Cooperative membership exerts a significant influence on farmers' adoption of the technological innovations examined. In most cases, the impact of cooperative membership was found to be higher than all other socioeconomic variables. As mentioned earlier, it is possible that the uptake of technological innovations can encourage and motivate some farmers to become members of cooperatives, but the logic of the stages involved in the adoption process suggests that it is more likely, at least with regard to initial awareness and technical information about innovation, that cooperative membership influences or encourages adoption and greater use intensity of technological innovations. The cooperative effect is particularly significant in light of the strengthening impacts it can have on other socioeconomic variables influencing the adoption of technological innovations. Among other things, membership in cooperatives can provide a more auspicious platform for awareness, in-depth technical information and speedy access to innovations, and pooling of funds and lands to deal more efficiently with financial constraints and issues relating to economy of scale.

Among the list of socioeconomic factors, access to land and the educational level of respondents appear to be especially important. The role of gender is important for some innovations, like adoption of tractors, apparently highlighting the more physical nature of tractor operation and maintenance.

This study provides insights into the benefits of innovation adoption, and of cooperative membership, using farm sales as an approximate measure. The results indicate the positive correlation of cooperative membership with farm sales, and the positive correlation of adoption of high-yield maize and irrigation with farm sales. We suggest that innovation adoption in the cooperative context can be more beneficial for adopters, compared with adoptions by non-cooperative members, due to the more favorable economy of scale, potential for more efficient marketing strategies and bargaining power, and better opportunities for value addition.

The considerable impact on land access is particularly instructive, indicating that land access can provide some leverage for otherwise low-income farmers, providing incentives for adoption and up-scaling of technological innovations.

The overall implication of our findings is that, as the main hypothesis suggests, farmers' cooperative is a particularly effective platform to build and strengthen social capital, which in turn positively influences traditional adoption factors. It is possible, and is sometimes the case, that farmers resort to temporary ad hoc arrangements to generate social capital. There are, for example, various farmer groups associated with specific projects of external funders who are perhaps interested in specific crops or methods. There are other ad hoc groups arranged from time-to-time by rural farmers to meet particular needs, say of input procurement or equipment hire. These ad hoc groups do not, however, provide the security and regularity of the cooperative arrangement, which gives farmers more room to plan ahead, and a more reliable platform to enjoy support and collaboration with external bodies.

The cooperative platform is severely underutilized in the Nigerian context. We recommend that policy-makers invest more resources in strengthening and expanding farmers' cooperatives to facilitate the better diffusion of innovations among rural farmers, as well as help farmers to reap optimum benefits from its adoption. Among others, government agencies can help facilitate and coordinate better links between farmers in cooperatives and industries and food companies, as well invest funds in storage and processing facilities accessible to, or controlled by, farmers' cooperative groups.

In future investigations, we aim to

(1) Compare the social capital of cooperative and non-cooperative farmers, with respect to access to general and technical information, bridging social capital with other networks, and linking social capital with extension agencies, policy-makers, and domestic and international markets. This will provide more insights on the possible direction of causation with respect to cooperative membership and innovation uptake. It will also further illuminate the factors influencing varying degrees of use intensities and benefits accrued from innovation uptake.

(2) Evaluate the perception of farmers and key stakeholders of the effectiveness of the cooperative arrangement, and opinions on institutional challenges – such as markets, infrastructure, credit institutions, and policy – to successful innovations. This investigation will employ a qualitative approach, with in-depth interviews with key stakeholders, and semi-structured interviews with farmers, to fill the gaps in knowledge, and ultimately inform better practice in terms of future intervention programs.

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