Farmer groups and input access: When membership is not enough

Lenis Saweda O. Liverpool-Tasie

Department of Agriculture, Food and Resource Economics,

Michigan State University

211B, Agriculture Hall, 446 W. Circle Drive,

East Lansing, MI, 48824

USA

lliverp@msu.edu, sawedal@gmail.com

Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Farmer groups and input access: When membership is not enough

Abstract

This paper uses a double hurdle model to explore whether different methods of distributing fertilizer through groups in a targeted input subsidy program affects an intervention's ability to increase farmer access to agricultural inputs. It uses a case study of Nigeria to demonstrate this. Farmer group membership was required for participating in a voucher program in Nigeria in 2009. However, for actual fertilizer distribution among participants, individual farmers were given their allotted share directly for one set of farmers while for the other set; the fertilizer was given indirectly through a group representative. Where fertilizer was given to a group representative for further distribution to members, respondents with close links to their farm group president received more bags of fertilizer than those without. Where fertilizer was given directly to farmers such results did not obtain. This differential outcome suggests that while groups may facilitate the process of farmer identification and coordination, intra group dynamics may affect their efficacy for providing equal access to inputs for members. A double hurdle model enables us to model the potentially separate processes that determine participation in the voucher program and one's experience, upon deciding to participate. With intentions to adopt and scale up voucher programs in various food security and poverty alleviation programs across developing countries, it is important to understand the role that intra group dynamics play in the successful implementation of such programs.

JEL: Input vouchers, farmer groups, intra group dynamics, Nigeria

1. Introduction

Farmer groups are considered potentially effective mechanisms to increase farmer livelihood by reducing information asymmetries (Kruijssen et al, 2009; Bernard and Spielman, 2009). Through membership in farmer groups, smallholders can pool resources and market their products collectively; overcoming the high transaction costs resulting from their small individual sizes. Farmer groups are believed to improve member access to resources (such as inputs, credit, training, transport and information), increase bargaining power and facilitate certification and labeling (Bosc et al., 2002). With regards to long-term investments such as those required for perennial crops and capital intensive processing technologies, collective action as is possible through farm groups can also reduce individual farmer risk (DiGregorio et al., 2004). Consequently, organized farm groups are promoted as useful avenues for increasing farmer productivity and for the implementation of food security and other development projects. They are particularly favored for dissemination of information (via extension) and inputs and the marketing of agricultural commodities (Davis, 2009). In Nigeria, there is a strong push for the use of organized groups in the implementation of numerous development programs. The World Bank-assisted Fadama[1] (I, II and III) are cases in point, as is the ongoing fertilizer input voucher

[1] The National Fadama project in Nigeria is a World Bank assisted project to increase farmer access to irrigation and other production and post harvesting technology in Nigeria. There have been 3 phases of the project implemented in the country since the early 1990's (World Bank, FGN, 2010).

program in Nigeria. The input voucher program is a relatively new targeted fertilizer subsidy approach that was piloted at state level in two Nigerian states in 2009, expanded to four states in 2010 with plans ongoing for expansion to all 36 states of the Nigerian federation.

This paper analyzes one important dimension of farmer experience when farmer groups are used for input distribution; intragroup dynamics. It uses a case of an input voucher program implemented in two Nigerian states. The voucher program was expected to improve on the traditional system of subsidized fertilizer distribution characterized by cumbersome administrative processes and diversion of the product from the proclaimed beneficiaries; smallholder farmers. Thus it was to make affordable fertilizer available to small holder farmers on time. Participation in the program was only available to farmers in organized groups. It has been demonstrated that the voucher program increased farmer access to subsidized fertilizer at a reduced price in 2009, though it was not generally on time (Liverpool-Tasie et al, 2010). However, no studies have been conducted on the potentially differential experience of farmers, upon participation. This is an important issue to consider when evaluating the use of such programs to expand farmer access to inputs and particularly as many countries across sub Saharan Africa are considering the experiences of other countries as they develop and or scale up their own programs. Since the general effect on farmer access to subsidized fertilizer at lower prices has already been demonstrated, this paper focusses on another important dimension; farmer experience of the program, conditional on participation. Using primary data collected from 1000 households, this study takes advantage of key state level differences in the use of

organized groups to explore the role of group dynamics in the successful implementation of the program. It considers the experience of participating farmers by testing for a difference in the quantity of fertilizer received by participating farmers depending on how fertilizer was distributed in their farm group.

Recognizing that a farmer's decision to participate in the voucher program (actually receive a voucher) and the extent of participation (number of bags of subsidized fertilizer they received) are possibly two different processes, this study uses a double hurdle model to explore if and how intra group dynamics affects farmers experiences of the voucher program. A tobit, Generalized tobit and a local government level fixed effects model are also estimated for comparison.

There is a current focus on using organized groups to improve access to extension, credit and other agricultural inputs in many developing countries. Consequently, understanding if intra group dynamics plays a significant role in input distribution when groups are used is important . More specifically, agricultural input vouchers are increasingly being employed across sub Saharan Africa to address problems of low agricultural productivity and food security and many operate through groups. Thus, it is important to understand the role that group dynamics play in the implementation of such targeted subsidy programs. It should not be taken for granted that working through farm groups or farmers organizations will improve outcomes for all members. This needs to be tested so that nuances about intra group dynamics are properly addressed in the development and implementation of such programs to maximize their impact.

The paper proceeds as follows: section 2 provides a brief summary of some relevant literature while section 3 describes the 2009 fertilizer voucher program in Kano and Taraba states. Section

4 presents the analytical framework while section 5 discusses the data used. Section 6 presents the study results and section 7 concludes.

2. Literature review:

Arguing the case for collective action among farmers dates back to the 1920's where active debates surrounded whether cooperatives were necessary to unite farmers on a commodity wide basis (for market power and higher returns to agriculture) or whether they were a means to increase competitiveness within the agricultural business system (Staatz, 1989). Several decades of productivity growth and the structural transformation of societies saw less emphasis placed on collective action among farmers and farmer cooperatives. There has been a recent refocus on smallholder agriculture for economic growth and poverty alleviation (World Bank, 2007). This has brought a renewed attention to institutions of collective action like farmer groups. This attention stems from their proposed ability to address a major challenge faced by small holders in developing countries; lack of market access (Barham and Chitemi (2009). Farmer groups are considered an efficient mechanism to improve the marketing performance of small holder farmers which is considered necessary to improve farmer welfare, food security, rural employment and sustained agricultural growth (Kariuki and Place, 2005;Dorward et al, 2003; Poulton et al, 1998). Consequently farmer groups and agricultural cooperatives are increasingly emerging as a potential means to help smallholders cope with production and marketing challenges, and take advantage of various opportunities at local and regional markets.

With the declining role of the state in many developing countries, rural development efforts have been gradually shifting from direct aid towards the promotion of employment and entrepreneurship. Within this realm, assisting smallholder farmers to access and participate in

various markets is increasingly being promoted as a sustainable approach to addressing problems of global malnutrition and poverty (Fafchamps, 2005; Reardon and Barret, 2000; Cook and Chaddad, 2000; Von Braun, 1995). Consequently, development agencies geared to improve farmer access to agricultural services and markets are increasingly working through local institutions like farmer groups (World Bank-assisted Fadama (2010); Stringfellow et al, 1997; Davis, 2009)

Majority of the literature on farmer groups in developing countries focus on their benefits. These include their ability to provide cost-saving and risk-sharing benefits to farmers in uncertain agri-commodity markets, their potential for generating economies of scale and scope contribute to reduce transaction costs and their ability to improve bargaining power vis-à-vis the market (Bonin et al., 1993; 1988; Dulfer, 1974); Kruijssen et al, 2009; Bernard and Spielman, 2009); DiGregorio et al., 2004). In the development assistance arena, farmer groups are also seen as an efficient mechanism for disseminating agricultural information as well as for coordinating program beneficiaries (World Bank-assisted Fadama (I, II and III); Marsh and Pannell(2000) Davis, 2009). Fewer studies have highlighted the challenges associated with farmer groups. This includes the complexities added when multiple individuals, rather than a single investor, engage in commercial activities discussed in the agribusiness literature (see Cook and Chambers, 2007; Putterman and DiGiorgio, 1985; Fama, 1980. Challenges also include the potential to exclude some subgroups or members of the community as documented by Arnaiz, 1995; Bebbington et al, 1994; Ashby and Sparling, 1994; Vanclay and Lawrence 1995).

Most of the discussion on challenges associated with farmer groups focus on the potential for some members (e.g. wealthier farmers) to be over represented in group activities, for some groups (like women) to benefit less from these groups or be excluded from such groups or for the

forced formation of groups to be unsustainable (Stringfellow et al, 1997). Limited emphasis is played on the effect of *intra group dynamics* on the potential benefits of farmer groups. Empirical studies have demonstrated that membership in farmer groups or cooperatives can have limited benefits for certain activities like the quality of output (Francesconi and Ruben, 2007). Studies have also demonstrated the limited benefits of such groups for some types of farmers like the poor or women (Bernard et al, 2008; Kerby et al, 1996). However, empirical work on the effect of intra group dynamics on farmer experiences of agricultural programs or interventions is rare. This study contributes to that limited literature by empirically testing for the effect of intra group dynamics on farmer experiences of an input voucher program in Nigeria.

Agricultural input vouchers are increasingly being used across sub Saharan Africa to address problems of low agricultural productivity and food security. In many cases, farmers are coordinated in groups for participation. It should not be taken for granted that working through farm groups or farmers organizations will improve outcomes for all members. This study specifically tests this hypothesis using a cross section of Nigerian farmers and their experience in a fertilizer voucher program in 2009. The study results provide guidance for input voucher program development particularly and development programs generally.

3. The 2009 Fertilizer voucher program in Kano and Taraba

In 2009, a fertilizer voucher program was piloted in Taraba and Kano States, Nigeria. It was a collaborative effort between the Nigerian government (Federal and State), the private sector suppliers and dealers and an implementing agency called “The International Center for soil fertility and development” (IFDC). It was designed to deliver subsidized fertilizer to 140,000 and 76,000 small holder farmers in Kano and Taraba respectively. The value of the voucher was a

N2,000 discount per bag on two bags of triple 15 Nitrogen Phosphorous Potassium (NPK 15:15:15) and one bag of Urea (46 percent Nitrogen(N) content) in Kano, and on two bags each of NPK 15:15:15 and Urea (46 percent N) in Taraba. Farmers were required to pay the difference between the market price and the N2, 000 discount per bag (IFDC, 2010).

The program in both states required participants to be member of an organized group. In Kano, a farmer group received a single voucher for all its members. The voucher entitled members to a N2, 000 discount on three bags of fertilizer per member. Thus a farmer group of 10 members would receive one voucher valued at N2000*3*10. However, in Taraba, upon verification of group membership, each individual member of the organized group received a voucher and could purchase up to four bags of fertilizer at the discounted rate. This is an important and distinguishing characteristic of the voucher program in both states. Giving one voucher for the entire group implies that the final amount of fertilizer received by each farmer in a group was linked not only to the number of bags the total group received but to the sharing rule within the group. In the case of Taraba however, since each farmer redeemed the voucher himself/herself, the role of the group was more for farmer identification and coordination and the amount of fertilizer a farmer received was only dependent on his personal desire and ability to pay the difference between the voucher value and the market price on the 4 bags of fertilizer allowed.

In Taraba, the operational procedure by which farmers received vouchers was as follows. Farmers from selected organized groups gathered at a voucher distribution center on a prearranged day. Each farmer was required to bring three passport photographs. The leader of the group would vouch for the identity of each of the groups' members as a farmer. Then each farmer was given a paper voucher divided into two sections as shown in Figure 1 below. A passport photograph was affixed to each section.

Figure 1: An example of the fertilizer voucher used in Taraba state in 2009

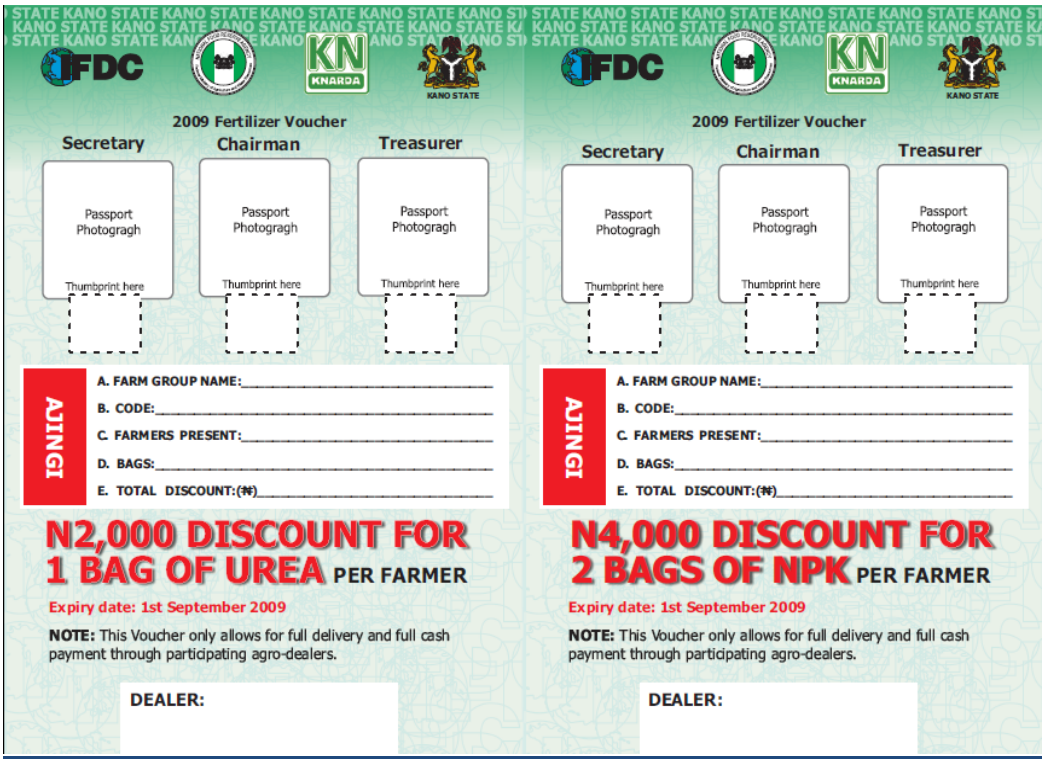
Source: IFDC Voucher program implementation manual

The third copy of the farmer's photograph was affixed to a roster to be given to the specific agricultural input dealer at which the farmer could use the voucher. Farmers were made to thumb sign in each of the sections of the voucher in the space indicated in Figure 1. Upon filling necessary documents, farmers were given the vouchers. A farmer and his or her assigned agricultural input dealer then arranged a day on which the farmer could purchase and pick up the 4 bags of fertilizer.

In Kano, on the other hand, farmer groups were required to bring their certificate of registration to verify their group's authenticity. Due to the long history of farmers with farm groups in Kano,

a single voucher was issued to the ***entire*** farmer group and the subsidized fertilizer for all members of the group had to be purchased as a group. Figure 2 shows an image of an example of a voucher used in the program in Kano. In Kano, rather than having the photos of individual farmers on the voucher as was the case in Taraba, only photos of the farm group representatives (i.e. Secretary, Chairman and Treasurer) were placed in the relevant slots shown in Figure 2. Individual members of the group also had to provide one single passport photo to the farm group executive to be presented at the voucher distribution day but the members of the group were not required to be present for the groups' voucher to be provided to the group leadership nor were they required to be present when the voucher was redeemed and fertilizer secured by the group leadership. Each voucher in Kano entitled a farmer group to receive fertilizer bags, numbering 3 times the number of farmer group members – the number of farm group members was indicated by the total deposit supplied by the farmer group divided by N6000.

Figure 2 : An example of the fertilizer voucher used in Kano state in 2009



Source: IFDC Voucher program implementation manual

4. Analytical framework:

Operating in rural Nigeria where rural financial markets are very thin and where villages are often isolated with limited access to various input and output markets, technology choice by a farmer can be modeled as a constrained utility maximization problem as in Singh, Squire and Strauss. In this context, the utility maximization problem that results is as follows:

$$\text{Max } U(c, z^h) \qquad (1)$$

This maximization is subject to various constraints; a cash income constraint, a credit constraint, a production technology constraint as well as to a price constraint (to reflect its endogeneity) and the necessary equilibrium condition for non tradables. As in the traditional analysis, *c* refers to

the goods consumed and z^h is a vector of farmer characteristics such as farm size, age and gender, farm implements, access to credit and education. As described in Sadoulet and de Janvry (1995), the solution to this constrained maximization problem yields reduced form specifications of demand for inputs and technologies and supply of outputs. The input demand for input i; can be expressed as:

$$q_i = q(p_i^*, z^{hq}) \tag{2}$$

Where q_i <0 since we are dealing with an input, z^{hq} refers to household characteristics associated with the need for input i and where p* refers to the endogenous prices for the relevant input. In this study, the resulting reduced form input demand for fertilizer corresponds to the quantity of fertilizer a farmer decides to use and his consequent interest in the fertilizer voucher program through which some portion of that need could be met at a discounted price.

The fertilizer voucher program (V) qualifies a farmer to receive a N2000 discount (between 55 and 65 percent of the total cost) on a certain amount of fertilizer. This reduces the decision price faced by the farmer and is expected to positively affect the use of input i since

$$\frac{\partial q_i}{\partial V} > 0 \tag{3}$$

It is expected that, after controlling for other factors that might affect farmers' access to and demand for subsidized fertilizer, the number of bags of subsidized fertilizer used by participants in the voucher program would increase. All voucher program participants were supposed to receive a fixed number of bags of fertilizer at the subsidized rate; three and four bags each in Kano and Taraba respectively. Consequently, in the event that there were no errors in program administration or inequities in distribution among groups, all farmers should have received a

fixed number of bags of subsidized fertilizer and farmer characteristics should not play a significant role in determining the number of bags of subsidized fertilizer received once their participation in the program has been accounted for (i.e. whether they or their group received a fertilizer voucher). In the event that inequities in distribution occurred within farm groups, an individual's characteristics might play a role in determining their allocation and lead to members receiving different quantities of subsidized fertilizer. This study explicitly tests this hypothesis by testing for the effect of being related to the farm group president on the quantity of subsidized fertilizer received.

Recognizing that a farmer's decision to participate in the voucher program (actually receive a voucher) and the extent of participation (number of bags of subsidized fertilizer they received) are possibly two different processes, this study uses a double hurdle model(DH) to explore if and how intra group dynamics affects farmers experiences of the voucher program. Cragg (1971) specified the double-hurdle model by modifying the standard Tobit model.

This study uses the DH model with the assumption that participation in the 2009 voucher program(receiving a voucher) and one's experience, upon participating (the number of subsidized fertilizer received) are two distinct processes with potentially different determining factors. This can be expressed as:

(a) The voucher participation decision:

$$V_i^* = \beta X_{1i} + u_i \qquad u_i \sim N(0,1) \qquad (4)$$

Where $V_i = \begin{cases} 1 \; if \; V^* > 0 \\ 0 \; if \; V^* \leq 0 \end{cases}$

(b) The extent of participation

$$Q^{*}_{si} = \beta_2 X_{2i} + v_i \qquad v_i \sim N(0, \sigma) \tag{5}$$

Where $Q_{si} = \begin{cases} Q^{*}_{si} \ if \ V_i = 1 \ and \ Q^{*}_{si} > 0 \\ 0 \ otherwise \end{cases}$ (6)

where V_i refers to whether an individual i participated in the voucher program or not and Q_{si} refers to the quantity of subsidized fertilizer received by individual i. This set up allows separate factors to determine participation in the voucher program from those that determine the quantity of subsidized fertilizer received by participants. X_{1i} and X_{2i} are vectors of explanatory variables that affect the two stages and are assumed to be uncorrelated with the respective error terms while β1 and β2 are the corresponding parameter vectors. Note that V_i* is a latent index variable that determines censoring, V_i is the observed value (1 or 0) which represents whether a respondent participated in the voucher program or not. Thus the observed number of subsidized bags of fertilizer received equals the unobserved latent value only when some subsidized fertilizer was received and is zero, otherwise.

The consequent likelihood function to be maximized as demonstrated in (Jones, 1992; Moffatt, 2005; Aristei et al, 2007):is:

$$LL = \sum_0 ln \left[1 - \phi(X'_{1i}\beta_1)\, \Phi\left(\frac{X'_{2i}\beta_2}{\sigma}\right)\right] + \sum_+ ln \left[\phi(X'_{1i}\beta_1)\, \frac{1}{\sigma}\, \varphi\left(\frac{Q_{si} - X'_{2i}\beta_2}{\sigma}\right)\right] \tag{7}$$

One important distinguishing feature of the DH model is the fact that the model considers the number of bags of subsidized fertilizer to be positive when an individual participates in the voucher program and we observe their positive receipt of some subsidized fertilizer. Thus it allows zero values to obtain when individuals don't participate in the program but also allows for zero values to obtain when respondents participated in the program (were in a farmer group that received vouchers) but do not receive any subsidized fertilizer themselves. This is captured by the first term in equation (7). This distinguishes the DH model from the standard tobit model as

well as the heckman type models. For the standard tobit model, while the model accounts for censoring at zero, the model assumes that the same process that drives participation in the voucher program also drives the number of subsidized fertilizer received. The generalized tobit model proposed by Heckman (1979) recognizes that the processes that determines the two stages might be different but assumes that the first stage decision dominates the extent of participation, i.e once an individual participates in the voucher program, they will receive some fertilizer.. Consequently, while the generalized tobit two stage model estimates a PROBIT model for the participation stage and then estimates an OLS model on the respondents with non zero subsidized fertilizer receipts, the DH model runs a nonlinear model like PROBIT for the first stage and then runs a truncated regression model on the non zero observations.

Another distinguishing feature between the Heckman two stage model and the DH model is the assumption about the relationship between the errors (u_i and $_{vi}$) of equations (4) and (5). The DH model assumes that these errors are normally and independently distributed indicating that these two decisions are made separately. Thus we have:

$$\begin{pmatrix} u_i \\ v_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & \sigma^2 \end{pmatrix}\right] \qquad (8a)$$

However, the generalized tobit model assumes that these errors are correlated and have a bivariate normal distribution as follows:

$$\left(\begin{pmatrix} u_i \\ v_i \end{pmatrix}\right) \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{pmatrix}\right] \qquad (8b)$$

As stated above, arguments in support of both the assumptions of the DH and the Heckman two stage models can be made in this paper. In line with the generalized tobit model, we can assume that the participation decision dominates the number of bags of fertilizer received by recipients and as such it is appropriate to think that those who received vouchers would record receiving some subsidized fertilizer, even if not the expected amount. However, recognizing that the two processes are separate and to account for the possibility that program participants might still record receiving zero bags of subsidized fertilizer (if for example they sold their voucher or did

not receive any fertilizer from the expected group representatives), we also estimate the DH model.

Consequently this study estimates equations (9) and (10):

$$\boldsymbol{Vi_{=}\alpha_1 + \beta_v}\text{VOUCHER} + \boldsymbol{\beta_z Z_{1i} + \beta_p PRESIDENT_i + \beta_L LGA_i + \varepsilon_1} \quad (9)$$

$$\boldsymbol{Q_{si=}\alpha_2 + \beta_v}\text{VOUCHER} + \boldsymbol{\beta_z Z_{2i} + \beta_p PRESIDENT_i + \beta_L LGA_i + \varepsilon_2} \quad (10)$$

where the dependent variable ($\boldsymbol{V}$) is a dummy variable, set to one if the farmer received subsidized fertilizer in 2009 and $\boldsymbol{Q_{si}}$is the number of 50kg bags of subsidized NPK and Urea fertilizer that a farmer received in 2009 . VOUCHER is a dummy variable equal to one if farmer *i* participated in the voucher program, PRESIDENT is a dummy variable equal to 1 if the respondent was the president or a family member of the farm group president and zero otherwise. $\boldsymbol{Z_{1i}}$ and $\boldsymbol{Z_{2i}}$ refers to a vector of household characteristics and other variables expected to affect a respondents probability of participating in the voucher program and the quantity of fertilizer that a farmer receives. Specifically, Z consists of the respondent's age, whether they were formally educated; if they held leadership positions in the village, land ownership and other proxies of wealth like livestock and non-livestock assets. Among the variables in $\boldsymbol{Z_1}$is whether a farmer's farm group procured fertilizer together in 2009" which is a proxy for the factor which lead the farmer to be selected for participation. LGA_i are local government dummies to account for any distinct local geographic or cultural reasons that could also affect farmer access to and demand for subsidized fertilizer. ε_1 and ε_2 refer to the respondent specific errors. Estimations

are run separately in Kano and Taraba to account for any state differences in demographics, agro ecology, history of fertilizer use and access, as well as to capture differences in the program implementation strategy as discussed in section 2.

Equation 9 is the first stage decision and is estimated using a limited dependent variable estimation (PROBIT) estimations. Several models are used to estimate equation 10.First a .local government area (LGA) level fixed effects model[2] is run on the quantity of subsidized fertilizer received. Next a tobit model that accounts for the censoring of subsidized fertilizer but considers participating in the voucher program and the quantity of subsidized fertilizer received to be driven by the same process is run. Then the heckman two stage model which considers the two processes as separate but with the first decision dominating the second is run. Finally, the DH which considers the two stages of participation as separate and independent is estimated[3]. The results from these estimations are shown in table 2.

Though a relevant question, the particular focus of this study was not the effect of participating in the voucher program on the quantity of subsidized fertilizer received. This study is particularly interested in the effect of intra group dynamics on farmer experience of a targeted subsidy program. Consequently though we recognize that the estimate of β_v might be subject to bias due to omitted variables or unobserved characteristics that could drive the respondents participation in the voucher program as well as the quantity of fertilizer that a farmer receives), we focus on precisely estimating β_p. Consequently we make significant effort to ensure that the variable used

[2] The LGA fixed effects model uses local government dummies to control for unobserved and time invariant heterogeneity across local governments in each state that is possibly correlated with other explanatory variables. See Chapter 10 of Wooldridge, 2002 for more details.

[3] The truncated regression for the second stage of the DH model is run on the log of bags received. The data was normalized by transforming to logs to enable the maximum likelihood estimation to converge. All continuous control variables in this model are also transformed to logs.

to capture respondent links to the farm group president is not endogenous and satisfies the necessary conditions for the proper estimation of $\beta_{p.}$

5. Data:

The National Bureau of Statistics (NBS) of Nigeria reports that in 2005 there were about 1,320,000 households in Kano and 447,000 households in Taraba (NBS 2005). The data used in this study come from a survey of 1000 households; 640 in Kano (North-West Nigeria) and 360 in Taraba in North-East Nigeria. This number exceeds the minimum sample size required to determine statistical differences between participants and non-participants in the voucher program with 95 percent confidence. In each state, the interviewed households were selected from 10 randomly selected Local Government Areas (LGAs); administrative units under each state constituting the third tier of the administrative structure in Nigeria. The 10 selected LGAs in each state represented potential LGA variation which could affect the level of exposures farmers had to the voucher program as well as other cultural, infrastructural or administrative differences that affect farmer access to fertilizer apart from the program.

Detailed information about the sampling and survey methodology are included in the appendix. However, the survey respondents were largely household heads, their spouses, other adult household members and for a few questions, children and youth in the household. Respondents were interviewed about their participation in various farm groups and other associations, their leadership positions in their farm group and local communities, their farming practices (input use, sources and prices) and about their participation in the 2009 voucher program. Household demographic information was also collected. Because more than one household member could

have participated in the voucher program, standard errors are clustered at the household level in all estimations.

6. Results and discussion

This paper explores the role of group dynamics on the quantity of fertilizer received by voucher program participants after controlling for voucher program participation. The key indicator of intragroup dynamics was the respondent's link to their farm group president. This is a dummy variable equal to 1 if the respondent was the president or a family member of their farmer group president, and zero otherwise. To avoid ambiguity in the role that closeness to farm group president plays, this study only considers respondents in both states who were members of farm groups. Thus it is assumed that closeness to farm group president matters when there is group allocation and not necessarily more so in farm groups than other kinds of organized groups.

Summary statistics of the variables used in the various estimations are found in table 1. They reveal that only about 20 percent of respondents in Taraba had received subsidized fertilizer prior to 2009 (when the program occurred) while almost 40 percent had received the product in Kano. Fertilizer (NPK and Urea) purchase, on average, in both states was quite low at 1.3 and 0.6 bags respectively in Kano and 0.45 and 0.39 bags respectively in Taraba. Though higher among voucher program participants, further disaggregation among recipients show that while some farmers received the expected 3 or 4 bags in total, some farmers who participated in the program received more than 4 bags while others received less than a bag of subsidized fertilizer.

The first estimation uses a Local Government fixed effects model to estimate equation 10. Results from this estimation for both states are shown in Table 2. The results indicate that the

major factor determining the number of bags of subsidized fertilizer that farmers received in both Kano and Taraba was their participation in the fertilizer voucher program. The results also reveal that that in Kano, where the subsidized fertilizer was given to the farm group representatives for further redistribution to members, respondents who were related to their farm group president on average received about one more bag of fertilizer compared to those who were not. In Taraba State, where farmers received individual vouchers which they could redeem themselves, respondents being related to their farm group president does not affect the number of bags of fertilizer received.

The Local Government fixed effects model does not address two issues. First it does not address the fact that certain farmers did not receive any subsidized fertilizer and that these farmers might be quite different from those who did. Second, the model does not address the fact that the drivers of receiving some subsidized fertilizer and the number of subsidized bags received might be different. Consequently, we then estimate several models that do account for these issues. As discussed earlier, we estimate the standard tobit model, the Heckman two stage model and the double hurdle model. This enables us to address any estimation bias due to the particular two stage nature of our dependent variable (quantity of subsidized fertilizer received) and also serves as a robustness check on our hypothesis on the effect of intra group dynamics on the quantity of subsidized fertilizer received by participants in the 2009 voucher program. The variable of interest (being a relative to the farm group president) is not a choice variable and thus we do not expect it to be endogenous. However, we explore these additional models for completeness and the results of these estimations are shown in Table 3 for Kano and Table 4 for Taraba.

The Tobit results in Table 3 and 4 reveal that participants in the voucher program received more bags of subsidized fertilizer than non-participants. The Heckman and Double Hurdle models

reveal that in both states, farmers in farmer groups who purchased inputs together (farmer group membership was a requirement for participation in the voucher program in 2009) were more likely to receive subsidized fertilizer even though it does not affect the quantity of subsidized fertilizer received. The Heckman and Double hurdle models for Kano (see Table 3) reveal that while being closely associated with the farm group president did not increase your likelihood of receiving subsidized fertilizer it was an important factor in determining the number of bags of subsidized fertilizer you received. While intragroup dynamics could imply subjective sharing rule once fertilizer is secured by a farmer group, it is not expected to significantly affect the likelihood of receiving subsidized fertilizer as this should rather be determined by participation in the program. This is confirmed by the results in both states that show that links to the farmer group does not affect the likelihood of receiving subsidized fertilizer. However, while table 3 reveals that links to farmer group president was important in Kano where vouchers and fertilizer were distributed at the group level, this variable was insignificant in Taraba (see table 4) where the farmers received individual vouchers which they took themselves to the agro dealers to procure their fertilizer products. These results are robust to estimation technique. Table 3 reveals that the effect of being related to the farm group president is consistently significant and positive in Kano across estimation techniques. Similarly being related to the farm group president is consistently insignificant in Taraba increasing our confidence that results are not driven by model choice.

In Kano, the probability of receiving subsidized fertilizer is positively associated with male respondents who were in a farm group that purchased fertilizer together and had more years of formal education. Wealthier farmers (measured by non-livestock assets) were less likely to participate in the voucher program. In Taraba, in addition to being in a group that purchased

fertilizer together, wealth and education were important factors. Farmers who had more land, more livestock assets and higher years of education were more likely to have participated in the program. In Kano, once participation was accounted for individuals who were related to the farm group president still consistently received more bags of subsidized fertilizer. The Double Hurdle model also finds that more subsidizer fertilizer went to less educated respondents though this is not significant at 10% or less in the Heckman model. However, most other household characteristics were not significantly different from zero. In Taraba, apart from the constant, no other household characteristics were significant determinants of the quantity of subsidized fertilizer received, once participation in the program was controlled for. This appears to reveal that upon participation, traditional household demographics generally did not affect the distribution of fertilizer. This is what we would expect given that participants were supposed to receive a fixed number of bags of subsidized fertilizer once they participated in the program. However the significance of the variable "being related to the farm group leadership" demonstrates that distribution was not uniform, conditional on participation but that your link to the farm group leadership affected the number of bags a participant received. Tables 3 and 4 reveal that the results from the Heckman 2 stage and Double Hurdle in both states are very similar. This probably indicates that assuming that the participation decision dominates the quantity of subsidized fertilizer received is valid in this case.

The fact that fertilizer distribution in Taraba was completely independent of group membership naturally serves as a robustness check for our results in Kano. Given that farmers individually redeemed their vouchers, one would not expect to find positive effects of being a relative of the farmer group president on the quantity of subsidized bags of fertilizer a respondent received. As

discussed above, the coefficient on links to the farmer group president are consistently insignificant for Taraba, as one would expect.

It could be argued that unequal distribution within a group might reflect some optimal sharing rule within the group. Anecdotal evidence reveals that several farmers in Kano complained about not receiving the number of bags of fertilizer they had been promised. Having close links to the farm group president could affect the probability of participating in the voucher program if relatives of farm group presidents were more informed about the existence of the program and the requirements to meet participation criterion. They might also have had easier access to assistance from the president to meet program participation requirements, particularly in large groups. In addition, being related to the farm group president might also increase the likelihood of participating in the program if relatives came together to form a farm group to enable interested members participate in the voucher program. This could optimally lead to unequal distribution within the group if farm group leaders who really need fertilizer rally their relatives who don't really need subsidized fertilizer to form a group so that they can participate in the voucher program with the intention to take his relatives share. In all these cases, one would expect being related to the farm group president to significantly affect participation in the program and where significant, one would expect such relationship to be negatively associated, if reflecting an optimal sharing rule. Estimating the two step models (shown in table 3 for Kano) consistently demonstrate that being related to the farm group president has no significant effect on the probability of receiving subsidized fertilizer and is only significant and positive once participation has been accounted for. This indicates that some sort of intra group dynamics occurred in Kano and affected farmers experience with the voucher program which was absent where distribution was conducted at the individual level

7. Conclusion

This paper explored whether different methods of distributing fertilizer through groups affect expected benefits from using groups to increase farmer access to subsidized inputs. Using a double hurdle model to differentiate participation in the voucher program in Nigeria from a farmers experience once participation is accounted for, we find evidence that farm group membership is not enough to guarantee improved access to subsidized inputs. The study finds that the quantity of subsidized fertilizer received by farmers was not equal (as was expected under the program) but depended on their association to the farm group leader. Farmers who were related to their farm group leader received more bags of subsidized fertilizer than those who were not. These results are robust to various model specifications and consistently reveal that where subsidized fertilizer was distributed through group representatives, outcomes were very different than when subsidized fertilizer was distributed directly to farmers.

These results indicate that partial use of organized groups for true farmer identification in rural areas or to coordinate farmers together for extension training can be useful. However, in the case of input vouchers and product distribution, provision of individual vouchers or mechanisms for individual redemption of fertilizer vouchers are likely to reduce the effect of inequities within groups on farmer access to agricultural inputs or other benefits.

The 2009 voucher program increased farmer access to subsidized fertilizer and farmers who received subsidized fertilizer paid significantly less than the market price for the product[4] (Liverpool-Tasie et al

[4] The four dimensions the program was supposed to address that are evaluated by Liverpool-Tasie et al (2010) are the quantity of fertilizer received, the price paid (which previously was often not different than the market price), the

2010). However, fertilizer was still received late by farmers and no evidence was found that the program improved the quality of fertilizer received (Liverpool-Tasie et al 2010). The results of this research indicate that reducing delays to fertilizer distribution should be accompanied by mechanisms that allow farmers to individually redeem their input vouchers. As efforts are geared towards improving the efficiency of using vouchers for input distribution in Nigeria and across sub Saharan Africa, addressing these issues can expand the benefits associated with such programs

References

Aristae, D.F., Pieroni, L., 2007. Cohort Age and Time Effects in Alcohol consumption by Italian Households: A Double-hurdle Approach. Empirical Economics. DOI 10.1007/s00181-007-0142-5

Arnaiz, M.. 1995. Farmers' Organisations in the Technology Change Process: an Annotated Bibliography. ODI Agricultural Research and Extension Network Paper 53. London: Overseas Development Institute

Ashby, J. , Sperling, L., 1994. Institutionalising Participatory, Client-driven Research and Technology Development in Agriculture. ODI Agricultural Research and Extension Network Paper 49. London:Overseas Development Institute

Banful, A. B, and O. Olayide. 2010. Perspectives of varied stakeholders in Nigeria on the federal and state fertilizer subsidy programs. IFPRI Discussion Paper 01010. Washington, DC: International Food Policy Research Institute.

Barham J, Chitemi C .2009. Collective action to improve marketing performance: lessons from farmer groups in Tanzania. Food Policy,34: 53-59.

Bebbington, A., et al.1994. Farmer and Community Organisations in Agricultural Research and Extension: Functions, Impacts and Questions. ODI Agricultural Research and Extension Network Paper 47. London: Overseas Development Institute

Bernard T., et al. 2008. Impact of Cooperatives on Smallholders' Commercialization Behavior: Evidence from Ethiopia. Agricultural Economics, 39: 1-15.

---

timeliness of fertilizer receipt and the quality of fertilizer measured by the presence of unwanted substances like grass and the prevalence of underweight bags.

Bernard, T. , Spielman, D., 2009. Reaching the rural poor through rural producer organizations? A study of agricultural marketing cooperatives in Ethiopia. *Food Policy, Vol 34, No 1,* February 2009, Pages 60-69.

Bonin, J.P., et al. 1993. Theoretical and Emprirical Studies of Producer Cooperatives: Will Ever the Twain Meet? Journal of Economic Literature, XXXI: 1290‑1320.

Bosc, P., et al.2002. The Role of Rural Producer Organizations in the World Bank Rural Development Strategy .*The World Bank Rural Development Family: Rural Development Strategy, Background Paper.* World Bank, Washington.

Cook, M., Chaddad,F., 2000. Agroindustrialization of the Global Agri-food Economy: Bridging Development Economics and Agri-business Research. Agricultural Economics, 23 (3): 207-218

Cook, M. ,Chambers,M., 2007. Role of Agricultural Cooperatives in Global Netchains. Working Paper for the Montpellier Workshop organised by INRA-MOISA and Wageningen University, Wageningen, the Netherlands.

Davis, K., 2009. The Important Role of Extension Systems. Agriculture and Climate Change: An Agenda for Negotiation in Copenhagen For Food, Agriculture, and the Environment. Focus Brief. 6.

Di Gregorio, M., et al.2004. Property rights, collective action and poverty: the role of institutions for poverty reduction. *Paper prepared for the Tenth Biennial Conference of the International Association for the Study of Common Property (IASCP)*, Oaxaca, Mexico, 9–13 August 2004.

Dorward, A., et al. 2003. A policy agenda for pro-pooragricultural growth. World Development 32 (1), 73–89.

Dulfer, E., 1974. Operational Efficiency of Agricultural Cooperatives in Developing Countries. Rome: FAO Agricultural Development Paper No. 96.

Fafchamps, M., 2005. Market Institutions in Sub-Saharan Africa, Cambridge, Mass.: MIT Press, USA

Fama, E.F., 1980. Agency Problems and the Theory of the Firm, The Journal of Political Economy,Vol.88: 288-307.

Francesconi, G.,Ruerd, R.,2007. Impacts of Collective Action on Smallholders' Commercialisation: Evidence from Dairy in Ethiopia. Paper presented at the European Association of Agricultural Economists 103rd Seminar, April 23-25,

International Fertilizer Developmetn Center (IFDC). 2010. Project Implementation Manual (PIM) For 2009 Fertilizer Voucher Program in Kano and Taraba States

Jones, A. 1992. A Note on Computation of the Double-Hurdle Model with Dependence

with an Application to Tobacco Expenditure. Bulletin of Economic Research, 44:1 (67-74).

Kariuki, G., Place, F., 2005. Initiatives for rural development through collective action: the case of household participation in group activities in the highlands of central Kenya. CAPRi Working Paper 43. IFPRI, Washington DC.

Kerby, J., et al. Valuing Women as customers. Technical Report 248, Primary Industries South Australia, Adelaide

Kruijssen, F., et al..2009. Collective action for small-scale producers of agricultural biodiversity**.** *Food Policy, Vol 34, Issue 1*, February 2009, Pages 46-52

Liverpool-Tasie, L., et al.2010. An assessment of the 2009 fertilizer voucher program in Kano and Taraba, Nigeria. IFPRI NSSP Working paper #17.

Magnani Robert, 1997. Sampling Guide. Food and Nutrition Technical Assistance (FANTA)publication, December 1997.

Maiangwa, M.G, Ogungbile, , A.O., Olukosi, J.O. and Atala, T.K. 2007. Adoption of Chemical Fertilizer for Land Management in the North-West Zone of Nigeria Tropical Agricultural Research and Extension, Vol 10 (2007)

Marsh, S.,Pannell, D.2000. Agricultural extension policy in Australia: the good, the bad and the misguided. Australian Journal of Agricultural and Resource Economics, 44: 605–627. doi: 10.1111/1467-8489.00126

Moffatt, P. 2005. Hurdle Models of Loan Default. Journal of the Operational

Research Society, 56 (1063-1071).

Nagy, J. G.,Edun, O.,2002. Assessment of Nigerian government of policy and suggested alternative market friendly policies. Confidential draft, September 26, 2002. International Fertilizer Development Center.
http://www.usaid.gov/ng/downloads/reforms/assessmentoffertilizerpolicy.pdf. Accessed May 10, 2010

National Bureau of Statistics .2005. Social Statistics in Nigeria. National Bureau of Statistics. Abuja.

Poulton, C., et al. 1998. A new institutional economics perspective on current policy debates. In: Dorward, A., Kydd, J., Poulton, C. (Eds.), Smallholder Cash Crop Production Under Market Liberalization: A New Institutional Economics Perspective. CAB International, Wallingford, UK.

Putterman, L., et al.1985. Choice and Efficiency in a Model of Democratic Semi Collective Agriculture. Oxford Economic Papers, 37 (1): 1-21

Reardon, T., Barrett,C., 2000. Agroindustrialization, Globalization, and International Development: an Overview of issues, patterns and determinants. Agricultural Economics, 23:195-205.

Staatz, J. 1989. Farmer Cooperative Theory: Recent Developments. United States Department of Agriculture (USDA) Agricultural Cooperative Services ACS Research Report Number 84

Stringfellow, R., et al. 1997. Improving the access of smallholders to agricultural services in sub Saharan Africa: Farmer cooperation and the role of the donor community. Overseas development Institute Natural Resources Perspective No. 20.

Vanclay,F.,Lawrence, G.,1995. The environmental imperative: eco-social concerns for Australian agriculture. Rockhampton: Central Queensland University Press

Von Braun, J., 1995. Agricultural Commercialization: Impact on Income and Nutrition and Implications for Policy. Food Policy, 20 (3): 187-202.

Wooldridge, J.M.2002. Econometric analysis of cross section and panel data, Cambridge, MIT Press

World Bank, 2007. Agriculture for Development. World Development Report 2008, Washington D.C., USA.

World Bank, Federal Government of Nigeria. 2010. The National Fadama Development Program. Retrieved on December 5, 2010 from http://fadama.org/

TABLES

Table 1: Summary Statistics

	Kano	Taraba	Kano Voucher participant	Taraba Voucher participant
Member of at least one farm group (1/0)	0.797 (0.403)	0.349 (0.477)	1.000 0.000 * (+)	0.436 (0.498) * (+)
Received subsidized fertilizer in the past (1/0)	0.368 (0.482)	0.198 (0.399)	0.430 (0.497) * (+)	0.541 (0.498) * (+)
Used irrigation in 2009 (1/0)	0.160 (0.367)	0.062 (0.201)	0.219 (0.415) * (+)	0.101 (0.345) * (+)
Used improved seed in 2009 (1/0)	0.551 (0.497)	0.154 (0.361)	0.612 (0.488) * (+)	0.222 (0.442) * (+)
Member of a group that purchased fertilizer together in 2009 (1/0)	0.681 (0.466)	0.295 (0.456)	0.829 (0.376) (+)	0.637 (0.441) * +
Number of 50kg bags of NPK fertilizer received (bags)	1.311 (2.393)	0.449 (1.659)	2.103 (3.387) * (+)	1.376 (3.873) * (+)
Number of 50Kg bags of Urea fertilizer received (bags)	0.631 (1.775)	0.394 (1.078)	1.604 (3.926) * (+)	2.738 (5.891) * (+)
Received subsidized fertilizer in 2009 (1/0)	0.769 (0.422)	0.549 (0.498)	0.887 (0.317) * (+)	0.437 (0.497) * (+)
Number of 50Kg bags of all fertilizer received (bags)	1.942 (3.821)	0.843 (2.405)	3.007 (2.171) * (+)	3.282 (1.496) * (+)
Participated in the 2009 voucher program (1/0)	0.119 (0.324)	0.100 (0.301)	1.000 0.000 * (+)	1.000 0.000 * (+)
Age (years)	33.572 (14.848)	34.925 (12.769)	24.868 (8.766) * (-)	31.222 (11.975) * (-)
Male (1/0)	0.586 (0.493)	0.419 (0.494)	0.656 (0.477) (+)	0.137 (0.345) (-)
Household head has been formally educated (1/0)	0.479	0.648	0.498	0.749

	Kano	Taraba	Kano Voucher participant	Taraba Voucher participant
	(0.500)	(0.478)	(0.500) * (+)	(0.434) * (+)
Land Area in 2009 (hectares)	3.491 (6.764)	3.424 (3.584)	4.233 (1.071) * (+)	4.212 (1.979) * (+)
Farming is the respondents primary occupation (1/0)	0.345 (0.475)	0.508 (0.500)	0.325 (0.501) (+)	0.480 (0.500) * (-)
Respondent is related to the president of their farm group (1/0)	0.799 (0.400)	0.750 (0.433)	0.787 (0.409) (-)	0.591 (0.492) * (-)
Respondent holds a position in the village (1/0)	0.065 (0.246)	0.094 (0.292)	0.072 (0.259) (+)	0.100 (0.301) (+)
Household asset index	2.125 (2.312)	1.576 (1.479)	3.907 (3.837) (-)	1.145 (0.985) +
Household total livestock asset	6.859 (20.195)	9.710 (114.420)	7.610 (23.100) * (+)	26.286 (204.100) * (+)
Respondent rents land (1/0)	0.104 (0.306)	0.120 (0.325)	0.109 (0.311) (+)	0.123 (0.323) (-)

Source: Generated by author with data from the fertilizer voucher program evaluation survey

Note: Standard deviation and the sign of mean differences are in parenthesis.

* denotes significant differences in means of voucher program participants and non participants at a significant level of 10 percent or less.

Table 2 Group dynamics and the quantity of subsidized fertilizer received

Local Government Fixed effects model		
	Kano	**Taraba**
	Number of bags	Number of bags
Participated in Voucher program (1/0)	2.705***	3.522***
	(0.82)	(0.89)
Member of a group that purchased fertilizer together in 2009 (1/0)	1.000*	0.21
	(0.60)	(0.63)
Used improved seed in 2009 (1/0)	0.99	-0.44
	(0.76)	(0.45)
Age (years)	(0.00)	0.02
	(0.01)	(0.01)
Male (1/0)	-0.10	-0.65
	(1.71)	(0.48)
Years of formal education	-0.08	-0.05
	(0.05)	(0.05)
Land Area in 2009 (hectares)	(0.01)	0.32
	(0.03)	(0.27)
Farming is the respondents primary occupation (1/0)	(0.08)	0.46
	(0.35)	(0.34)
Respondent is related to the president of their farm group (1/0)	1.315**	0.26
	(0.65)	(0.41)
Respondent holds a position in their village (1/0)	-0.588*	0.62
	(0.33)	(0.96)
Household asset index	-0.06	-0.01
	(0.12)	(0.14)
Household total livestock asset	0.00	0.00
	(0.01)	(0.00)
Respondent rents land (1/0)	1.52	-0.19
	(1.03)	(0.48)
Constant	0.51	-0.39
	(2.25)	(0.68)
LGA Dummies	YES	YES
Number of observations	1389	861
R-squared (Pseudo r squared)	0.15	0.17

Source: Generated by author with data from the fertilizer voucher program evaluation survey. Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are shown in parentheses. Each regression includes a full set of local government area dummies to capture location specific effects. 1/0 refers to dummy variables with 1 for affirmative responses and zero, otherwise. All standard errors are clustered at the household level since more than one household member could have participated in the voucher program.

Table 3 Intragroup dynamics and the quantity of subsidized fertilizer received in Kano

	Tobit	Heckman model		Double Hurdle (DH)	
	Number of bags	(Probability of receiving subsidized fertilizer)	Number of bags	(Probability of receiving subsidized fertilizer)	Log of number of bags
Participated in Voucher program (1/0)	4.956***	-	-	-	-
	(1.22)	-	-	-	-
Member of a group that purchased fertilizer together in 2009 (1/0)	2.574***	0.688**	-	0.379*	-
	(0.87)	(0.20)	-	(0.22)	-
Used improved seed in 2009 (1/0)	1.17	0.12	-	-0.08	-
	(1.03)	(0.20)	-	(0.22)	-
Age (years)	0.00	0.00	-0.007	0.00	-0.02
	(0.02)	(0.00)	(0.01)	(0.00)	(0.08)
Male (1/0)	0.70	0.88	-0.048	0.810*	-0.15
	(2.54)	(0.47)	(0.27)	(0.46)	(0.30)
Years of formal education	-0.05	0.080***	-0.074	0.0603***	-0.123**
	(0.07)	(0.02)	1.00	(0.02)	(0.06)
Land Area in 2009 (hectares)	(0.02)	(0.02)	0.001	(0.01)	0.00
	(0.03)	(0.01)	(0.58)	(0.01)	(0.08)
Farming is the respondents primary occupation (1/0)	0.03	0.34	-	0.18	0.07
	(0.50)	(0.41)	-	(0.43)	(0.07)
Respondent is related to the president of their farm group (1/0)	1.787**	(0.11)	1.200*	0.10	0.208*
	(0.81)	(0.19)	(0.72)	(0.21)	(0.11)
Respondent holds a position in their village (1/0)	(0.64)	0.13	-0.570	0.02	0.08
	(0.44)	(0.25)	(0.37)	(0.25)	(0.07)
Household asset index	-0.20	-0.19***	0.177	-0.157***	0.04
	(0.18)	(0.05)	(0.19)	(0.05)	(0.09)
Household total livestock asset	0.01	0.01	-0.015	0.01	-0.06
	(0.01)	(0.00)	(0.01)	(0.00)	(0.04)
Respondent rents land (1/0)	1.87	0.14	1.471	0.19	0.25
	(1.35)	(0.37)	(1.10)	(0.37)	(0.16)
Constant	-3.43	-0.73	3.534***	-0.377	1.433***
	(3.35)	(0.54)	(0.98)	(0.45)	(0.52)

LGA Dummies	YES	YES	YES	YES	YES
Number of observations	1389	1389		1038	873
R-squared (Pseudo r squared)	0.06			0.27	

Source: Generated by author with data from the fertilizer voucher program evaluation survey

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are shown in parentheses. 1/0 refers to dummy variables with 1 for affirmative responses and zero, otherwise. All standard errors are clustered at the household level since more than one household member could have participated in the voucher program.

Table 4 Intragroup dynamics and the quantity of subsidized fertilizer received in Taraba

	Tobit model	Heckman Model		Double Hurdle Model	
	Number of bags	(Probability of receiving subsidized fertilizer)	Number of bags	(Probability of receiving subsidized fertilizer)	Log of number of bags
Participated in Voucher program (1/0)	17.09***	-	-	-	-
	(4.01)	-	-	-	-
Member of a group that purchased fertilizer together in 2009 (1/0)	3.371**	0.271***	-	1.084***	-
	(1.58)	(4.03)	-	(0.27)	-
Used improved seed in 2009 (1/0)	0.23	0.10	-	0.10	-
	(1.04)	(0.29)	-	(0.29)	-
Age (years)	0.0758*	0.01	0.02	0.01	-0.05
	(0.04)	(0.00)	(0.01)	(0.00)	(0.10)
Male (1/0)	-2.17	-0.23	-0.01	-0.23	-0.26
	(1.79)	(0.35)	(0.47)	(0.35)	(0.17)
Years of formal education	0.01	0.034**	-0.03	0.0344***	-0.04
	(0.11)	(0.01)	(0.08)	(0.01)	(0.06)
Land Area in 2009 (hectares)	0.594*	0.005**	0.42	0.00474***	0.20
	(0.36)	(0.00)	(0.34)	(0.00)	(0.19)
Farming is the respondents primary occupation (1/0)	2.027*	6.576***	-	0.00	0.01
	(1.06)	(0.24)	-	0.00	(0.09)
Respondent is related to the president of their farm group (1/0)	1.11	-0.18	-0.47	-0.19	0.01
	(0.95)	(0.21)	(0.41)	(0.21)	(0.10)
Respondent holds a position in their village (1/0)	0.97	0.00	0.55	0.00	0.21
	(1.87)	(0.19)	(1.32)	(0.19)	(0.17)
Household asset index	0.12	-0.08	0.40	-0.08	0.08
	(0.44)	(0.08)	(0.30)	(0.08)	(0.13)
Household total livestock asset	0.00	0.0007**	0.00	0.000736**	0.03
	(0.00)	(0.00)	(0.00)	(0.00)	(0.05)
Respondent rents land (1/0)	-0.44	-0.38	-0.03	-0.38	-0.13
	(1.67)	(0.28)	(0.67)	(0.28)	(0.24)
Constant	-19.37***	-0.68	1.624*	-0.68	1.924***
	(5.51)	(0.51)	(0.95)	(0.51)	(0.42)

LGA Dummies	YES	YES	YES	YES	YES
Number of observations	861	324	861	790	246
R-squared (Pseudo r squared)	0.17	0.18		0.309	

Source: Generated by author with data from the fertilizer voucher program evaluation survey

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are shown in parentheses. 1/0 refers to dummy variables with 1 for affirmative responses and zero, otherwise. All standard errors are clustered at the household level since more than one household member could have participated in the voucher program.

APPENDIX

A.1.Sample selection

The domain for this analysis is smallholders in Kano and Taraba States; the subpopulations for which we want survey estimates of the outcome of participation in the voucher program. We randomly selected 10 local government areas each in both states. To ensure a level of generalization was possible from our survey, we confirmed that the 10 LGAs selected represented potential LGA variation such as proximity to state capitals (Kano city and Jalingo), population and accessibility in terms of road availability and quality as can be seen in figures 1 and 2.

Our measurement units are the households and household members surveyed in both states. The key variables of interest that were used to determine the minimum sample size necessary for our analysis are quantity of subsidized fertilizer used as well as price of fertilizer purchased. We used the formula given in the sampling guide provided by the Food and Nutrition Technical Assistance (FANTA) for calculating the minimum necessary sample size. Our calculations were done to ensure with 95% confidence that estimated differences between program participants and non participants (or participants over time) are not purely by chance and to have 80% confidence that an actual change or difference will be detected (power of the test) (Magnani, 1997).

Data on fertilizer consumption by states was not readily available. Thus our minimum sample size requirements were estimated using approximations from available data as follows: For quantity of fertilizer used, Banful et al, 2010 reveal that the average quantity of fertilizer that farmers in Kano and Taraba states would have if subsidized fertilizer were equally distributed across households would be 97kg and 117kg respectively. However, Nagy and Edun (2002)

estimate that only about 30 percent of subsidized fertilizer reaches small farmers at the subsidized price. Thus we can estimate that farmers in Kano and Taraba on average receive about 29.1kg and 35.1kg each of subsidized fertilizer through the traditional distribution mechanism. The goal of the voucher program was to increase the quantity of subsidized fertilizers farmers received through the use of vouchers rather than the previous government controlled distribution mechanism. Participating farmers in Kano and Taraba should have received 3 bags (150kg) and 4 bags (200kg) respectively. Using these figures, we can estimate that the sample size needed to identify the changes due to the program required samples of between 30 and 35 households on the quantity of subsidized fertilizer used in each state using the following FANTA formula:

$$n=D[(Z_\alpha+Z_\beta)^2*(⟦sd⟧_1^2+⟦sd⟧_2^2)/(X_2-X_1)^2]$$

Where:

n = required minimum sample size per survey round or comparison group

D = design effect for cluster surveys indicating the factor by which the sample size for a

cluster sample would have to be increased in order to produce survey estimates with the same

precision as a simple random sample (We use the default value of 2 as suggested by Magnani, 1997.

X1 = the estimated level of fertilizer a household has access to prior to the program

X2 = the expected level of subsidized fertilizers households have access to after participation sd1 and sd2 = expected standard deviations for the indicators for the comparison groups being compared

$Z\alpha$ = the z-score corresponding to the degree of confidence with which it is desired to be able to conclude that an observed change of size (X2 - X1) would not have occurred by chance (statistical significance), and

$Z\beta$ = the z-score corresponding to the degree of confidence with which it is desired to be certain of detecting a change of size (X2 - X1) if one actually occurred (statistical power).

NOTE: For the standard deviation, we used estimates on the ratio of mean to standard deviation of fertilizer use from a subsample of largely cereal producing households in another northern state, Kaduna in 2008 (IFPRI, 2008). The mean to standard deviation ratio was 1.07. This ratio was applied to our mean quantity of subsidized fertilizer before and after the voucher program to get the associated standard deviations. Even if there was no diversion of subsidized fertilizer in both states, applying the same formula indicates that we need between 170 and 250 respondents in Taraba and Kano respectively.

For further confirmation, the minimum sample calculation was also conducted using secondary data from other studies. A 2007 study cites 41kg/ha as the average fertilizer use for Kano state (Maiangwa et al, 2007). Discussions with Kano's Agricultural research development authority informs that average land size in Kano of about 1.9 ha. This amounts to about 78kg per household. Using the same standard deviation as above, we estimated the new minimum size necessary to satisfactorily capture a change in quantity of fertilizer used from 78 kg per household to about 150 kg (the three subsidized bags to be available through the program). It is estimated that a sample size of 118 is necessary.

For price of fertilizer, we used the August 2009 price of Urea (as that was the date at which about 80% and 90% of the vouchers had been distributed in Taraba and Kano respectively. The price of Urea at Dawanau market in Kano was about N3200 per 50 kg bag (N64/kg) . The vouchers were individually worth a total value of N 2,000/50 kg bag. Thus, the benefit of receiving the voucher should translate to a N2000 difference in the price of Urea. Using this in the above formula to calculate the minimum sample size with standard deviation calculated again using the ratio of the mean to standard deviation of prices paid by farmers in Kaduna, we estimate that the minimum sample size would be about 80 households in Kano. Recognizing that farmers in more remote rural areas are likely to pay higher prices for their fertilizer, we simulated the price estimates and find that even if Urea prices were 50% higher in the rural areas (N4500 per bag), the minimum sample size would be about 210 .

Solely based on population, our sample should be composed of 80 % of households in Kano and 20 % in Taraba. However, to ensure adequate number of full respondents per state, the population difference of our 1000 households between the two states is reflected by a 640/360 split which reflects the state proportions within the total voucher program target group and is

greater than the minimum desired sample size based on the most demanding sample size requirements based on earlier discussed calculations. Consequently, we surveyed 1000 households; 640 in Kano and 360 in Taraba and the respondents are largely household heads, their spouses, other adult household members and for a few questions, children and youth in the household.

Table A1. Distribution of sample households across the 10 Local government areas in Kano

Kano			
Local Government Area	**Number of households surveyed**	**Local Government Area**	**Number of households surveyed**
Bagwai	64	Ungoggo	91
Takai	64	Gezawa	83
Dambatta	60	Gabasawa	60
Dala	82	Rano	49
Karaye	37	Kura	50
Total		**640**	

Source: Generated by author from the fertilizer voucher program evaluation survey