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Farmer Groups, Input Access, and Intragroup Dynamics

A Case Study of Targeted Subsidies in Nigeria

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ABSTRACT

Farmer groups are considered potentially effective mechanisms to increase farmer livelihood by reducing information asymmetries and transaction costs. In many countries, farmers are coordinated in groups for participation in poverty reduction programs. This is common practice in many input voucher programs in Sub-Saharan Africa. While the effect of farmer groups on certain outcomes such as price received and marketing has been studied, few studies, if any, have examined the effect of intragroup dynamics on farmer experience of input voucher programs. Consequently, this research uses a fertilizer voucher scheme in Nigeria to explore whether different methods of distributing fertilizer through farmer groups can affect an intervention's ability to increase farmer access to agricultural inputs. To receive a fertilizer voucher in a pilot targeted subsidy program in Nigeria, all farmers were required to be members of an organized group. However, for fertilizer distribution among one set of participants, individual farmers were given their allotted share directly, whereas farmers in the other set received their fertilizer 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 did those without. When fertilizer was given directly to farmers, such results did not occur. Separating the factors that determined if farmers received fertilizer from those that determined how much fertilizer they received once they participated in the program, strong evidence of intragroup dynamics was found only for the quantity of subsidized fertilizer received. The different outcome suggests that whereas groups may facilitate the process of farmer identification and coordination, intragroup dynamics may affect their efficacy for providing equal access to inputs for members. 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 social capital and intragroup dynamics plays in the successful implementation of such programs.

Keywords: input vouchers, farmer groups, intragroup dynamics, social capital, fertilizer subsidies, Nigeria

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1. INTRODUCTION

Farmer groups are considered potentially effective mechanisms to increase farmer livelihood by reducing information asymmetries and transaction costs (Kruijssen, Menno, and Giuliani 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). Collective action, as is possible through farm groups, can also reduce individual farmer risk with long-term investments such as those required for perennial crops and capital-intensive processing technologies (Di Gregorio 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. 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 program in Nigeria. The input voucher program is a relatively new, targeted, fertilizer subsidy approach that was piloted at the state level in 2 Nigerian states in 2009 and expanded to 4 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 with the 2009 input voucher program that was implemented in two Nigerian states: intragroup dynamics. 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 smallholder farmers on time. Participation in the program was 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. Using primary data collected from 1,000 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 groups.

Using a local-government-level fixed-effects and limited-dependent-variable models that distinguish the factors affecting the likelihood of receiving of any subsidized fertilizer from those that determine the number of subsidized bags participants received, the study finds that the quantities of fertilizer received by farmers were not equal and depended on the farmers' association to the farm group leaders. Farmers who had close links to their farm group leaders received more bags of subsidized fertilizer than those who did not. These findings are important given the current focus on using organized groups to improve access to extension, credit, and other agricultural inputs such as fertilizer. Agricultural input vouchers are increasingly being employed across Sub-Saharan Africa to address problems of low agricultural productivity and food security through increased and timely access to inputs. Consequently, it is important to understand the role that group dynamics plays in the implementation of such targeted subsidy programs. Program implementers might want to coordinate farmers in groups but ensure that inputs are distributed to farmers individually to avoid any inequities that could arise when the fertilizer is

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

given to farm group leaders. To maximize the impact of programs, nuances about intragroup dynamics must be considered.

The paper proceeds as follows: Section 2 provides a brief summary of some relevant literature, and Section 3 describes the 2009 fertilizer voucher program in Kano and Taraba states. Section 4 presents the analytical framework, and Section 5 discusses the data used. Section 6 presents the study results, followed by some robustness checks in Section 7. Section 8 concludes.

2. LITERATURE REVIEW

Arguing the case for collective action among farmers dates back to the 1920s, when 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 renewed attention to institutions of collective action such as farmer groups. This attention stems from their proposed ability to address a major challenge faced by smallholders in developing countries: lack of market access (Barham and Chitemi 2009). Farmer groups are considered an efficient mechanism to improve the marketing performance of smallholder 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 toward 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 Barrett 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 such as farmer groups (World Bank 2010; Stringfellow et al. 1997; Davis 2009).

The majority of the literature on farmer groups in developing countries focuses on their benefits. These include their ability to provide cost-saving and risk-sharing benefits to farmers in uncertain agricommodity markets, their potential for generating economies of scale and scope that contribute to reducing transaction costs, and their ability to improve bargaining power vis-à-vis the market (Bonin, Jones, and Putterman 1993, Dulfer 1974; Kruijssen, Menno, and Giuliani 2009; Bernard and Spielman 2009; Di Gregorio et al. 2004). In the development-assistance arena, farmer groups are seen as an efficient mechanism for disseminating agricultural information as well as for coordinating program beneficiaries (for example, World Bank–assisted Fadama [I, II, and III]; see Marsh and Pannell 2000; Davis 2009). Fewer studies have highlighted the challenges associated with farmer groups. These include 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, Merrill-Sands, and Farrington (1994); Ashby and Sperling (1994); and Vanclay and Lawrence (1995).

Most of the discussion about challenges associated with farmer groups focuses on the potential for some members (for example, wealthier farmers) to be overrepresented in group activities, for some groups (such as 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 placed on the effect of intragroup 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 such as the quality of output (Francesconi and Ruben 2007). Studies have also demonstrated the limited benefits of such groups for some types of farmers such as the poor or women (Bernard, Taffesse, and Gabre-Madhin 2008; Kerby et al. 1996). However, empirical work on the effect of intragroup dynamics on farmer experiences of agricultural programs or interventions is limited. This study

contributes to that scarce literature by empirically testing for the effect of intragroup 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[2]). It was designed to deliver subsidized fertilizer to 140,000 and 76,000 smallholder farmers in Kano and Taraba, respectively. The value of the voucher was a N2,000[3] discount per bag on two bags of triple 15 Nitrogen Phosphorous Potassium (NPK 15:15:15) and one bag of Urea (46 percent N) content) in Kano, and on two bags each of NPK 15:15:15 and Urea (46 percent N) in Taraba. According to the Nigeria Agri Markets Information Service, fertilizer prices in central markets in Kano and Taraba were about N3,000 and N3,600, respectively, for a 50-kilogram bag of NPK 15:15:15 and N3,200 and N3,650, respectively, for a 50 kg bag of Urea. Thus, the voucher value was roughly 55 to 65 percent of the NPK 15:15:15 and Urea market prices in the two states. Farmers were required to pay the difference between the market price and the N2,000 discount per bag (IFDC, 2010).

The programs in both states required each participant to be a 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 N2,000 × 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 programs in the two 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 Taraba, however, since each farmer redeemed the voucher himself or herself, the role of the group was more for farmer identification and coordination, and the amount of fertilizer a farmer received was dependent on only his or her personal desire and ability to pay the difference between the voucher value and the market price on the four bags of fertilizer allowed.

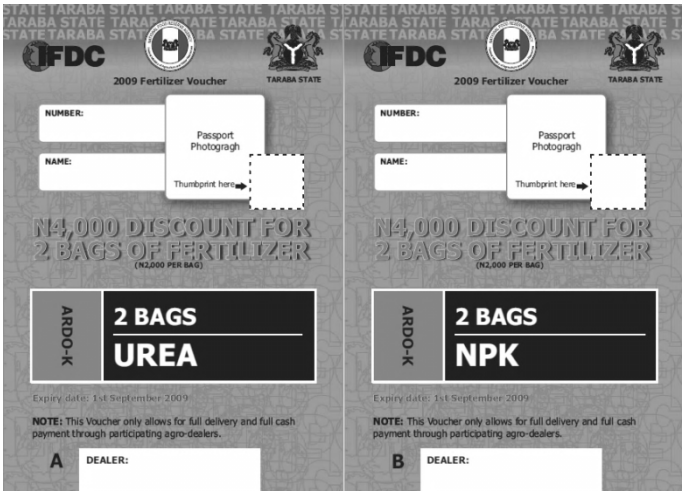
In Taraba, the operational procedure by which farmers received vouchers was as follows. Farmers from selected organized groups gathered at a voucher distribution center on a prearranged day. Each farmer was required to bring three passport photographs. The leader of the group vouched for the identity 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 3.1. A passport photograph was affixed to each section.

The third copy of the farmer's photograph was affixed to a roster to be given to the specific agricultural input dealer with whom 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 3.1. Upon filing 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 four bags of fertilizer.

[2] IFDC is also known as the International Fertilizer Development Center. Though the name has changed, the organization's acronym continues to be used interchangeably

[3] $1is equivalent to about N155.00

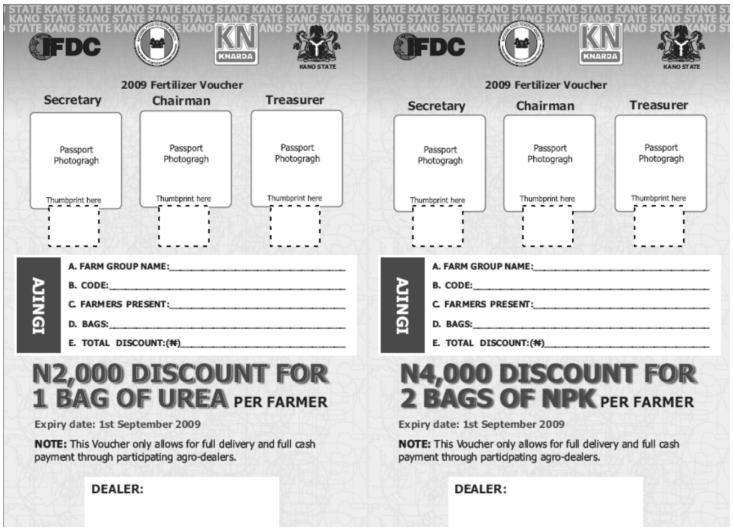
Figure 3.1—An example of the fertilizer voucher used in Taraba State in 2009



Source: International Center for Soil Fertilizer and Development voucher program implementation manual.

In Kano, on the other hand, farmer groups were required to bring their certificates of registration to verify their groups' authenticity. Due to the long history of 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 3.2 shows an example of a voucher used in the program in Kano. In Kano, rather than having the photos of individual farmers on the vouchers as was the case in Taraba, only photos of the farm group representatives (that is, secretary, chairman, and treasurer) were placed in the relevant slots shown in Figure 3.2. Each individual member of the group had to provide one single passport photo to the farm group executive to be presented on 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 three 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 N6,000.

Figure 3.2—An example of the fertilizer voucher used in Kano State in 2009



Source: International Center for Soil Fertility and Development voucher program implementation manual.

4. ANALYTICAL FRAMEWORK

Operating in rural Nigeria, where rural financial markets are 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(1986). In this context, the utility maximization problem that results is as follows:

$$Max_c \ U(c, z^h) \tag{1}$$

This maximization is subject to various constraints: a cash income constraint, a credit constraint, a production technology constraint, and a price constraint (to reflect its endogeneity) as well as the necessary equilibrium condition for nontradables. 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 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 or her 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 N2,000 discount 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 and the probability that program participants received subsidized fertilizer would be greater than those of their counterparts who did not participate in the program. Furthermore, in the event that there were no inequities in a farm group or no effect of group dynamics, an individual's characteristics should not affect the quantity of subsidized fertilizer received. More specifically, one's link to the farm group president should not have a significant effect on the quantity of bags of fertilizer received, once participation in the program had been accounted for.[4] Consequently this study estimates equations 4 and 5:

$$Y1 = \alpha_1 + \beta_{v1}VOUCHER_i + \beta_{P1}PRESIDENT_i + \beta_{z1}Z_i + \beta_{L1}LGA_i + \varepsilon_{i1,} \tag{4}$$

$$Y2 = \alpha_2 + \beta_{v2}VOUCHER_i + \beta_{P2}PRESIDENT_i + \beta_{z2}Z_i + \beta_{L2}LGA_i + \varepsilon_{i2,} \tag{5}$$

[4] It is possible that deviations from the program-sharing rule (three bags each for every farm group member in Kano: two bags of NPK 15:15:15 and one bag of Urea) reflect an equilibrium-sharing rule within the group. However, anecdotal evidence revealed numerous complaints of farmers about the quantity of fertilizer they received being less than what they were promised.

where the dependent variable (Y1) is a dummy variable set to 1 if the farmer received subsidized fertilizer in 2009 in equation 4 and the number of 50-kilogram bags of subsidized NPK 15:15:15 and Urea fertilizer (Y2) that a farmer received in 2009 in equation 5. $VOUCHER_i$ is a dummy variable equal to 1 if farmer *i* participated in the voucher program; $PRESIDENT_i$ is a dummy variable equal to 1 if the respondent was the president, a family member of, or a friend of the farmer group president and 0 otherwise; and Z refers to a vector of household characteristics and other variables expected to affect the quantity of fertilizer that a farmer would use. Specifically, Z consists of the respondent's age, whether he or she was formally educated, and whether he or she held leadership positions in the village, owned land, and had other proxies of wealth like livestock and non-livestock assets. Among the variables in Z is the membership of a respondent in at least one farmer group and/or whether a farmer's farm group procured fertilizer together in 2009, which are our best proxies for the factor that led the farmer to be selected for participation. Z also includes dummies to distinguish respondents who are household heads and their spouses from other family members. 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_i is the respondent-specific error, which is assumed to be random with a zero mean. Estimations are run separately in Kano and Taraba to account for any state differences in demographics, agroecology, and history of fertilizer use and access as well as to capture differences in the program implementation strategy as discussed in Section 3. The relationship between links to the farmer group president and the probability of receiving subsidized fertilizer as well as the quantity of subsidized fertilizer received are estimated using a limited-dependent-variable estimation (probit) and a local government area (LGA)–level fixed-effects model[5] to estimate equations 4 and 5, respectively. A double hurdle model that estimates equation 4 using a probit model and equation 5 using a truncated regression on the non-zero values of *Y2* was also estimated. These results which are effectively the same are shown in Appendix B.

Although it is a relevant question, the effect of participating in the voucher program on the quantity of subsidized fertilizer received (see Liverpool-Tasie et al (2010) for that analysis) was not the particular focus of this study. This study is particularly interested in the effect of intragroup dynamics on farmer experience of a targeted subsidy program. Consequently, although 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 a significant effort to ensure that the variable used to capture respondent links to the farm group president is not endogenous and satisfies the necessary conditions for the proper estimation of β_p.

[5] The local government area 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 Wooldridge (2002, chap. 10) for more details.

5. DATA

The National Bureau of Statistics of Nigeria reports that in 2005 there were about 1,320,000 households in Kano and 447,000 households in Taraba (National Bureau of Statistics 2005). The data used in this study come from a survey of 1,000 households, 640 in Kano (northwest Nigeria) and 360 in Taraba in northeast Nigeria. This number exceeds the minimum sample size required to determine statistical differences between participants and nonparticipants in the voucher program with 95 percent confidence. In each state, the interviewed households were selected from 10 randomly selected 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 that 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 Appendix A. However, the survey respondents were largely household heads, their spouses, other adult household members, and for a few questions, children and youth in the households. Respondents were interviewed about their participation in various farm groups and other associations, their leadership positions in their farm groups and local communities, their farming practices (input use, sources, and prices), and 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. EMPIRICAL ESTIMATION AND RESULTS

The voucher program was intended to improve on the traditional fertilizer distribution system characterized by numerous leakages and the late delivery of poor-quality fertilizers to farmers at often close-to-market price (Nagy and Edun 2002; IFDC 2010). Thus, an improved system would be expected to reduce fertilizer leakages and increase the quantity of subsidized fertilizer that farmers accessed. 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). Consequently, rather than focusing on the effect of program participation alone on the quantity of fertilizer, 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 his or her farm group president. This is a dummy variable equal to 1 if the respondent was the president or a family member or friend of the farmer group president and 0 otherwise. To avoid ambiguity in the role that closeness to farm group president plays, this study considers only 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, not necessarily more so in farm groups than in other kinds of organized groups. The effects of program participation and links to the farm group president on quantity of fertilizer received are explored using linear and nonlinear models of multivariate analysis wherein the outcome variables are continuous and binary, respectively.

Summary statistics of the variables used in the various estimations are found in Table 6.1. They reveal that only about 20 percent of respondents in Taraba had received subsidized fertilizer prior to 2009, whereas almost 40 percent had received the product in Kano. Fertilizer (NPK 15:15:15 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. Although purchasing was higher among voucher program participants, further disaggregation among recipients shows that whereas some farmers received the expected three or four bags in total, some farmers who participated in the program received more than four bags, and others received less than a bag of subsidized fertilizer.

Table 6.1—Summary statistics

	Kano	Taraba	Kano Voucher Participant	Taraba Voucher Participant
Ever participated in an agriculture-related training (1/0)	0.228	0.114	0.338	0.145
	(0.420)	(0.318)	(0.475)	(0.354)
			*(+)	(+)
Member of a rotating savings and credit arrangement (1/0)	0.161	0.263	0.020	0.564
	(0.368)	(0.441)	(0.140)	(0.498)
			* (–)	(+)
Member of at least one farm group (1/0)	0.797	0.349	1.000	0.436
	(0.403)	(0.477)	0.000	(0.498)
			* (+)	* (+)
Received subsidized fertilizer in the past (1/0)	0.368	0.198	0.430	0.564
	(0.482)	(0.399)	(0.497)	(0.498)
			* (+)	* (+)
Used irrigation in 2009 (1/0)	0.160	0.042	0.219	0.137
	(0.367)	(0.201)	(0.415)	(0.345)
			* (+)	* (+)
Used improved seed in 2009 (1/0)	0.551	0.154	0.612	0.222
	(0.497)	(0.361)	(0.488)	(0.442)

Table 6.1—Continued

	Kano	Taraba	Kano Voucher Participant	Taraba Voucher Participant
			* (+)	* (+)
Member of a group that purchased fertilizer together in 2009 (1/0)	0.385	0.078	0.444	0.427
	(0.487)	(0.268)	(0.498)	(0.497)
			(+)	* +
Number of 50-kilogram bags of NPK 15:15:15 fertilizer received (bags)	1.311	0.449	2.103	1.376
	(2.393)	(1.659)	(3.387)	(3.873)
			* (+)	* (+)
Number of 50-kilogram bags of Urea fertilizer received (bags)	0.631	0.394	1.604	2.738
	(1.775)	(1.078)	(3.926)	(5.891)
			* (+)	* (+)
Received subsidized fertilizer in 2009 (1/0)	0.769	0.549	0.887	0.437
	(0.422)	(0.498)	(0.317)	(0.497)
			* (+)	* (+)
Number of 50-kilogram bags of all fertilizer received (bags)	1.942	0.843	3.007	3.282
	(3.821)	(2.405)	(2.171)	(1.496)
			* (+)	* (+)
Price paid for NPK 15:15:15 in 2009	2267.08	4019.02	1568.15	3354.17
	(1541.60)	(938.98)	(966.89)	(678.91)
			* (–)	* (–)
Price paid for Urea in 2009	2182.58	3737.97	1083.72	2441.03
	(1467.6)	(1311.21)	(333.21)	(185.65)
			* (–)	* (–)
Age (years)	33.572	34.925	24.868	31.222
	(14.848)	(12.769)	(8.766)	(11.975)
			* (–)	* (–)
Male (1/0)	0.586	0.419	0.656	0.137
	(0.493)	(0.494)	(0.477)	(0.345)
			(+)	(–)
Household head has been formally educated (1/0)	0.479	0.648	0.498	0.749
	(0.500)	(0.478)	(0.500)	(0.434)
			* (+)	* (+)
Land area in 2009 (hectares)	3.491	3.424	4.233	4.212
	(6.764)	(3.584)	(1.071)	(1.979)
			* (+)	* (+)
Farming is the respondent's primary occupation (1/0)	0.333	0.424	0.338	0.482
	(0.471)	(0.494)	(0.475)	(0.130)
			(+)	* (–)
Respondent is closely associated with the president of the farm group (1/0)	0.847	0.849	0.787	0.591
	(0.361)	(0.358)	(0.479)	(0.492)
			(–)	* (–)
Respondent holds a position in the village (1/0)	0.065	0.094	0.072	0.100
	(0.246)	(0.292)	(0.259)	(0.301)

Table 6.1—Continued

	Kano	Taraba	Kano Voucher Participant	Taraba Voucher Participant
			(+)	(+)
Household asset index	2.125	1.576	3.907	1.145
	(2.312)	(1.479)	(3.837)	(0.985)
			(–)	+
Household total livestock asset	6.859	9.710	7.610	26.286
	(20.195)	(114.420)	(23.100)	(204.100)
			*(+)	* (+)
Respondent rents land (1/0)	0.104	0.120	0.109	0.123
	(0.306)	(0.325)	(0.311)	(0.323)
			(+)	(–)
Respondent is the household head (1/0)	0.308	0.337	0.318	0.330
	(0.462)	(0.473)	(0.466)	(0.471)
			(+)	(–)
Respondent is the spouse of the household head (1/0)	0.429	0.431	0.438	0.394
	(0.495)	(0.495)	(0.496)	(0.490)
			(+)	(–)
Respondent is another household member other than the head or spouse of the head	0.263	0.232	0.243	0.275
	(0.440)	(0.423)	(0.429)	(0.448)
			*(–)	*(+)

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

Note: 1/0 refers to dummy variables with 1 for affirmative responses and 0 otherwise. Standard deviations and the signs of mean differences are in parenthesis.
*Denotes significant differences in means of voucher program participants and nonparticipants at a significant level of 10 percent or less.

The results from estimating equations 4 and 5 (shown in Table 6.2) reveal that participants in the voucher program were more likely to receive subsidized fertilizer and also received more bags of subsidized fertilizer than nonparticipants. The findings also showed that although being closely associated with the farm group president did not increase one's likelihood of receiving subsidized fertilizer in both states, it was an important factor in determining the number of bags of subsidized fertilizer one received in Kano. Although intragroup dynamics could imply a subjective sharing rule once fertilizer was secured by a farmer group, it is not expected to significantly affect the likelihood of receiving subsidized fertilizer; this rather should be determined by participation in the program. This is confirmed by the results that show that links to the farmer group do not affect the likelihood of receiving subsidized fertilizer (whereas participation in the voucher program does), but it is significant and positively associated with the number of bags of subsidized fertilizer received. Similarly, although having links to the farmer group president was important in Kano, where vouchers and fertilizer were distributed at the group level, this variable was insignificant in Taraba, where the farmers received individual vouchers that they took themselves to the agro dealers to procure their fertilizer products.

Table 6.2—Group dynamics and the quantity of subsidized fertilizer received

	Probit Models (Probability of Receiving Subsidized Fertilizer)		Fixed-effects Model (Number of Bags)	
	Kano	Taraba	Kano	Taraba
Participated in voucher program (1/0)	0.764***	7.170***	2.568***	3.556***
	(0.24)	(0.62)	(0.81)	(0.87)
Member of a group that purchased fertilizer together in 2009 (1/0)	0.250	0.420	0.930*	–0.007
	(0.220)	(0.390)	(0.540)	(0.510)
Used improved seed in 2009 (1/0)	–0.345	–0.009	1.123	–0.493
	(0.250)	(0.010)	(0.820)	(0.440)
Age (years)	0.0154*	0.529*	–0.0004	–0.006
	(0.010)	(0.280)	(0.030)	(0.010)
Male (1/0)	0.340	0.152	–0.424	0.105
	(0.280)	(0.180)	(0.650)	(0.410)
Household head has been formally educated (1/0)	0.152	0.008	–0.164	–0.798
	(0.190)	(0.020)	(0.370)	(0.750)
Land area in 2009 (hectares)	–0.006	–0.250	–0.013	0.318
	(0.020)	(0.170)	(0.030)	(0.270)
Farming is the respondent's primary occupation (1/0)	–0.292*	0.044	–0.131	–0.652*
	(0.170)	(0.310)	(0.510)	(0.350)
Respondent is closely associated with the president of the farm group (1/0)	0.0293	–0.076	1.247*	–0.618
	(0.270)	(0.260)	(0.690)	(0.380)
Respondent holds a position in the village (1/0)	0.135	–0.231**	–0.514	0.235
	(0.260)	(0.110)	(0.370)	(1.030)
Household asset index	–0.170***	0.005	–0.030	0.056
	(0.050)	(0.010)	(0.110)	(0.150)
Household total livestock asset	0.007	–0.555	–0.004	–0.003
	0.000	(0.470)	(0.010)	0.000
Respondent rents land (1/0)	0.508	0.330	1.817*	–0.344
	(0.340)	(0.400)	(1.070)	(0.480)
Respondent is the household head (1/0)	–0.609**	0.440	0.0497	0.884
	(0.27)	(0.28)	(1.05)	(0.63)
Respondent is the spouse of the household head (1/0)	–0.191	–0.609	–0.557	–0.156
	(0.250)	(0.370)	(0.630)	(0.370)
Constant	5.114***	–0.747	0.040	0.765
	(0.480)	(0.510)	(2.150)	(0.600)
Local government area dummies	Yes	Yes	Yes	Yes
Number of observations	1,021	739	1,389	739
R-squared (pseudo *R*-squared)	(.396)	(.571)	.146	.1731
Adjusted *R*-squared			.131	.145

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

Note: 1/0 refers to dummy variables with 1 for affirmative responses and 0 otherwise. Standard errors are in parentheses. Each regression includes a full set of local government area dummies to capture location-specific effects.

*$p < .10$. **$p < .05$. ***$p < .01$.

The results also indicated that whereas wealthier families (measured by the asset index) in Kano were less likely to receive subsidized fertilizer, when they did receive fertilizer, they tended to procure more bags (as indicated by the land ownership variable). Respondents in Kano who rented the land they farmed on received more bags of subsidized fertilizer than those who owned land. Given limited availability of land and high land rent costs, renting land might actually be more prevalent among richer farmers. Household heads were less likely to receive subsidized fertilizer compared to other family

members. This suggests that once a household head was a program participant, several other members of the same household were also indicated as members of an organized group and therefore also eligible to receive fertilizer. The data confirms this interpretation as about 95 percent of other family members in households where the head participated in the voucher program also participated in the program.

In Taraba, older farmers were more likely to receive subsidized fertilizer, and after accounting for program participation, respondents who held leadership positions in their villages were less likely to receive subsidized fertilizer than those who did not hold positions. Since estimation is at the individual level, this might be due to village leaders' being less involved in agriculture (for example, if they are elders or chiefs) and thus less likely to seek subsidized fertilizer. The LGA in which an individual is located is a significant determinant of the probability of receiving subsidized fertilizer and the quantity of bags received.

7. ROBUSTNESS CHECKS

A respondent's link to the farm group president as expressed in equations 4 and 5 is arguably exogenous since there is less of a choice element about to whom one is related. It is also unlikely that there are unobservable characteristics of an individual that would jointly determine his or her relationship to the farmer group president and the quantity of fertilizer received. However, it could be argued that the friendship component of the link to farmer group president (since it contains relatives and friends) makes the "link to farm group president" variable endogenous in equations 4 and 5. This would occur, for example, if individuals who are friends of farm group leaders are also more progressive farmers and therefore more likely to manage to get more fertilizer or to have already put themselves in a position to have a higher return to fertilizer use, say growing higher-value crops or using irrigation. Thus, a robustness check was conducted that involved dropping respondents who were merely friends of the farm group president and rerunning estimations of equations 4 and 5 where the link to farm group president was based solely on kinship ties. Thus, in this estimation, an individual was considered linked to the farm group president only if he or she was the farm group president himself or herself or if that person was a relative of the farm group president. The results of this estimation (found in column 2 of Table 7.1) confirm that relatives of the farmer group president received more bags of subsidized fertilizer than those who were not related to the farmer group president. This confirms that friendship is not what is driving the results but rather an association that is not dependent on choice (family ties) but strongly indicating closeness to the farm group president.

Table 7.1—Group dynamics and the number of bags of subsidized fertilizer received in Kano

Explanatory Variables	Kano State (Only Voucher Participants)	Kano State (Only Relatives of the Farm Group President)
Participated in voucher program	—	3.189***
	—	(0.739)
Member of a group that purchased fertilizer together in 2009	1.008	0.409
	(0.970)	(0.524)
Number of trade groups individual belongs to	–1.623	–0.655
	(1.089)	(0.432)
Major decisionmaker on household plots (1/0)	–0.153	0.152*
	(0.172)	(0.083)
Used improved seed in 2009	1.077	1.266
	(1.217)	(0.830)
Age	–0.008	–0.007
	(0.040)	(0.026)
Male (1/0)	0.090	–0.410
	(0.744)	(0.469)
Head has been formally educated	–0.648	–0.223
	(0.543)	0.366
Land area in 2009	0.017	–0.007
	(0.038)	0.030
Farming is the respondent's primary occupation	0.197	–0.057
	(0.823)	0.447
Respondent is closely associated with the farm group president	1.653*	1.253**
	(1.000)	(0.558)
Respondent is the household head	–0.283	0.238
	(1.577)	(0.961)
Respondent is the spouse of the household head	–0.364	–0.370
	(0.901)	(0.535)

Table 7.1—Continued

Explanatory Variables	Kano State (Only Voucher Participants)	Kano State (Only Relatives of the Farm Group President)
Household asset index	0.052	–0.017
	(0.194)	(0.115)
Household total livestock asset	–0.003	–0.003
	(0.019)	(0.011)
Respondent rents land	3.259**	1.690*
	(1.717)	(0.975)
Bagwai	—	—
	—	—
Takai	0.451	–3.616*
	(1.714)	(1.896)
Danbatta	2.759*	–1.934
	(1.550)	(1.858)
Dala	1.356	–3.958**
	(1.493)	(1.995)
Karaye	2.758	–2.440
	(2.418)	(1.777)
Ungogo	1.948*	–3.015
	(1.023)	(2.045)
Gezawa	12.343**	2.455
	(5.040)	(2.155)
Gabasawa	–0.124	–4.906***
	(1.037)	(1.685)
Rano	4.383	–2.655
	(4.759)	(1.882)
Kura	1.107	–3.391**
	(1.247)	(1.610)
Constant	–0.156	3.226*
	(2.173)	(1.706)
Number of observations	829	1,343
R-squared	.191	.168
Adjusted *R*-squared	.166	.152

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

Note: Standard errors are in parentheses. 1/0 refers to dummy variables with 1 for affirmative responses and 0 otherwise.

*$p < .10$. **$p < .05$. ***$p < .01$.

A hyphen (-) indicates that the item is not applicable

Given that fertilizer distribution in Taraba was completely independent of group membership, results from estimating equation 5 for Taraba State also serve as a robustness check as 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 participant received. Consequently, the model is run for Taraba State only, where only relatives of the farmer group president are considered respondents with close links to the president. As can be seen in column 2 of Table 7.2, the coefficient on links to the farmer group president are insignificant in this model for Taraba, as one would expect.

Table 7.2—Group dynamics and the number of bags of subsidized fertilizer received in Taraba

Explanatory Variables	Taraba State (Only Voucher Participants)	Taraba State (Only Relatives of the Farm Group President)
Participated in voucher program	—	3.624***
	—	0.800
Member of a group that purchased fertilizer together in 2009	–0.119	0.430
	(1.390)	(0.540)
Number of trade groups individual belongs to	–0.889	–0.597**
	(0.730)	(0.300)
Major decisionmaker on household plots (1/0)	–0.036	0.012
	(0.340)	(0.090)
Used improved seed in 2009	0.060	–0.431
	(1.450)	(0.530)
Age	–0.027	–0.001
	(0.050)	(0.020)
Male (1/0)	–1.059	0.123
	(0.750)	(0.390)
Head has been formally educated	0.167	–0.780
	(1.130)	(0.890)
Land area in 2009	0.871*	0.309
	(0.530)	(0.230)
Farming is the respondent's primary occupation	–1.085	–0.715**
	(0.890)	(0.280)
Respondent is closely associated with the president of the organized group	–2.210	–0.926
	(1.670)	(0.620)
Respondent is the household head	2.633*	0.870
	(1.610)	(0.730)
Respondent is the spouse of the household head	0.116	0.150
	(0.990)	(0.390)
Household asset index	0.278	0.093
	(0.940)	(0.180)
Household total livestock asset	–0.004	–0.003
	(0.070)	(0.030)
Respondent rents land	–2.627	–0.341
	(2.470)	(0.470)
Sardauna	—	—
	—	—
Gassol	–1.250	–1.512**
	(1.460)	(0.680)
Ussa	–0.636	2.157
	(2.910)	(1.880)
Kurmi	3.934	2.305
	(7.980)	(2.390)
Ardo Kola	0.372	–0.548
	(2.130)	(0.570)
Jalingo	0.231	–0.231
	(1.550)	(0.690)
Donga	–3.112	–0.943**
	(2.150)	(0.460)
Karim Lamido	–0.138	–0.649
	(1.650)	(0.450)

Table 7.2—Continued

Explanatory Variables	Taraba State (Only Voucher Participants)	Taraba State (Only Relatives of the Farm Group President)
Lau	3.070	1.120
	(6.500)	(1.950)
Yorro	0.576	0.576
	(1.220)	(0.600)
Constant	3.611	0.346
	(2.570)	(0.740)
Number of observations	229	739
R-squared	.327	.176
Adjusted *R*-squared	.248	.147

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

Note: Standard errors are in parentheses. 1/0 refers to dummy variables with 1 for affirmative responses and 0 otherwise.
*$p < .10$. **$p < .05$. ***$p < .01$.
A hyphen (-) indicates that the item is either not applicable thus not included in the model or is the reference Local Government Area.

In addition to their implications for intragroup dynamics, close links to the farm group president could affect the probability of participating in the voucher program. Friends and relatives of farm group presidents might be more informed about the existence of the program and the requirements to meet participation criteria. They might also have easier access to assistance from the president to meet such requirements, particularly in large groups. To isolate intragroup dynamics that affect the likelihood of program participation from those that determine how fertilizer is distributed, equation 5 is estimated only on the subsample of respondents who actually received subsidized fertilizer under the voucher program in 2009[6]. These results for Kano are shown in column 1 of Table 7.1. Yet again the results indicate that links to the farmer group president are positively associated with the number of bags a respondent receives. As was done with the restricted definition of links to the farm group president, this estimation is run for Taraba, where fertilizer distribution was not done as a group. The results shown in column 1 of Table 7.2 confirm that links to the farmer group president were insignificant in Taraba, as would be expected.

[6] This estimation is comparable to the second stage in a double hurdle model or a Heckman model. We run equation 4 and 5 within a double hurdle model framework as well with similar results which are included in appendix2. In summary, the double hurdle model estimated here (following Cragg 1971) assumes that receiving subsidized fertilizer in 2009 and one's experience, upon participating (the number of subsidized fertilizer received) are two distinct processes with potentially different determining factors. Stage 1 is run using a probit model and stage 2 is run using a truncated regression on the subset of the sample with non-zero quantities of subsidized fertilizer received.

8. CONCLUSION

This paper explored whether different methods of distributing fertilizer through groups affect expected benefits from using groups to increase farmer access to fertilizer in two Nigerian states, Taraba and Kano. In Kano, where fertilizer was given to farm group leadership (president, secretary, or treasurer) to be distributed to the entire group, the study found that links to the farmer group president were important in determining the number of bags of fertilizer an individual member received. However, in Taraba, where fertilizer vouchers were redeemed by individual farmers (not the entire group), links to the farm group president had no significant effect on the quantity of fertilizer received by farmers. These results show that whereas organized groups can be an efficient way to identify farmers and to coordinate them for participation in various programs geared to increase their access to various inputs, it is important to recognize that intragroup dynamics is a potential challenge. These results indicate that partial use of organized groups for true farmer identification in rural areas or to coordinate farmers for extension training can be useful. However, for 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[7] (Liverpool-Tasie et al 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.

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

APPENDIX A: 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 (LGA) 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 road availability and accessibility, and quality, as can be seen in Figures 3.1 and 3.2.

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 percent confidence that estimated differences between program participants and nonparticipants (or participants over time) are not purely by chance and to have 80 percent confidence that an actual change or difference will be detected (power of the test) (Magnani 1997).

Data about fertilizer consumption by states were not readily available. Thus, our minimum sample size requirements were estimated using approximations from available data. 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 97 kilograms and 117 kilograms (kg) 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 29.1 kg and 35.1 kg 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 three bags (150 kg) and four bags (200 kg), 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:

$$n=D[(Z_\alpha+Z_\beta)^2*(sd1)^2+(sd2)^2)/(X_2-X_1)^2],$$

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 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 were 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 also was conducted using secondary data from other studies. A 2007 study cites 41 kg per hectare (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 percent and 90 percent of the vouchers had been distributed in Taraba and Kano, respectively). The price of Urea at Dawanau market in Kano was about N3,200 per 50-kilogram bag (N64/kg). The vouchers were individually worth a total value of N2,000 per50-kilogram bag. Thus, the benefit of receiving the voucher should translate to a N2,000 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 found that even if Urea prices were 50 percent higher in the rural areas (N4,500 per bag), the minimum sample size would be about 210.

Solely based on population, our sample should be composed of 80 percent of households in Kano and 20 percent in Taraba. However, to ensure an adequate number of full respondents per state, the population difference of our 1,000 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, which in turn are based on earlier discussed calculations. Consequently, we surveyed 1,000 households, 640 in Kano and 360 in Taraba; the respondents were largely household heads, their spouses, other adult household members, and for a few questions, children and youth in the households. See Table A.1.

Table A.1—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.

APPENDIX B: DOUBLE HURDLE MODEL RESULTS

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, a double hurdle model (DH) was also used to explore if and how intragroup dynamics affects farmers experiences of the voucher program.

Following Cragg (1971), this approach assumes 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:

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

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

(b) The extent of participation

$$Q_{si}^{*} = \beta_2 X_{2i} + v_i \qquad v_i \sim N(0, \sigma) \tag{B.2}$$

where

$$Q_{si} = \begin{cases} Q_{si}^{*} \; if \;\; V_i = 1 \; and \; Q_{si}^{*} > 0 \\ 0 \;\; otherwise \end{cases} \tag{B.3}$$

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.

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. The double hurdle results are shown in Table A.2 are effectively the same as the results from the previous models and reveal evidence of intragroup dynamics in Kano.

Table A.2—Double hurdle model results

	(Probability of receiving subsidized fertilizer)	Log of number of bags
Member of a group that purchased fertilizer together in 2009 (1/0)	0.379*	-
	(0.220)	-
Used improved seed in 2009 (1/0)	-0.080	-
	(0.220)	-
Age (years)	0.000	-0.020
	(0.000)	(0.080)
Male (1/0)	0.810*	-0.150
	(0.460)	(0.300)
Years of formal education	0.060***	-0.123**
	(0.020)	(0.060)
Land Area in 2009 (hectares)	(0.010)	0.000
	(0.010)	(0.080)
Farming is the respondents primary occupation (1/0)	0.180	0.070
	(0.430)	(0.070)
Respondent is related to the president of their farm group (1/0)	0.100	0.208*
	(0.210)	(0.110)
Respondent holds a position in their village (1/0)	0.020	0.080
	(0.250)	(0.070)
Household asset index	-0.157***	0.040
	(0.050)	(0.090)
Household total livestock asset	0.010	-0.060
	(0.000)	(0.040)
Respondent rents land (1/0)	0.190	0.250
	(0.370)	(0.160)
Constant	-0.377	1.433***
	(0.450)	(0.520)
LGA Dummies	YES	YES
Number of observations	1038	873
R-squared (Pseudo r squared)	0.270	

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.
A hyphen (-) indicates that the item is not included in the estimation.

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