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Did Using Input Vouchers Improve the Distribution of Subsidized Fertilizer in Nigeria?

The Case of Kano and Taraba States

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ABSTRACT

Though input vouchers are increasingly being used as a mechanism to target subsidies in developing countries, limited empirical evidence of their performance relative to other distribution mechanisms exist. Consequently this study contributes to this scarce literature by comparing an input voucher program piloted in Nigeria in 2009 to the previous government led distribution mechanism. Input purchase experiences are compared when subsidized fertilizer was distributed through a voucher program or by the government. Using propensity score matching techniques, the study finds that voucher program participants received more bags of subsidized fertilizer than nonparticipants and paid a price significantly lower than the market price. However, they received their fertilizer later than nonparticipants and where significant had more underweight bags than nonparticipants. Given the costs associated with voucher programs, this study demonstrates when the distribution of subsidized fertilizer via vouchers improved farmers' timely access to good and more affordable fertilizer.

Keywords: input vouchers, fertilizer, Nigeria, Africa

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1. INTRODUCTION

Fertilizer consumption in Nigeria was only 13.27 kilograms per hectare(kg/ha) of arable land in 2008 (World Bank 2008) compared to greater than 100 kg/ha in India and Pakistan. Low fertilizer application rates persist despite the Nigerian government's prominent engagement in procuring and distributing fertilizer since the early 1970s. Although the fertilizer subsidy programs absorb a large proportion of the national budget, the impact of the programs on agricultural productivity has been mixed at best, and the programs have not created sustained increases in fertilizer consumption (Banful et al. 2010). Apart from leakages and diversions common with government procurement and distribution of agricultural inputs, another major problem with this system is the lengthy and cumbersome bureaucratic tendering process that often causes inputs to reach beneficiaries long after they are needed (Minot and Benson 2009). Agricultural input vouchers are seen to be more flexible, enabling holders to purchase desired quantities and types of inputs from authorized input dealers who accept the vouchers as payment. Dealers then redeem vouchers with the government or voucher program organizers, often with an agreed margin to cover their expenses and agreed level of profit (Gregory 2006).

A properly developed and administered voucher program could improve the implementation of a fertilizer subsidy program compared to government-led distribution in at least four ways. First, private-sector procurement and distribution of fertilizer should reduce the delay of bureaucratic fertilizer procurement by government and ensure timely fertilizer access for farmers. Second, public and private vested interests should introduce accountability and more transparency into the distribution process. This should reduce fertilizer diversion[1] and increase the proportion of subsidized fertilizer that reaches farmers. Third, if subsidized fertilizer is distributed through vouchers, there should also be a reduction in the distortion to the market price caused by subsidized fertilizer leakages and resale. Fourth, the provision of a guaranteed market for input suppliers creates an incentive for suppliers to invest in the production of fertilizer, wholesale procurement of fertilizer, or both while establishing links between the suppliers and users of fertilizer, thus promoting the development of the private sector. An improved fertilizer distribution system should ultimately lead to an increase in farmer access to (and use of) chemical fertilizers with consequent productivity effects. This paper examines the 2009 input voucher program that was implemented in two Nigerian states: Kano (in northwest Nigeria) and Taraba (in the northeast). The program was the joint effort of the federal government of Nigeria, the respective state governments, and a nongovernmental organization, the International Center for Soil Fertility and Agricultural Development (IFDC). This paper explores the ability of the voucher program in Nigeria to achieve the first three expected benefits of a properly administered voucher program.

Many input voucher studies evaluate the effectiveness of input subsidy use by looking at how voucher programs increase farmer incomes and food security (through increased fertilizer use, better yields, or both) or how they affect fertilizer markets by crowding out or displacing private commercial activity (Chinsinga 2006; Xu et al. 2009; Denning et al. 2009; Ricker-Gilbert, Jayne, and Chirwa 2011). This study differs from those in its focus. This paper does not analyze adoption or productivity effects of the program. Rather, it focuses on the time lines, quality, price, and availability of fertilizer when distributed through the voucher system as opposed to the traditional government-led system.

The use of fertilizer subsidies in Nigeria has existed for more than three decades, and justification of subsidies' use (though a valid concern) was not the direct issue of interest to the government or the program-implementing agency in 2009. The main concern was whether the voucher program would be a more efficient mechanism to procure and distribute subsidized fertilizer compared to the status quo of government procurement and distribution. Thus, rather than exploring whether participation in the program increased farmers' fertilizer use and productivity (which is another critical question), this study

[1] Political interference and lack of accountability often lead to large diversions of subsidized fertilizer into the hands of nonfarmers (politicians and well-connected traders or individuals) who make a profit by reselling the product to farmers, traders, or both, thus distorting the private market (Nagy and Edun 2002).

examines whether the voucher program was able to address the inherent challenges in the government-led system of subsidized fertilizer distribution in Nigeria. Consequently it asks if certain conditions faced by input buyers (quantity, price, timeliness of receipt, and quality) were superior when subsidized fertilizer was distributed through the voucher program rather than distributed by the government.

A farmer in either state is considered treated if he or she participated in the 2009 fertilizer voucher program in his or her state in 2009. Although details of the voucher programs including criteria to participate are discussed in section 2, participation in the voucher program was partly a choice and thus potentially subject to selection bias. To address key identification problems that arise when measuring the impact of such a program, in which data were not generated from a random experiment, I use propensity score matching techniques.[2] This enables me to construct appropriate treatment and control groups for comparison of farmer experiences. Various strategies are adopted to minimize bias to impact estimates due to program placement and farmer selection and to ensure that results are not driven by the estimation procedure. However, in recognition that some bias may still exist due to unobservable characteristics of program participants, the study includes Rosenbaum bounds to simulate the effect of such unobservables on impact estimates.

Several studies have looked at the successes and failures of both recent and past input subsidy programs across the world (Morris et al. 2007; Dorward, Hazell, and Poulton 2007; Holmén 2005; Donovan 2004). However, fewer studies have looked at the necessary and sufficient conditions for achieving beneficial impacts. These include the level of government involvement and the maturity of the private sector (Banful 2010; Dorward, Hazell, and Poulton 2007; Ricker-Gilbert, Jayne, and Chirwa 2011). The results of this analysis contribute to this limited literature and inform how and when input vouchers can improve farmer timely access to affordable inputs. It reveals some of the ways that revealed impacts (or lack thereof) from studies of vouchers, subsidy effects on input use and yields, or both can be explained.

As mentioned earlier, since the effects being studied are largely farmer experiences rather than outright decisions, this study is more amenable to the use of propensity score matching techniques. It provides convincing evidence of the impact of the fertilizer voucher program in Nigeria. This study also contributes to the limited empirical evidence of the effects of input vouchers in Nigeria. Nigeria is currently attempting to move beyond pilot projects to full expansion of input voucher use across its 36 states. Thus it is important to understand how and if the mechanisms of subsidized fertilizer distribution (as conducted under the pilot program in 2009) improved Nigerian farmers' timely access to good-quality fertilizer at affordable prices. It reveals some of the implications of government participation in the program's success, which if addressed will assist in the design of any scale-up program to ensure that farmers' access to and use of fertilizer is improved. Many voucher programs across the globe have significant government participation beyond funding the input subsidy. Thus, as many developing countries, particularly in Sub-Saharan Africa, adopt the use of input vouchers or scale up already existing programs, this study highlights some key issues to be considered to expand the dimensions of success of well-targeted input voucher programs.

The structure of this paper is as follows: Section 2 describes the 2009 fertilizer voucher program in Kano and Taraba. Sections 3 and 4 provide a description of the data and analytical framework and the data used, respectively. Section 5 presents the empirical estimation results. Section 6 summarizes the paper's key findings and their policy implications and then concludes.

[2] I recognize that being based on observables, propensity score matching techniques are often criticized for not addressing the challenge caused by unobservable differences between treatment and control groups. Given that this study focuses largely on experiences of participants (such as quality of fertilizer and timeliness) rather than on decisions such as input use, I do not expect the severity of this issue to be much in this study.

2. FERTILIZER VOUCHERS IN NIGERIA AND THE 2009 FERTILIZER VOUCHER PROGRAM IN KANO AND TARABA

The traditional system of government procurement and distribution of subsidized fertilizer in Nigeria has been fraught with persistent problems of late delivery and the diversion of fertilizer from the intended beneficiaries (Nagy and Edun 2002). Leakages of the product into the regular market were common, distorting the market price and providing arbitrage opportunities. Despite many years of fertilizer subsidy programs, only about 50 percent and 40 percent of households used fertilizer in Kano and Taraba in 2010 (Nigerian National Bureau of Statistics, 2010). Studies have shown that policy inconsistencies, timely access to fertilizer, price, and poor fertilizer quality are major constraints to fertilizer use (Banful et al. 2010; Liverpool-Tasie, Banful, and Olaniyan 2010). Consequently, the voucher program has been proffered as a potential solution to the shortcoming of subsidized fertilizer distribution by the government (IFDC 2010).

The 2009 voucher program in Kano and Taraba was a collaborative effort between the government (federal and state), private-sector suppliers and dealers, and IFDC. This was the first statewide administration of input vouchers in Nigeria.[3] It was designed to deliver subsidized fertilizer to smallholder farmers in both states. As stated earlier, the programs were designed to address fertilizer distribution challenges and, as such, did not involve or accompany any substantial policy change in the fertilizer subsector. Three fertilizer suppliers[4] and more than 150 private-sector agro dealers participated in the program. Participating farmers were provided vouchers, which were redeemable at agricultural input dealers certified by the program implementers within their local government of residence. The subsidy value of the voucher was a N 2,000 discount per bag on two bags of triple 15 Nitrogen Phosphorous Potassium (NPK 15:15:15) and one bag of Urea (46 percent nitrogen content) in Kano and on two bags each of NPK 15:15:15 and Urea (46 percent nitrogen) in Taraba. Farmers were required to pay the difference between the market price and the N 2,000 discount per bag. According to the Nigeria Agri Markets Information Service, fertilizer prices in central markets in Kano and Taraba were about N 3,000 and N 3,600, respectively, for a 50-kilogram bag of NPK 15:15:15 and N 3,200 and N 3,650, respectively, for a 50-kilogram bag of Urea.[5] Thus the voucher value was between 55 and 60 percent of the NPK market price and between 50 and 55 percent of the Urea market price in the two states (Liverpool-Tasie, Banful, and Olaniyan 2010).

Due to state-level differences, the program was administered differently in the two states. In Kano, a farmer group received a single voucher that entitled each of its members to a N 2,000 discount on three 50-kilogram bags of fertilizer (two NPK and one Urea). In Taraba, each individual member of the organized group received a voucher personally and could purchase four bags of fertilizer (two NPK and two Urea) at the discounted rate. An important characteristic of the 2009 voucher program was that although fertilizer was to be distributed through the voucher program, it was still procured through the government-directed process that includes the award of contracts to various suppliers equal to the amount of fertilizer requested by the various states. Through the Federal Fertilizer Department, the federal government procures and delivers the requested amount to the various state ministries of agriculture at a subsidy of 25 percent. Then the state ministries of agriculture distribute the fertilizer to the farmers either directly through various distribution committees at local government levels, farm groups, or farm service centers or indirectly through state agricultural input supply companies and farmer service centers. In addition to further subsidizing this fertilizer received from the federal government, several states also procure fertilizer outside of the federally provided fertilizer to augment that provided by the federal

[3] It followed smaller pilots in a few villages in three states in 2004 and two states in 2008.

[4] The three suppliers are the three companies that produced or imported the fertilizer used in the program. They were Notore Chemicals Industry, Golden Fertilizer, and TAK Fertilizer.

[5] Prices for August 2009 were used since this was around the time that a lot of fertilizer distribution for the voucher program occurred. Prices in January and June were within a N 5–band difference, indicating that prices in August are satisfactory to represent fertilizer price in both states. The exchange rate in the last quarter of 2009 was approximately N 150 = US$1.

government (Nagy and Edun 2006; Banful et al. 2010). This has two implications for the program and consequently for this evaluation. First, it indicates that the supply of fertilizer is still dependent on the government as it depends on when the contracts were awarded and the consequent supply available. Second, the extra amount purchased by states directly for their farmers (also subsidized) indicates that there are multiple sources of subsidized fertilizers in a state.

3. EVALUATION METHODOLOGY

This study estimates the treatment effect of a farmer's participating in the 2009 fertilizer voucher programs in the states of Kano and Taraba, Nigeria. It assesses the effect of participation on the quantity of subsidized fertilizer received, the price paid, and the quality and timeliness of fertilizer receipt. A major challenge in measuring the impact of the voucher program on farmer experience of timely access to affordable inputs is selection bias because participation in the program was not mandatory. Ability to participate in the voucher program is likely correlated with household characteristics such as education or wealth, which may influence a farmer's likelihood of being aware of the program or his or her use of fertilizer and thus interest in the program. Program participation could also be correlated with various household characteristics (such as social capital) that could affect a farmer's ability to secure access to the program in the event that participation opportunities were limited. Not accounting for these could introduce a bias in the estimation as the distribution of these characteristics might not be the same across program participants and nonparticipants. Another challenge in evaluating the voucher program is potential endogeneity of access to the program due to a nonrandom program placement. This occurs when there are intentional targeting rules for assigning the program to different villages or communities (for example, poorer or more politically favored communities). This will lead to village-level characteristics' being correlated with certain explanatory variables and a bias in the estimation of the program effects.

In the 2009 voucher program implementation being studied here, there was no evidence of community selection for program placement, and any program participation criteria were at the farmer level. The voucher program was implemented at the state level with all local governments in each state participating. However, to capture any location-specific characteristics that would affect participation in the program (such as local government administration), study outcome variables, or both, village-level dummies are included in estimating the likelihood of participation in the program.

To address selection bias at the participant level, this study uses propensity score matching techniques. As developed and discussed by Rubin (1974), Wooldridge (2002), Caliendo and Kopeinig (2005), and Heinrich, Maffioli, and Vázquez (2010), the impact of the voucher program can be defined as the difference between the outcome of those who participated in the voucher program and the outcome that would have obtained for those same individuals if they had not participated in the voucher program. Propensity score matching estimates a propensity score defined as the conditional probability measure of treatment participation, given observable characteristics that are expected to have an effect on farmers' likelihood of participating in the program and the outcome variables in the construction of an appropriate control group for estimating program effects. Conditional on satisfying key assumptions of unconfoundedness[6] and the overlapping condition,[7] Cameron and Trivedi (2009); Heckman, LaLonde, and Smith (1999), and Rubin (1974) have demonstrated that we can estimate the treatment effect as the following:

$$ATT(PSM) = E_{P(x)|W}\{\text{E[Y(1)|W=1,P(X] - E[Y(0)|W=0, P(X)]}, \quad (1)$$

where Y is the outcome variable, X the conditioning participant characteristics, $P(X)$ the propensity score based on the observable characteristics (X), and W a dummy variable equal to 1 if the respondent was a participant in the 2009 voucher program. The propensity score matching estimator is the mean difference in outcomes between treatment and control groups over the common support, appropriately weighted by the propensity score distribution of participants.

[6] This refers to independence, conditional on a set of covariates X, which has been shown to be equivalent for a propensity score based on such covariates, P(X).

[7] This ensures that persons with the same X values have a positive probability of being both participants and nonparticipants.

The use of propensity score matching implies that selection is based solely on observable characteristics and that all variables that influence participation in the voucher program and potential outcomes simultaneously are observed by the researcher. This is a strong assumption, particularly in cases wherein the outcome variables are yield or decision variables (such as fertilizer use). Ignoring the effect of unobservable characteristics affecting both program participation and these outcome variables (such as ability) could lead to biased estimates of the program effect. In this study, our focus is more on the fertilizer procurement experience (for example, time of receipt and price paid) rather than yield or input use decisions directly, and thus unobservable characteristics are less likely to play a role here. This will be verified by the satisfaction of the balancing property,[8] and the model will also be subjected to a sensitivity analysis to check the robustness of results to this problem. One of the experiences studied here, quantity of subsidized fertilizer received, might appear more amenable to violating the assumption of validity of selection conditional on observables than the other three (price, time, and quality). It could be argued that if people who plan to buy more fertilizer seek out vouchers, then having a voucher is not the only thing that affects fertilizer purchase compared to nontreated, and there is some unobservable factor affecting the tendency to use fertilizer (such as progressiveness) that also affects selecting in to use the voucher. However, given the program description above, this study assumes that the quantity of subsidized fertilizer received by farmers in the program is largely fixed (three bags in Kano and four bags in Taraba) conditional on participation. Differences in quantity received are largely an indication of the effect of participation in the voucher program or the difference between those who participated in the voucher program under study relative to those who received subsidized fertilizer from an alternative source.[9] Factors likely to drive differential quantity of subsidized fertilizer (as shown in Ricker-Gilbert, Jayne, and Chirwa 2011) are like sociopolitical capital, which is controlled for in the propensity score generation.

This study applies four matching procedures where possible to ensure that the results are not driven by estimation procedure and for comparison.[10] Nearest-neighbor matching ensures that each treated observation is matched and compares individuals from the control group to a matching partner closest in propensity score (Caliendo and Kopeinig 2005). However, it could be affected by poor matches in which the distribution of scores across treated and control individuals are very different. Thus I also use radius matching, which specifies a caliper, or maximum propensity score distance, by which matches can be made, thus increasing the quality of matching. Where possible, matching by stratification is also used to get at potential bias due to the unconfoundedness property's not being satisfied by particular covariates (Caliendo and Kopeinig 2005; Rosenbaum and Rubin 1983). Here, the common support of the propensity score is partitioned into a set of intervals (strata), and the impact within each interval is calculated by taking the mean difference in outcomes between treated and control observations. Finally, I use nonparametric Kernel matching,[11] which tends to have a lower variance since more information is used (Caliendo and Kopeinig 2005; Heinrich, Maffioli, and Vázquez 2010). To address the possibility of bad matches, this study uses only observations that lie within the common support and compares the results to those of other matching procedures.

[8] Satisfaction of the balancing property is an indication of the quality of matching. A test is conducted to check whether the propensity score adequately balances characteristics between the treatment and comparison group units (Heinrich, Maffioli, and Vázquez 2010). The mean characteristics of these two groups should not be statistically significantly different, indicating that conditional on observable characteristics, we are comparing similar households only distinguishable by their treatment status into the voucher program.

[9] Given that fertilizer in the program was less than 50 percent of the market price, even if a less-progressive farmer did not want to use the fertilizer, I expect that once a farmer got the voucher, the farmer would still take the fertilizer at the discounted price and resell it.

[10] I also vary the parameters associated with the various estimation procedures.

[11] The kernel matching operates as a weighted regression of the counterfactual outcome on an intercept with weights given by the kernel weights. Weights depend on the distance between each individual from the control group and the participant observation for which the counterfactual is estimated (Caliendo and Kopeinig 2005).

4. SENSITIVITY ANALYSIS

Although propensity score matching satisfies the balancing property (indicating that conditional on the observable characteristics included in our propensity score generation, the treatment and control groups are similar) and I use only observations that lie within the common support, it is still possible that there is some unobserved characteristic that drives participation in the voucher program that is also driving the treatment effects. Thus, I run the Rosenbaum sensitivity analysis for matched data, which provides a method to assess how robust my findings are to hidden bias due to an unobserved confounder.

Given two individuals *i* and *j* with the same observed characteristics (x_i an x_j), they should have the same probability of participating in the voucher program:

$$P(X_i) = P(T_i=1/x_i) = P(X_j) = P(T_j=1/x_j) = F[(\beta(x)], \quad (2)$$

where $x = \{x_i, x_j\}$.

In the presence of an unobserved characteristic u_i, which could drive program participation, we now have $P(X_i) = F(\beta(x_i) + \gamma u_j)$, and two individuals with the same observable characteristics may not have the same probability of participating in the voucher program.

We can write a logistic regression model linking the odds of assignment to these two covariates as

$$Log\left(\frac{P(x_i)}{(1-P(x_i))}\right) = F(\beta(xi) + \gamma u_i) , \quad (3)$$

with a constraint on u_i of $0 \leq u_i \leq 1$. Where F( ) is some function and γ is an unobserved parameter. If units *i* and *j* have the same values on x, then $x_i = x_j$ and we can write the odds ratio of treatment for these two units as

$$\left(\frac{P(x_i)/1-P(x_i)}{P(x_j)/1-P(x_j)}\right) = \frac{P(x_i)}{(1-P(x_i))}\frac{(1-P(x_j))}{P(x_j)} = \exp\{\gamma(u_j - u_i)\}. \quad (4)$$

Here two individuals with the same x values differ in their odds of participating in the voucher program by a factor of γ and the difference in the unobserved covariate. If the unobservable characteristics of the two individuals are the same ($u_j = u_i$) or if they do not affect the probability of participating in the voucher program $\gamma = 0$, participation in the program is truly driven by the observables, our matching based on these observables is sufficient, and we would then not expect our treatment estimates to be biased due to selection. However, if $u_j \neq u_i$ or $\gamma \neq 0$, then our treatment estimates are likely to be biased (Rosenbaum 2002; Keele 2010).

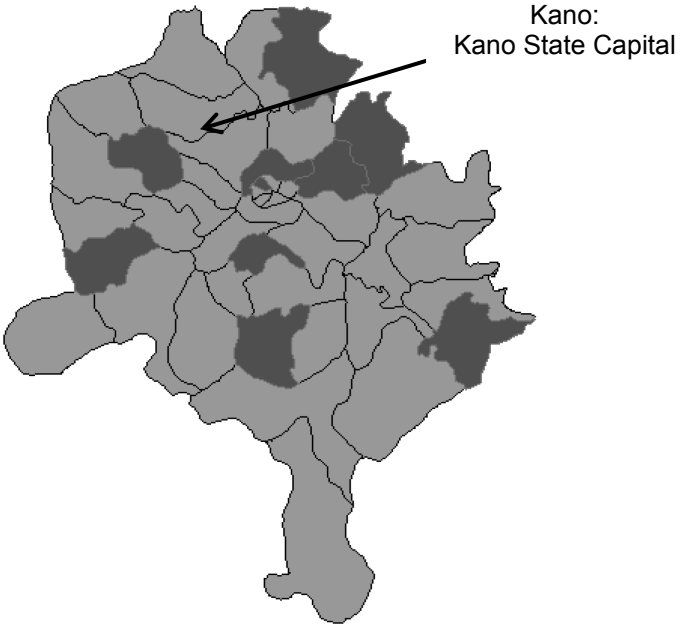
Gamma is the size of log of the coefficient for the unobserved covariate *u.* Rosenbaum (2002) shows that it can also be thought of as a sensitivity parameter that measures the degree of departure from random assignment of treatment. Here two subjects with the same observed characteristics may differ in their odds of receiving the treatment by a factor of gamma.[12] The sensitivity analysis uses several values of gamma to show how inferences might change if a hidden bias were present.

[12] Thus if gamma = 2, then two units that have the same values of x could differ in their odds of receiving treatment by as much as a factor of 2.

5. DATA AND VARIABLES

Data for this study come from a survey of 1,000 households: 640 in Kano and 360 in Taraba. In each state, interviewed households were selected from 10 randomly selected local government areas (LGAs).[13] The 10 selected LGAs in each state represented potential LGA variation, which could affect the administration of the voucher program as well as other cultural, infrastructural, or administrative differences that affect farmer access to fertilizer apart from the program (see Figures 5.1 and 5.2). The number of survey households in each local government was proportional to population. In Kano, a list of all the villages in the various LGAs was compiled based on information supplied by LGAs and the Kano Agricultural Development Agency. A total of 80 villages were then randomly selected from this list. The surveys were conducted in February 2010 with field staff recruited from Universities and colleges within the respective states. The field staff in Kano interviewed in pairs, with each of 10 pairs interviewing eight households in about 8 villages.[14] Households within each village were randomly selected but with due consideration that at least one out of the four households interviewed participated in the voucher program. In Taraba, due to the unavailability of a complete list of villages in each local government, the following approach was taken: A list was obtained from the voucher-implementing agency of all farmers who had participated in the voucher program in each of the randomly selected LGAs. A list of all villages with at least one voucher program participant was compiled. Several villages per LGA were then randomly selected from the list, and households were randomly selected within these.

Figure 5.1—Survey local government areas in Kano State

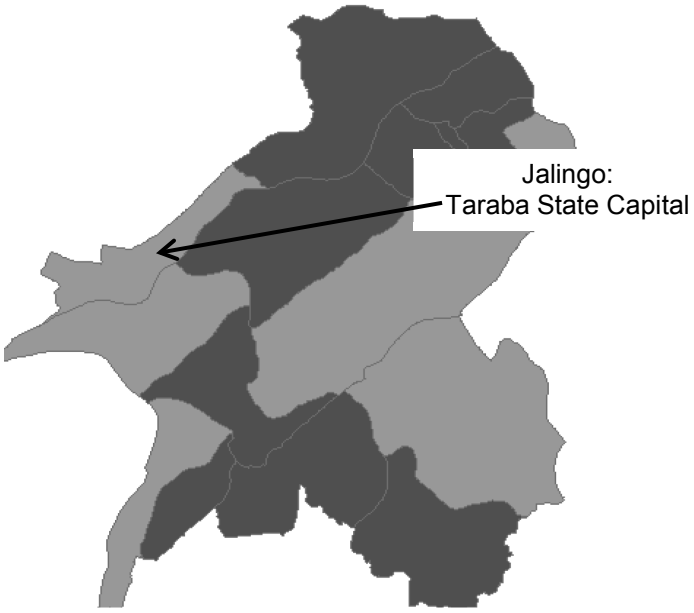


Source: Figure generated by author using Geographic Information System software.

[13] Local government areas are administrative units under each state, constituting the third tier of the administrative structure in Nigeria.

[14] Eight households in eight villages gives us about 64 households per pair. With 10 pairs of field staff, this gives us our 640 households in Kano state.

Figure 5.2—Survey local government areas in Taraba State



Source: Figure generated by author using Geographic Information System software.

The survey respondents were primarily household heads, their spouses, and other adult household members. This implies that several respondents could have participated in the voucher program from one household.[15] Respondents were interviewed about their participation in various farm groups and other associations, their leadership positions in their local communities, their farming practices (input use, sources, and prices), and their participation in the 2009 voucher program. Household demographic information was also collected.

Explanatory Variables

The propensity score is estimated using a nonlinear probit regression from a set of observable characteristics that are expected to affect both the probability that the individual participated in the program and the outcome variables. However, the variables used for the propensity score should not be affected by the respondents' participation in the voucher program (Becker and Ichino 2002; Caliendo 2006; Heinrich, Maffioli, and Vázquez 2010). In this study the propensity scores are based on either respondent characteristics that do not change much over time or characteristics that are not expected to be affected by participation in the voucher program in 2009. They include respondent's age, sex, years of education, land area in 2008 (prior to the program), whether the respondent used improved seed in 2008 (before the program started), whether the respondent holds a leadership position in the community,[16] and whether the respondent's farm group purchased fertilizer collectively in 2008.[17] The propensity score is estimated separately in both states, and observations with propensity scores out of the common support were dropped.

[15] In all estimations standard errors are clustered at the household level to account for this.

[16] Including this variable in the propensity score estimation could bias results if participation in the program could improve an individual's standing in society and likelihood of being given a leadership position. We estimate our treatment effects with the village leadership position included and excluded from the propensity score estimation, and this does not change the significance of our results. This is not surprising given that the variable is not significant in the propensity score estimations.

[17] Bias could be introduced into the treatment effects if participation in the pilot voucher program in Kano in 2004 and 2008 drove participation in 2009, the outcome variables, or both. I confirmed that the pilots were done in only three sites in Kano in the two years and that none of these sites were in our sample.

Study Outcome Variables

The voucher program was intended to improve fertilizer distribution in Nigeria considering the numerous leakages and late delivery of poor-quality fertilizers to farmers often at close to the market price (Nagy and Edun 2002; IFDC 2010). Expected effects include increased quantity of subsidized fertilizer to which farmers had access, better quality fertilizer's being distributed to program participants, improved timeliness, and a price significantly lower than the market price.18 Thus this study empirically tests whether the voucher program improved these four outcomes for participants: quantity, quality, timeliness, and price of subsidized fertilizer eventually purchased through the program. Table 5.1 provides the summary statistics associated with the key variables included in the propensity score, the key outcome variables, and other controls used in the average treatment effect estimation.

Table 5.1—Summary statistics

	Kano (Total)	Taraba (Total)	Kano Voucher Participant	Taraba Voucher Participant
Number of 50-kilogram bags of all fertilizer purchased (bags)	1.942	0.843	3.007	3.282
	(3.821)	(2.405)	(2.171) *(+)	(1.496) *(+)
Price paid for nitrogen phosphorous potassium in 2009	2267.080	4019.022	1568.148	3354.167
	(1541.6)	(938.978)	(966.889) *(–)	(678.908) *(–)
Price paid for Urea in 2009	2182.580	3737.967	1083.721	2441.026
	(1467.6)	(1311.211)	(333.206) *(–)	(185.651) *(–)
Deviation in number of months fertilizer was received relative to ideal month (May)	2.546	2.184	2.451	2.581
	(1.693)	(1.297)	(0.779) *(+)	(0.734) *(+)
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) (–)
Number of years of education	7.597	8.245	7.957*	9.545*
	(3.250)	(5.028)	(3.533) *(+)	(5.088) *(+)
Land area in 2008 (hectares)	4.364	3.851	3.784	3.838
	(6.065)	(4.529)	(5.758) *(+)	(3.7191) *(+)
Member of a group that purchased fertilizer together in 2008	0.877	0.362	0.908	0.505
	(0.329)	(0.481)	(0.288) *(+)	(0.50) *(+)
Used improved seed in 2008	0.516	0.110	0.565	0.150
	(0.49)	(0.309)	(0.49) *(+)	(0.355) *(+)

[18] The true market price is hard to identify for several reasons. Diversion of fertilizer during the distribution process often sees subsidized fertilizer diverted to traders or nonfarmers and then reintroduced into the market as nonsubsidized fertilizer. Also different states in Nigeria provide different levels of additional subsidy (beyond the 25 percent provided by the government), and this causes leakages across state boundaries to take advantage of price differentials distorting market prices.

Table 5.1—Continued

	Kano (Total)	Taraba (Total)	Kano Voucher Participant	Taraba Voucher Participant
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)
			(+)	(+)
Number of nonfull bags of fertilizer	2.664	0.148	2.962	0 .096
	(18.767)	(0.925)	(14.538)	(0.428)
			(+)	(+)

Source: Liverpool-Tasie, Banful, and Olaniyan (2010).

Note: Standard deviations and the signs of mean differences are in parenthesis.
*Significant differences in means of voucher program participants and nonparticipants at a significant level of 10 percent or less.

The typical respondent in both states was about 35 years old. Given multiple respondents per household, about 60 percent and 42 percent of respondents were male in Kano and Taraba, respectively. Voucher program participants in both states had more average bags of subsidized fertilizer received compared to nonparticipants and recorded paying on average less than the market price. Fertilizer receipt on average was later than ideal in both states, with no significant difference in the mean number of underweight bags received by participants compared to nonparticipants in both states. When asked about their perceptions of the voucher program, 90 percent of voucher program participants in Kano indicated they would like to participate in the program in the future, and 85 percent of those who were not participants in 2009 indicated interest in such a program if it were offered in the future. In Taraba, 98 percent of participants indicated interest in future participation, and 90 percent of nonparticipants would be interested in such a program if it were offered in the future.

6. MODEL ESTIMATION AND RESULTS

The propensity score estimations shown in Table 6.2 were estimated using a robust nonlinear probability model (probit).

Table 6.2—Probit estimation results for estimating propensity score

Explanatory Variable	Kano	Taraba	Local Government
			Taraba
Age	0.002	0.010+	
	(0.00)	(0.01)	
Male (1/0)	–0.057	–0.334**	
	(0.09)	(0.15)	
Years of formal education	0.047**	0.050**	
	(0.02)	(0.02)	
Land area in 2008	0.0347**	0.063**	
	(0.01)	(0.03)	
Respondent holds a position in the village	–0.173	–0.084	
	(0.18)	(0.26)	
Respondent's farmer group purchased fertilizer as a group in 2008	0.400***	0.695***	
	(0.13)	(0.16)	
Respondent used improved seeds in 2008	0.322***	.185***	
	(0.09)	(0.24)	
Constant	–0.646**	–1.924***	
	(0.24)	(0.33)	
Bagwai	–0.163	—	**Sardauna**
	(0.21)	—	
Takai	0.125	1.007***	**Gassol**
	(0.22)	(0.23)	
Danbatta	0.100	–0.227	**Ussa**
	(0.20)	(0.37)	
Dala	0.361**	1.077***	**Kurmi**
	(0.18)	(0.35)	
Karaye	–0.463**	1.625***	**Ardo Kola**
	(0.21)	(0.34)	
Ungogo	0.201	1.028***	**Jalingo**
	(0.19)	(0.24)	
Gezawa	0.270	1.068***	**Donga**
	(0.17)	(0.23)	
Gabasawa	2.024***	2.058***	**Karim Lamido**
	(0.32)	(0.45)	
Rano	–0.957***	1.285**	**Lau**
	(0.20)	(0.57)	
Kura	—	0.943***	**Yorro**
	—	(0.29)	
Number of respondents	1212	412	
Pseudo R-square	0.1708	0.2060	
Common support	0.179, 0.997	0.077, 0.966	

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

Note: + indicates significant at 15%. Standard errors are in parenthesis. Dashes indicate that all results are relative to that local government **Significant at 5 percent. ***Significant at 1 percent.

Explanatory variables used were selected to account for factors likely to affect both program participation and outcome variables as well as to ensure that the balancing property was satisfied and the mean of variables in the treatment group was not significantly different from the mean of those in the control group. This includes household characteristics such as the age, education, and sex of the participant. Since the program required farmers to be members of organized groups to participate, nonmembership in a farm group was a perfect predictor of failure in the probit model. Consequently I use the variable "whether your farm group purchased fertilizer together in 2008" instead. This variable captures group membership and also indicates farmers likely to be interested in the program given their use of fertilizer in the past. I also use a variable that measures whether respondents used improved seed in 2008 as fertilizer is often a complementary good to improved seed given the responsiveness of improved seed to fertilizer application. To capture the possibility that certain respondents might be favored in the system or have preferential access to the program, I include a dummy variable equal to 1 if the respondent held a leadership position in his or her village and had wealth captured by land size in 2008. In Kano, farmers who were educated, had larger plots of land, planted improved varieties of cereals, or purchased fertilizer through their farm groups in the past were more likely to participate in the 2009 voucher program (see Table 6.2). Taraba voucher program participants were largely female farmers[19] who were more educated, had used improved seeds in 2008, had larger land size, and were members of groups that purchased fertilizer together in 2008. The LGA in which a respondent resided was an important determinant of program participation in both states. This variable[20] is also important as local government characteristics such as infrastructure, leadership, and governance are likely to be key determinants of the timely availability of affordable and good-quality fertilizer to residents.

The common support was estimated to ensure that individuals with the same or very similar propensity score values have a positive probability of being both participants and nonparticipants in the 2009 voucher program. The common support was between 0.180 and 0.997 in Kano, with six blocks selected within which the mean propensity score for treatment and control were not different. In Taraba, six blocks were selected with mean propensity not different for treatment and controls, and the common support was between 0.08 and 0.966. All estimations of average treatment effects on the treated were conducted with only observations that fell within the common support.

Quantity

The voucher program was meant to increase the quantity of fertilizer that actually got to farmers by going directly to the farmers and reducing the leakages and diversions common with the cumbersome traditional distribution process (Chude 2006; Nagy and Edun 2002). Consequently, I expect the number of bags of subsidized fertilizer that program participants received in 2009 to be higher than the number received by their counterparts who did not participate in the program. On proper identification of an appropriate comparison group, this would yield a positive average treatment effect on the treated ATT.[21]

Table 6.3 shows the ATT effect is positive in both Kano and Taraba irrespective of the matching technique that was used. Apart from kernel matching in Kano, which is significant at 5 percent, these treatment effects are all significant at 1 percent.

[19] The prevalence of female participants in Taraba may reflect the prevalence of polygamy among respondents in Taraba. A total of 88 percent of spouses whose husbands participated in the program also participated. Whether this prevalence of female participation translates into women's use of the received product is another question but beyond the scope of this paper.

[20] The local government of residence can be considered exogenous as it is unlikely that individuals would have chosen their local government of residence to take advantage of the pilot program. Furthermore, the majority of respondents had lived in their local governments of residence since birth or marriage.

[21] Note that the quantity received was supposed to be fixed for participants. Thus I do not expect unobservable factors such as ability to be driving participation and quantity purchased. Upon participation, farmers could receive the discount of greater than 50 percent on up to three (in Kano) or four (in Taraba) bags, and even if they were not going to use the fertilizer, profit opportunities at such a discount are expected to encourage voucher redemption. Thus factors likely to drive differential quantity of subsidized fertilizer (as shown in Ricker-Gilbert, Jayne, and Chirwa 2011) are like social capital, for which I control.

Table 6.3—Impact of voucher program participation on the number of 50-kilogram bags of subsidized fertilizer received

Number of 50-kilogram Bags of Fertilizer	Nearest-neighbor Matching	Radius Matching	Matching by Stratification	Kernel Density
Kano				
ATT	1.597	1.15	1.293	1.312
Bootstrapped standard error	0.545	0.578	0.541	0.559
Significance (less than 10%)+	***	***	***	**
Number of observations	1,212	1,212	1,212	1,212
Taraba				
ATT	3.300	3.114	3.334	3.114
Bootstrapped standard error	0.466	0.462	0.476	0.517
Significance (less than 10%)+	***	***	***	
Number of observations	412	412	412	412

Source: Generated by author with data from the fertilizer voucher program evaluation survey.
Note: + indicates significance at less than 15% **Significant at 5 percent. ***Significant at 1 percent.

The results obtained by radius matching, kernel matching, and stratified matching in Kano are quite close to each other, and taken together they give evidence of a positive ATT in the range of 1.15 to 1.32 additional bags of fertilizer for participants in the fertilizer voucher program. In Taraba, ATT ranges between 3.1 and 3.3 and is significant at 1 percent in all matching procedures. This shows that on average participating in the voucher program in Taraba would enable farmers to have between 3.1 and 3.3 more bags of subsidized fertilizer. Bootstrapping was used to generate all standard errors, and the standard errors are all clustered at the household level to account for intrahousehold correlation where there was more than one participant per household. Various matching algorithms were explored (using one, two, and five neighbors in nearest-neighbor matching and changing the size of the caliper [0.01, 0.05, and 0.1] for radius matching), and the significance of the estimates are robust to the different specifications.[22]

Price

Dual markets with one selling subsidized fertilizer create arbitrage opportunities. This results in much of the subsidized fertilizer's being sold at higher prices closer to or equivalent to the market price to the benefit of arbitragers whereas most farmers remain no better off (Nagy and Edun 2002; IFDC 2010). A more efficient distribution system would be expected to minimize leakages and diversions such that the price paid by program participants should be significantly lower than the market price.23 In Kano, as shown in Table 6.4, all matching methods yield a negative ATT on price of both NPK and Urea fertilizers, significant at 1 percent. This provides convincing evidence that 2009 voucher program participants in Kano paid significantly lower than the market price for both types of fertilizer available through the program. On average participants paid N 2,500 less than their counterparts who purchased nonsubsidized fertilizer from the market. The value of the voucher was N 2,000 per bag. The higher treatment effect might reflect the reduction or removal of certain transaction costs associated with fertilizer delivery to various communities that the voucher program bore.

[22] These are available from the author on request.

[23] Difficulties in capturing market price were explained in section 3. I use the reported price for nonsubsidized fertilizer by respondents who purchased from the market as the market price for fertilizer.

Table 6. 4—Impact of voucher program participation on the price paid for fertilizer in Kano

Price	Nearest-neighbor Matching	Radius Matching	Matching by Stratification	Kernel Density
Nitrogen phosphorous potassium prices in Kano				
ATT	–2509.290	–2545.380	–2500.220	–2529.200
Bootstrapped standard error	98.802	103.896	96.577	99.364
Significance (less than 10%)+	***	***	***	***
Number of observations	1,144	1,144	1,144	1,144
Urea prices in Kano				
ATT	–2509.360	–2518.220	–2538.110	–2490.460
Bootstrapped standard error	121.250	113.648	111.420	127.684
Significance (less than 10%)+	***	***	***	***
Number of observations	1,019	1,019	1,019	1,019

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

Note: + indicates significance at less than 15% **Significant at 5 percent. ***Significant at 1 percent.

Given the presence of multiple sources of subsidized fertilizer, I ran the same nearest-neighbor and kernel estimations for only households that received some sort of subsidized fertilizer and found that farmers who participated in the 2009 voucher program paid about N 500 more than those farmers who received subsidized fertilizer from other programs.[24] This is in line with anecdotal evidence from discussions with farmers in Kano State who indicated that sometimes fertilizer is distributed by local governments at very low prices.

Table 6.4 reveals similar results for Taraba, and in this case, results from all matching techniques are in the same direction and are statistically significant at 1 percent. ATT ranges in magnitude from about N 1,600 to N 1,750 for NPK and on average N 2,200 for Urea, indicating the lower price paid by voucher program participants compared to their counterparts who purchased directly from the market. Running the estimations on the subsample of farmers who received some sort of fertilizer indicated that farmers who participated in the 2009 voucher program in Taraba paid significantly higher prices (around N 1,000 more) for NPK compared to their counterparts who received subsidized NPK from other sources. However, there is no significant difference between Urea prices.

Timeliness

The delivery of subsidized fertilizer in Nigeria is persistently late (Banful and Olayide 2010). This estimation tests whether voucher program participants tended to receive fertilizer closer to the ideal time it was needed. The outcome variable for this treatment effect is the deviation of number of months from the ideal month in which the farmer should have received fertilizer, which in both states was May 2009.

For Kano, Table 6.5 reveals evidence of a positive ATT significant at 10 percent and 15 percent when using nearest neighbor and kernel matching, respectively. However, this effect is not significant less than 15 percent for radius matching. This indicates that although participants in the voucher program tended to receive their fertilizer later than nonparticipants, these results must be interpreted with caution. In Taraba, however, results are always significant at or less than 15 percent (being significant at 10 percent and 1 percent when nearest neighbor and kernel matching are used, respectively). This increases my confidence in concluding that the farmers in Taraba who participated in the voucher program tended to receive their fertilizer about a third to two thirds of a month later than the ideal month: May.[25]

[24] These results are available from the author on request.

[25] It was not possible to empirically estimate ATT on the timeliness of fertilizer receipt using the stratification matching procedure in Taraba.

Table 6.5—Impact of voucher program participation on the price paid for fertilizer in Taraba

Nitrogen Phosphorous Potassium prices in Taraba				
Price	**Nearest-neighbor Matching**	**Radius Matching**	**Matching by Stratification**	**Kernel density**
ATT	–1637.50	–1716.85	–1751.79	–1598.66
Bootstrapped standard error	256.52	288.26	272.40	262.93
Significance (less than 10%)+	***	***	***	***
Number of observations	231	231	231	231
Urea prices in Taraba				
Price	**Nearest-neighbor Matching**	**Radius Matching**	**Matching by Stratification**	**Kernel Density**
ATT	–2244.57	–2240.08	–2278.55	–2213.14
Bootstrapped standard error	193.29	188.71	245.67	185.01
Significance (less than 10%)+	***	***	***	***
N	290	290	290	290

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

Note: + indicates significance at less than 15% **Significant at 5 percent. ***Significant at 1 percent.

Table 6.6—Impact of voucher program participation on the time of fertilizer receipt

	Kano			**Taraba**		
Time (Deviation in Months from the Ideal Month to Receive Fertilizer, That Is, May)	**Nearest-neighbor Matching**	**Radius Matching**	**Kernel Matching**	**Nearest-neighbor Matching**	**Radius Matching**	**Kernel Matching**
ATT	0.414	0.350	0.350	0.660	0.571	0.345
Bootstrapped standard error	0.252	0.270	0.135	0.340	0.391	0.140
Significance (less than 10%)*	*	–	+	*	+	***

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

Note: +Significant at 15 percent. *Significant at 10 percent. ***Significant at 1 percent.

As mentioned earlier, since fertilizer available for distribution under the voucher program was that secured by the state governments from the federal government, if the product was procured late by the government, then the product distributed through the voucher program would automatically be distributed late as well.[26]

Quality

Other commonly cited problems with fertilizer in Nigeria are that it is adulterated, that fertilizer bags are underweight, or both (Chude 2006; Ayoola, Chude, and Abdulsalaam 2002). Fertilizer suppliers themselves complain about the adulteration to their products that occurs between production and distribution of the product to farmers.[27] A voucher program, particularly the 2009 program, which worked with only three suppliers, could improve the fertilizer delivery along these dimensions. Farmers could trace bad products to input dealers and then suppliers, and suppliers could also hold input dealers accountable depending on where the adulteration occurred. We capture quality challenges by asking farmers how many of the bags of fertilizer they received or purchased in 2009 were not full.[28] When

[26] Discussion with the program implementers and some fertilizer supply companies indicated that this was the case in 2009.

[27] Fertilizer roundtable discussion organized by PropCom, held in October 2011.

[28] Although it may have been ideal to test the chemical composition of the fertilizer, the survey team did not have the

asking, we distinguished between the various sources of such fertilizer. Table 6.7 reveals that by three of the four matching procedures estimated, ATT was positive and statistically significant for Kano whereas it was not statistically significant for Taraba.

Table 6.7—Impact of voucher program participation on the number of underweight bags

Number of Underweight Bags of Fertilizer	Nearest-neighbor Matching	Radius Matching	Matching by Stratification	Kernel Density
Kano				
ATT	2.797	2.620	2.355	2.431
Bootstrapped standard error	1.652	1.702	1.273	1.323
Significance (less than 10%)+	***	+	**	*
Number of observations	1,064	1,064	1,064	1,064
Taraba				
ATT	–0.013	–0.00	–0.038	–0.037
Bootstrapped standard error	0.1472	0.1432	0.151	0.134
Significance (less than 10%)+	—	—	—	—
Number of observations	310	310	310	310

Source: Generated by author with data from the fertilizer voucher program evaluation survey.
Note: + indicates significant at less than 15% . Dashes indicate significance was at greater than 10%
*Significant at 10 percent. **Significant at 5 percent. ***Significant at 1 percent.

This means that participants in the voucher program in Kano reported more underweight bags of fertilizer than did nonparticipants. In Taraba, there is no evidence that farmers who participated in the program were more likely to complain about underweight bags, indicating that the fertilizer distributed through the voucher program was on average not less than the expected 50 kg[29]

To explore the sensitivity of my analysis to any unobservables, the Rosenbaum bounds are estimated for the nearest-neighbor estimates for Kano and Taraba as shown in Tables 6.8 and 6.9.

capacity to do that and thus asked various questions about quality such as how many bags were not full and whether any of the fertilizer bags had unwanted particles such as straw and stones in them.

[29] The study recognizes that farmers probably do not carry around scales and thus may not have been able to identify some nonfull bags if the difference in weight was minimal. However, this variable captures clear discrepancies where bags have obviously been tampered with.

Table 6.8—Rosenbaum bounds of treatment effect estimates in Kano

	Quantity (50Kg Bags)			Price NPK			Price Urea			Timeliness			Number of underweight bags			Complaint about unwanted substances in fertilizer		
Gamma	*UB Sig level*	*confidence interval*		*UB Sig level*	*confidence interval*		*UB Sig level*	*confidence interval*		*UB Sig level*	*confidence interval*		*UB Sig level+*	*confidence interval*		*UB Sig level*	*confidence interval*	
1	0.00	1.00	1.00	0.00	-2800	-2800	0.00	-2900	-2900	0.01	1.00	1.00	0.73	0.00	0.00	0.17	0.00	0.00
1.5	0.00	0.50	1.50	0.00	-3000	-2600	0.00	-3000	-2700	0.49	0.50	1.50	0.22	0.00	0.00	0.96	0.00	0.00
2	0.05	0.25	2.00	0.00	-3050	-2450	0.00	-3150	-2525	0.95	0.25	2.00	0.04	0.00	0.00	1.00	0.00	0.00
2.5	0.49	0.00	2.50	0.00	-3100	-2250	0.00	-3250	-2450	1.00	0.00	2.50	0.01	0.00	0.00	1.00	0.00	0.00
3	0.91	-0.25	2.75	0.00	-3200	-2200	0.00	-3300	-2325	1.00	-0.25	2.75	0.00	0.00	0.00	1.00	0.00	0.00

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

Note: Kg = kilogram; NPK = Nitrogen Phosphorous Potassium; UB Sig = upper-bound significance. +=the significance level of the upper bounds falls and then rises for number of underweight bags indicating a negative significant treatment effect at high levels of unobservable factor effects.

Table 6.9—Rosenbaum bounds of treatment effect estimates in Taraba

	Quantity (50-kilogram Bags)			Price Nitrogen Phosphorous Potassium			Price Urea			Timeliness			Number of Underweight Bags		
Gamma	*UB Sig Level*	*Confidence Interval*		*UB Sig Level*	*Confidence Interval*		*UB Sig Level*	*Confidence Interval*		*UB Sig Level*	*Confidence Interval*		*UB Sig Level++*	*Confidence Interval*	
1	0.000	3.000	3.000	0.000	–1475	–1475	0.000	–2250	–2250	0.000	1.000	1.000	0.861	0.000	0.000
1.5	0.000	2.500	3.000	0.000	–1662.5	–1300	0.000	–2400	–2025	0.003	1.000	1.500	0.604	0.000	0.000
2	0.000	2.500	3.500	0.000	–1787.5	–1200	0.000	–2525	–1925	0.015	0.500	1.500	0.379	0.000	0.000
2.5	0.000	2.000	3.500	0.000	–1950	–1100	0.000	–2600	–1775	0.038	0.500	1.500	0.225	0.000	0.000
3	0.000	2.000	4.000	0.000	–2087.5	–1050	0.000	–2650	–1750	0.071	0.500	1.500	0.130	0.000	0.000

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

Note: UB Sig = upper-bound significance. ++The significance level of our upper bounds falls and then rises for the number of underweight bags, getting to 0.01 when gamma is 5.

Table 6.8 shows that even if unobservable characteristics increased the likelihood of a voucher program participant's being treated by a factor of 2, our estimated higher quantity of bags received by participants would still be significant at 5 percent. For the price of both NPK and Urea in Kano, my results are robust to increasing the influence of the unobservables by a factor of 3. My results on the timeliness of fertilizer receipt in Kano are not robust to even increasing the influence of unobservables by a factor of 1.1, thus limiting the confidence I have in stating that voucher participants in Kano received their fertilizer later than their counterparts who did not participate in the program. Interesting to note, the upper-bound significance level for the number of underweight bags received by participants falls and then rises. As explained by Becker and Caliendo (2007), this indicates that at higher levels of influence for unobservables, we have negative treatment effects at high levels of unobservables. Our confidence in the robustness of our results in Kano to the influence of unobservables is strengthened by the confidence intervals' not bracketing zero for up to a factor of 2.5, and this goes beyond 3 for all except the number of bags of fertilizer received.

All results in Taraba (apart from the number of underweight bags) are consistently robust to any influence of unobservable characteristics beyond a factor of three, and our confidence intervals (at levels of gamma equal to three or less) on the three outcome variables never bracket zero. Thus I am quite confident to state that participants in the voucher program in Taraba received more bags of fertilizer than their nonparticipating counterparts and at a price significantly cheaper than the market price. They also tended to receive their fertilizer later than desired.

7. SUMMARY AND CONCLUSION

This study used propensity score matching techniques to analyze an input voucher program in Kano and Taraba in 2009. This voucher program was meant to demonstrate an alternative and more efficient distribution mechanism for subsidized fertilizer in Nigeria. Given the stated goals, the voucher program was expected to increase the quantity of subsidized fertilizer that reached farmers at an affordable price and on time. It was also expected that the challenge of low-quality fertilizer (number of underweight bags) would be somewhat addressed by the program.

The study results revealed that participants in the 2009 voucher program in both Kano and Taraba received more bags of subsidized fertilizer than nonparticipants. Program participants in both states also paid significantly lower prices compared to those who purchased directly from the market. On average, participating in the voucher program did not improve the timeliness of fertilizer receipt; rather where significant, it appears that participants in the voucher program received their fertilizer late. This result highlights the limitations of input programs tied to government bureaucracy. The fertilizer distributed under the 2009 voucher program was that procured by the government. Thus, the ability to get subsidized fertilizer to farmers on time was dependent on the same government system that has been characterized as bureaucratic and inefficient. If more fertilizer is available to farmers at an affordable price but the product is available much later than when it is most needed by farmers, then it is of little to no value to the farmer since the timeliness of fertilizer application is an important determinant of its positive effect on crop yields.

The study also showed that participating in the voucher program did not provide farmers in Kano with better-quality fertilizer. Program participants in Kano received more underweight bags of fertilizer than their counterparts who did not participate in the program. In Taraba, although there appear to have been fewer problems with underweight bags among voucher program participants, these results are not statistically significant. This means that although I cannot claim that program participants in Taraba had a significantly lower number of bags of underweight fertilizer, at least the situation was not worse for participants. The prevalence of problems with underweight bags in Kano alone, despite the program's operating in both states, appears to reveal state-level differences. These could include differences in the regulation of the product by state authorities, the voucher program–implementing agency, or both. Thus, this reveals a further potential limitation of a voucher program. If proper quality regulatory frameworks are not in place, the efficiency of such programs in improving farmer productivity and the food security situation will be reduced.

The study shows that the 2009 voucher program has the potential to be a mechanism for increasing farmer access to fertilizer. However, to improve the probability that using vouchers will address issues of farm productivity and food security, there is a need to ensure that farmers receive appropriate amounts of affordable and good-quality inputs on time. If the program is to be expanded across states, fertilizer quality regulation and timeliness of fertilizer access need to be more carefully considered by program developers and implementers to enhance program efficiency.

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