AGRODEP Working Paper 0036

October 2016

Does an Inorganic Fertilizer Subsidy Promote the Use of Organic Fertilizers in Nigeria?

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Acknowledgments

This research benefited from the INNOVATIVE RESEARCH GRANT of the African Growth and Development Policy (AGRODEP) Modeling Consortium. The authors are grateful to Prof. Antoine Bouët, Dr. Betina Dimaranan, and an anonymous referee for their comments and suggestions.

This research was undertaken as part of, and partially funded by, the CGIAR Research Program on Policies, Institutions, and Markets (PIM), which is led by IFPRI and funded by the CGIAR Fund Donors. This paper has gone through AGRODEP's peer-review procedure. The opinions expressed here belong to the authors, and do not necessarily reflect those of AGRODEP, IFPRI, PIM or CGIAR.

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Abstract

This study examines the crowding-out or -in effect of organic fertilizers as a result of the inorganic fertilizer subsidy program in Nigeria. The study made use of the Nigeria General Household Survey (GHS) dataset from 2010-2011, which contains 5,000 farmers. We estimate the probability and intensity of organic and inorganic fertilizer use conditioned on the amount of fertilizer subsidy accessed by the farmers using Probit and Tobit IV methodologies. The results reveal that organic fertilizer is being used as an alternative to inorganic fertilizer and that the farmers who are not able to access the fertilizer subsidy rely on organic fertilizer. Apart from revealing the crowding-out effect of the fertilizer subsidy on the use of organic fertilizers, our findings also bring to the fore the role that transportation and regional constraints play in stimulating inorganic fertilizer application among farmers outside the fertilizer subsidy scheme. We conclude with some recommendations on how to increase organic fertilizer use and promote integrated soil fertility management among farmers in Nigeria.

Résumé

Cette étude examine les effets d’entrainement ou d'éviction ou des engrais organiques à la suite du programme de subvention des engrais inorganiques au Nigeria. L'étude a fait usage de l'ensemble des données de l’Enquête générale sur les ménages (GHS) du Nigeria de 2010-2011, qui contient 5.000 agriculteurs. Nous estimons la probabilité et l'intensité de l'utilisation d'engrais organique et inorganique conditionné sur le montant de la subvention des engrais reçus par les agriculteurs en utilisant un Probit et un Tobit avec variables instrumentales. Les résultats révèlent que l'engrais organique est utilisé comme une alternative à l'engrais inorganique et que les agriculteurs qui ne sont pas en mesure d'accéder à la subvention des engrais inorganiques comptent sur l'engrais organique. Outre le fait de révéler l'effet d'éviction de la subvention des engrais inorganiques sur l'utilisation d'engrais organiques, nos résultats mettent aussi en évidence le rôle que le transport et les contraintes régionales jouent dans la stimulation de l'application d'engrais inorganique chez les agriculteurs en dehors du régime de subvention. Nous concluons avec quelques recommandations sur la façon d'accroître l'utilisation d'engrais organiques et de promouvoir la gestion de la fertilité des sols chez les agriculteurs au Nigeria.

1. Introduction

According to the World Bank (2010), growth in agriculture is twice as effective in reducing poverty as growth in other sectors in Africa south of the Sahara (SSA). The Bank indicates that increases in agricultural productivity will reduce poverty in SSA more than any other regions in the world (World Bank, 2010). Historically, gains in agricultural production in Nigeria have come through expansion of cultivated area rather than use of more productive techniques, and this increased cultivation on less productive lands is a major cause of declining yields in many parts of the country. To reverse this trends, agricultural intensification through the use of fertilizers and other land-augmenting inputs (coupled with other agricultural best practices) is essential. Experience has shown that chemical fertilizers are one of the most powerful productivity-enhancing inputs available. One-third of the increase in cereal production worldwide and as much as half of the increase in India's grain production have been attributed to fertilizer-related factors[1]. Within Africa south of the Sahara, substantially increased crop yields have only been achieved through the use of fertilizers and other inputs (Sanders and Ahmed, 2001; Sheahan and Barrett, 2014). However, available evidence indicates that fertilizer application has remained low in most parts of Nigeria (Olayide et al, 2010), lower than that observed in other parts of the developing world, especially Asia, where fertilizers (along with other productivity-enhancing technologies) have been credited with large increases in yields (Sheahan and Barrett, 2014). Furthermore, it is estimated that Nigeria is experiencing increasing annual nutrient depletion (Liverpool-Tasie, 2010), risking its ability to sustain the modest gains achieved from recent agricultural growth[2].

To stimulate inorganic fertilizer use among resource-poor farmers, the Federal Government of Nigeria introduced a fertilizer subsidy to make fertilizer prices more affordable to smallholder farmers. While this subsidy may be desirable because of the need to increase farmers' productivity and ensure food security in Nigeria, various concerns have been raised regarding the environmental effects of inorganic fertilizers (Jaeger et al., 1999; Duflo et al., 2011). Intensive crop cultivation using high levels of inorganic fertilizer may lead to soil degradation (Marenya and Barrett, 2009), and the continuous use of high levels of inorganic fertilizers can cause soil acidification (Bekunda et al., 1997). The use of organic manure may prevent these declines in soil fertility, but the preparation, transportation, and application of organic manure are labor-intensive (Holden and Lunduka, 2012). In addition, fertilizer subsidies may increase dependency on inorganic fertilizer simply because inorganic fertilizers are the ones being subsidized (Holden and Lunduka,

[1] Data on agricultural potential for six continents rank Africa second (after Latin America) in terms of the theoretical maximum levels of attainable production, yet without increased use of improved inputs, such as fertilizers, this potential may not be realized without the use of fertilizer (Alabi, 2014).

[2] Nutrient depletion in Nigeria (N.P. K) was estimated at 2.89 million tonnes, accounting for 35 percent of total depletion in Africa.

2012)[3]. The tendency of subsidized fertilizers to crowd out private sector participation and limit the use of alternative organic manure are thus important considerations (Ricker-Gilbert et al., 2011; Holden and Lunduka, 2012), particularly because using both organic and inorganic fertilizer together can improve long-term integrated soil fertility management (Sheahan and Barrett, 2014).

The question that arise immediately is that, do Nigerian farmers use organic fertilizer as substitute or complement? According to Holden and Lunduka (2012), if farmers are aware of the complementary effect of organic fertilizers on inorganic fertilizer use efficiency, they may prefer to combine these inputs. Access to subsidized fertilizers could then serve to promote higher use of organic fertilizers to enhance inorganic fertilizer use efficiency. However, if Nigeria's fertilizer subsidy crowds out the use of organic fertilizer, it may have detrimental implications on long-term soil fertility management. This study examines the crowding-out or -in effect of Nigeria's inorganic fertilizer subsidy on organic fertilizer use. We also estimate the proportion of farmers who use organic and inorganic fertilizers based on farm size, income, and region. In addition, the effects of fertilizer prices and transportation costs on the probability and intensity of inorganic and organic fertilizer use were also determined.

2. Data Sources and Collection

The study uses the Nigeria General Household Survey (GHS) Dataset of 2010-2011, implemented by the National Bureau of Statistics (NBS)[4]. The survey was the result of a partnership between NBS and the Federal Ministry of Agriculture and Rural Development (FMARD), the National Food Reserve Agency (NFRA), the Bill and Melinda Gates Foundation (BMGF), and the World Bank (WB). These partners developed a method to collect agricultural and household data in such a way as to allow the study of agriculture's role in household welfare over time. The dataset covers 5,000 farming households with information on multiple agricultural activities and household consumption for 2010-20111, drawing heavily on the Harmonized National Living Standards Survey (HNLSS-a multi-topic household survey) and the National Agricultural Sample Survey (NASS- Nigeria's key agricultural survey). The survey was carried out in two visits to the panel households (post-planting visit in August-October 2010 and post-harvest visit

[3] Commonly used organic fertilizers include animal manure, household wastes, plant materials (including crop residues), and compost made from one or more of these sources. In addition to providing nutrients, organic fertilizers contribute to soil quality by improving the structure, chemistry, and biological activity level of soil. Commonly used inorganic fertilizers include straight fertilizers containing a single nutrient—usually nitrogen (N), phosphorus (P), or potassium (K)—and compound or mixed fertilizers containing more than one of these so-called macronutrients, plus, in some cases, trace elements such as zinc or boron.

[4] The Nigeria GHS was supported by the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) project undertaken by the Development Research Group at the World Bank. The LSMS-ISA project aims to support governments in seven SSA countries to generate nationally representative household panel data with a strong focus on agriculture and rural development. The surveys under the LSMS-ISA project are modeled on the multi-topic integrated household survey design of the LSMS; Household, Agriculture, and Community questionnaires are an integral part of every survey effort.

in February-April 2011). The dataset can be downloaded at the World Bank's Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) website[5].

The sample design uses two-stage probability sampling. The primary sampling Unit (PSU) was the Enumeration Area (EA). These areas were selected based on probability proportional to size (Pps) of the total EAs in each state and Federal Capital Territory (FCT) and the total household listed in those EAs. A total of 500 EAs were selected using this method. Households were selected randomly using the systematic selection of ten households per EA. This involved obtaining the total number of households listed in a particular EA and then calculating a sampling interval (S.I) by dividing the total households by ten. The next step was to generate a random start 'r' from the table of random numbers which stands as the first selection. Consecutive selection of households was obtained by adding the sampling interval to the random start. In all, 500 clusters/EAs and 5,000 households were interviewed and relevant information were collected based on their plots and farming activities. These samples were proportionally selected in the states such that different states had different sample sizes. However, the selection covers all rural and urban areas, all Local Government Areas, and all the states in Nigeria, including FCT. Further description of the questionnaire used for data collection is available in Appendices 1a and 1b. Appendix 2 shows that about 90 percent of the sampled farmers have one or two farm plot(s). The relevant information based on their farm plots, such as farmers' socio-economic characteristics, access to fertilizer, types of fertilizer used, fertilizer subsidy amount, cost of transportation, fertilizer prices, etc. were extracted for the purpose of this study. The unit of analysis was farm plots, and our analyses were focused on the farming households that applied fertilizer.

3. Methods of Data Analysis

The probability and intensity of organic and inorganic fertilizer use were investigated using Probit IV and Tobit IV methodologies. These instrumental variable methodologies were implemented because access to subsidized inputs is not random and is likely to be influenced by supply- and demand-side factors such as the fertilizer subsidy program's poverty reduction objectives and the social capital of individual households (Holden and Lunduka, 2012). These factors require the identification of exogenous variables that are correlated with the access to input subsidies but that do not directly affect demand for organic fertilizer. Such identification will control for potential endogeneity caused by the non-random targeting of fertilizer subsidy recipients (Ricker-Gilbert et al., 2011).

Endogeneity can lead to inconsistency of traditional mean estimators by inducing correlation between regressors and unobservables. The basic idea in Probit and Tobit IV methodologies is to add a variable to

[5] http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:22949589~menuPK:4196952~pagePK:64168445~piPK:64168309~theSitePK:3358997~isCURL:Y~isCURL:Y~isCURL:Y,00.html

the regression such that, once we condition on this variable, regressors and unobservables become independent. The instrumental variable added will address the potential endogeneity and self-selectivity issues associated with the use of subsidized fertilizers among surveyed farmers. The traditional instrumental variables used in the literature include the distance between the farm and the fertilizer selling points and social capital proxied by how long the farmer has lived in the community. Unfortunately, such statistical information is not available in our dataset; we thus followed the recent approach adopted by Seck (2016), using farmers' political preferences to instrument for the amount of fertilizer subsidy used by the famers. Theoretically, farmers with a greater connection with the incumbent political party are more likely to benefit from special treatment in the allocation of the subsidy program (Seck, 2016).

Apart from endogeneity, censoring is also a problem in econometric analysis because many economic data are top-coding and are naturally bounded from below zero. This can also lead to inconsistency of traditional mean estimators by inducing correlation between regressors and unobservables. In addition to controlling for endogeneity in the model, Tobit IV also takes care of any censoring that may be associated with zero application of fertilizer and with fertilizer subsidy amount.

Probit and Tobit IV methodologies are full information maximum likelihood estimators. They fit models where one or more of the regressors is endogenously determined. The Probit IV fits models with dichotomous dependent variables and endogenous regressors, while the Tobit IV fits models with continuous dependent variables and endogenous regressors. The two methodologies are useful when one or more of the regressors are correlated with the error term. Alternatively, Newey's (1987) minimum chi-squared estimator can be invoked with the two-step option (Wooldridge, 2010)[6].

We dealt with the possibility of heteroskedasticity in this study by estimating heteroskedasticity-consistent standard errors (or robust errors) developed by White[7]. We estimated the Probit and Tobit IV and reported heteroskedasticity-consistent standard errors (robust errors), which were compared with Probit and Tobit IV (standard errors). Chernozhukov et al (2015) have shown that the Tobit IV estimator provides a good comparison to the Censored Quantile Instrumental Variable (CQIV) estimator because it incorporates

[6] Despite the coefficients not being directly comparable to their maximum likelihood counterparts, the two-step estimator is nevertheless useful. The maximum likelihood estimator may have difficulty converging, especially with multiple endogenous variables. The two-step estimator, consisting of nothing more complicated than a probit regression, will almost certainly converge. Moreover, although the coefficients from the two models are not directly comparable, the two-step estimates can still be used to test for statistically significant relationships. The number of excluded exogenous variables (that is, the additional instruments) be at least as great as the number of included endogenous variables. ivprobit checks this for you and issues an error message if the order condition is not met.

[7] With Stata, robust standard errors can usually be computed via the addition of two parameters, robust and cluster. The robust option relaxes the assumption that the errors are identically distributed, while cluster relaxes the assumption that the error terms are independent of each other.

endogeneity and censoring. Kowalski (2009) has demonstrated that the Tobit IV estimator is consistent and efficient[8].

We stated the Probit or Tobit IV model as:

$$Y^*1i = Y2i\beta + X1i\gamma + \mu i \tag{1}$$

$$Y2i = X1i\Pi 1 + X2i\, \Pi 2 + \nu i \tag{2}$$

where i= 1, 2, 3, …… N (Number of the farm plots), Y2i is the endogenous variable (fertilizer subsidy amount in Naira), X1i represents included exogenous variables (household income proxied by non-food expenditure in Naira), fertilizer cost in Naira, cost of transporting fertilizer in Naira, presence of a child in the family (dummy), and gender and regional dummies. X2i represents excluded exogenous regressor (farmers' political preference), and the equation for Y2i is written in reduced form. By assumption (μi, νi) ~ N(0). β and γ are vectors of structural parameters, and Π1 and Π2 are matrices of reduced form parameters. Y*1i is the dependent variable which stands for the probability of a farmer using organic fertilizer (Organic fertilizer model) or inorganic fertilizer (Inorganic fertilizer model) in the case of the Probit IV models. Y*1i is the intensity of organic fertilizer use (Organic fertilizer model) or inorganic fertilizer use (Inorganic fertilizer model) in the case of Tobit IV models. The intensity of fertilizer use is measured as gramme of fertilizer applied per square meter (g/m2), which was then converted to kilogramme per hectare (kg/ha). However, in the case of Probit IV, we do not observe Y*1i; instead we observe:

$$Y1i = \begin{cases} 0 & Y^*1i < 0 \\ 1 & Y^*1i \geq 0 \end{cases} \tag{3}$$

4. Results and Discussion

4.1 Descriptive Results

Only 44 percent of the surveyed farming households applied any form of fertilizer (organic or inorganic). Out of the farming households that applied fertilizer, only 6 percent applied organic fertilizer, as presented in Table 1. Sheahan and Barrett (2014) report low use of organic fertilizer among farmers in Nigeria compared with countries like Malawi and Ethiopia. The low crop yield reported by Nigerian farmers may be predicated on a lack of proper combination of organic fertilizers with inorganic fertilizers because organic fertilizers, where they are available, can be an integral component of long-term soil fertility management strategies (Morris et al., 2007). Only 38 percent of the surveyed farmers accessed subsidized fertilizers, and the average subsidy amount is N 896 out of an average fertilizer cost of N 11969[9]. Inorganic

[8] Eichner (1997, 1998) have used a version of the Tobit IV estimator to analyze the demand for medical care and medical expenditure.

[9] N Stands for Naira which is Nigeria National currency.

fertilizers are more expensive than organic fertilizers (N 11072 compared to N 868). The fact that fertilizer is expensive is evidenced by the fact that the cost of fertilizer (N 11969) is higher than the non-food expenditure (income) of N 11211. This suggests that fertilizers may not be affordable for average farmers in Nigeria and may play a role in Nigerian farmers' low use of inorganic fertilizers (Olayide et al, 2010), particularly compared to the rest of the developing world (Liverpool-Tasie et al, 2010). Table 1 corroborates the lower rates of fertilizer application; the intensity of inorganic and organic fertilizer use is 11.3kg/ha and 0.2kg/ha, respectively. This low fertilizer use can explain the rationale behind Nigeria's fertilizer subsidy scheme; however, only 38 percent of the surveyed farmers actually accessed subsidized fertilizer and Nigeria's total fertilizer use is still below the 50kg/ha target set forth during the Africa Fertilizer Summit in Abuja.[10]

Table 1: Summary Statistics of Farmers' Socio-economics Characteristics

	Mean Value	**Standard Error**
% of Farmers who used Organic Fertilizer	5.93	0.3144
% of Farmers who used Subsidized Fertilizer	37.84	0.6455
Subsidy Amount(N)	896.22	282.4482
Total Fertilizer Cost(N)	11968.63	353.62
Inorganic Fertilizer Cost(N)	11071.89	347.70
Organic Fertilizer Cost(N)	868.07	89.27
Cost of transporting Fertilizer(N)	11.30	1.23
Cost of transporting Inorganic Fertilizer(N)	10.75	1.2290
Cost of transporting Organic Fertilizer(N)	0.55	0.0768
Expenditure(N)	11211.30	1068.64
Inorganic Fertilizer Use Intensity(Kg/ha)	11.3	7.136
Organic Fertilizer Use intensity(Kg/ha)	0.2	0.043

Source: Computed by the Authors

Table 2 compares the probability and intensity of fertilizer use by both subsidized and un-subsidized farmers. All the farmers who accessed the fertilizer subsidy used inorganic fertilizers, while less than 0.5 percent used organic fertilizers. The table shows further that 79 percent and 9 percent of the farmers who did not access the fertilizer subsidy used organic and inorganic fertilizer, respectively. The differences in

[10] The Africa Fertilizer Summit was convened by the African Union's New Partnership for Africa's Development (NEPAD) and implemented by IFDC. The Summit was held in Abuja, Nigeria, in June 2006. According to the Abuja Declaration on Fertilizer for an African Green Revolution, "Africa's farmers face a variety of constraints including low productivity, limited access to new agricultural technologies and weak markets. Without adequate inputs, farmers often cannot meet the food needs of their own families, much less those of a rapidly growing population. To feed themselves and their countries, farmers will need to shift from low-yielding, extensive land practices to more intensive, higher-yielding practices, with increased use of improved seeds, fertilizers and irrigation." The Abuja Declaration continued, "A move toward reducing hunger on the continent must begin by addressing its severely depleted soils. Due to decades of soil nutrient mining, Africa's soils have become the poorest in the world. It is estimated that the continent loses the equivalent of over $4 billion worth of soil nutrients per year, severely eroding its ability to feed itself. Yet farmers have neither access to nor can they afford the fertilizers needed to add life to their soils. And no region of the world has been able to expand agricultural growth rates, and thus tackle hunger, without increasing fertilizer use." (Roy, 2006).

farmers' probability of using inorganic and organic fertilizer are statistically is significant at 5 percent. This creates the impression that organic fertilizers are being used as an alternative to the formal fertilizer subsidy, with farmers who are not able to access the fertilizer subsidy relying on organic fertilizers. Table 2 also reveals that the intensity of organic fertilizer use by unsubsidized farmers is significantly higher than that of subsidized farmers. The cost implication of the fertilizer subsidy is evident - the cost of fertilizer (N 12647) for unsubsidized farmers is almost the double the cost of fertilizer for subsidized farmers (N 6765), and the difference is significant at 5 percent. The differences in the mean yield, plot size, and expenditure (proxied for income) of subsidized and unsubsidized farmers are not statistically significant at 5 percent.

Table 2: Probability and Intensity of Fertilizer Use among Subsidized and Unsubsidized Farmers

	Subsidized	**Non-Subsidized**	**Difference**	**T-statistics**
% of Farmers who used Inorganic Fertilizer	100.00	78.76	20.87	23.24**
% of Farmers who used Organic Fertilizer	0.37	8.56	-8.19	-13.39**
Inorganic Fertilizer Use Intensity(Kg/ha)	28.03601	0.873367	27.16265	1.4406
Organic Fertilizer Use intensity(Kg/ha)	0.000137	0.240789	-0.240652	-3.2602**
Total Fertilizer Cost(N)	6765.274	12647.45	-5882.179	-8.1044**
Expenditure(N)	5580.838	13480.6	-7899.76	-1.4623
Plot Size(ha)	0.6539.851	0.6964.979	-0.425	-0.8960
Yield(tonne/ha)	0.6266.648	0.3981.606	0.2285	1.8689

Source: Computed by the Authors ** Significant at 5%

In Table 3, we examine the distribution pattern of fertilizer use (both organic and inorganic) based on farm plot size and income. The table shows that the smallest scale farmers used about 2 percent organic fertilizers compared with 20 percent inorganic fertilizers. The poorest farmers used 24 percent organic fertilizers compared with 20 percent inorganic fertilizers. This indicates that small-scale and poor farmers' probability of using organic fertilizers is higher than their probability of using inorganic fertilizers. Table 4 shows that the probability of the smallest scale and poorest farmers accessing the inorganic fertilizer subsidy is 18 percent and 22 percent, respectively. This demonstrates that small-scale and poor farmers' probability of using organic fertilizers is higher than their probability of using the fertilizer subsidy.

In terms of regional patterns in the probability of farmers' using the inorganic fertilizer subsidy, Appendix 3 indicates that about 85 percent of subsidized inorganic fertilizers are accessed in the Northern regions, while the Southern regions accessed 15 percent of subsidized inorganic fertilizer subsidy fertilizers. The Northern regions utilized 82 percent and 62 percent of inorganic and organic fertilizers, respectively.

Generally, Nigeria's Northern regions are known to use more fertilizers than the Southern regions. Oxfam (2009) has indicated that the Northern regions account for more than 70 percent of total annual consumption of inorganic fertilizers allocated by Nigeria's federal government. This has been attributed to crop production patterns; grain dominates the Northern regions while tubers dominate the Southern regions (Olomola, 2015). Moreover, most of the land in the North is degraded; hence farmers in those regions are likely to be willing to apply fertilizer that can improve their land productivity and boost their yields (Liverpool-Tasie et al, 2010). Appendix 3 also demonstrates that the Southern regions that received only 15 percent of the fertilizer subsidy used 18 percent inorganic and 28 percent organic fertilizers, respectively.

Table 3: Share of Organic and Inorganic Fertilizer used Based on Plot size and Expenditure

	Farm Plot size		**Expenditure (Income)**	
	Organic (%)	**Inorganic (%)**	**Organic (%)**	**Inorganic (%)**
Smallest	27.50	19.60	23.90	19.50
Small	23.30	19.70	15.50	20.50
Medium	14.00	21.20	18.50	20.00
Large	18.20	19.90	23.30	20.00
Largest	17.00	19.60	18.80	20.10

Source: Computed by the Authors from the survey

Table 4: Share of Inorganic Fertilizer Subsidy Among Farmers

	Share by Farm Plot size (%)	**Share by Expenditure (Income) (%)**
Smallest	17.50	21.90
Small	20.70	19.70
Medium	21.20	19.60
Large	20.10	18.90
Largest	20.50	20.00

Source: Computed by the Authors from the survey data

4.2 Determinants of Probability of Organic and Inorganic Fertilizer Use

Table 5 reports Probit IV (robust errors) estimation of the determinants of the probability of organic fertilizer use. The table shows that the Wald statistic of 629.58 and the p-value of 0.0000 implies that the variables estimated in the model are joint significant determinants of the probability of farmers using organic fertilizers. Comparing Probit IV (robust errors) estimation with Probit IV (standard errors) estimation[11] reveals that Probit IV (robust errors) is better than Probit IV (standard errors), as more coefficients are significant in Probit IV (robust errors) estimation than in Probit IV (standard errors)

[11] Ordinary Least Square (OLS) assumes that errors are both independent and identically distributed; robust standard errors relax either or both of those assumptions. Hence, when heteroskedasticity is present, robust standard errors tend to be more trustworthy.

estimation. As expected, the major differences between the two models are the estimated standard errors. The Probit IV estimation (standard error) of the determinants of the probability of organic fertilizer use is presented in Appendix 4. In addition, we estimate Newey's (1987) minimum chi-squared estimator with the two-step option; this is reported in Appendix 5. All the coefficients that are significant in Probit IV (robust errors) estimation are also significant in Probit IV with Newey's (1987) two-step option except for expenditure (income). All of these results surmise that Probit IV (robust errors) estimation is more robust than the other two alternatives. A Wald test of the exogeneity of the instrumented variables is presented at the bottom of Table 5. With a P-value > 0.0000, we reject the null hypothesis of no endogeneity. Since the test statistic is significant, a regular Probit regression may be inappropriate to use as the estimation model. This justifies our use of Probit IV (robust error) estimation model.

In Table 5, the coefficients of the fertilizer subsidy amount, expenditure, and region are negative but significant determinants of the probability of organic fertilizer use, while transportation costs, child (dummy), and fertilizer price are positive and significant determinants of the probability of organic fertilizer use. The negative coefficient of the inorganic fertilizer subsidy amount indicates that an increase in the fertilizer subsidy amount will decrease the probability of farmers using organic fertilizers. This implies that the inorganic fertilizer subsidy crowds out the probability of using organic fertilizers. The negative coefficient of expenditure (income) suggests that an increase in farmers' incomes will decrease the probability of farmers using organic fertilizer. It also indicates that low-income farmers have a higher probability of using organic fertilizers than high-income farmers. The majority of low-income farmers cannot afford inorganic fertilizers; hence they may use organic fertilizers as an alternative. The fact that the region (dummy) coefficient is negative suggests that the farmers in the Northern regions have a lower probability of using organic fertilizers than those in the Southern regions. The negative coefficient of transportation cost demonstrates that an increase in the cost of transporting fertilizers can increase the use of organic fertilizers.[12] Since transportation cost is positively correlated with distance, an increase in the distance between fertilizer supplies, especially inorganic fertilizers, and the farm may increase the use of organic fertilizers if farmers treat organic fertilizers as a substitute. Holden and Lunduka (2012) have shown that children can help farming households gather and compost manure to use as organic fertilizer. This may explain the positive relationship between the child dummy and farmers' probability of using

[12] Fertilizer transportation cost is the combination of the cost of transporting organic and inorganic fertilizers; however, transportation of inorganic fertilizers constitutes 95 percent of the cost of transporting fertilizers (Table 1). We combine the transportation cost because the farmers may jointly transport organic and inorganic fertilizers. Moreover, like Probit, Logit, and Logistic, Probit IV checks the exogenous and endogenous variables to see if any of them predict the outcome variable perfectly. It will then drop offending variables. Hence, when we used cost of transportation for inorganic or inorganic fertilizers, this was dropped out of the model for perfectly predicting outcome variable.

organic fertilizers. The fact that the fertilizer price coefficient is positive[13] implies that as the price of inorganic fertilizers increase, farmers' probability of using organic fertilizers also increases. This is also evidence that inorganic and organic fertilizers are being treated as substitutes by the surveyed farmers.

Table 6 reports the determinants of the probability of farmers using inorganic fertilizers.[14] All the variables that are significant as determinants of the probability of using organic fertilizers are also significant as determinants of inorganic or inorganic fertilize the probability of using inorganic fertilizers, but with opposite signs. A Wald test of the exogeneity of the instrumented variables is presented at the bottom of Table 6. With a P-value > 0.0000, we reject the null hypothesis of no endogeneity. Since the test statistic is significant, a regular Probit regression may be inappropriate to use as the estimation model of farmers' probability of using inorganic fertilizers. This justifies our use of Probit IV estimation model.

Table 6 further shows that the coefficients of the fertilizer subsidy amount, expenditure (income), and region are positive and significant determinants of the probability of inorganic fertilizer use. The coefficients of fertilizer transportation cost, child (dummy), and fertilizer price are negative but significant determinants of inorganic fertilizer use. The evidence that the coefficient of the fertilizer subsidy amount is positive and significant suggests that an increase in the fertilizer subsidy will increase the use of inorganic fertilizers. This finding supports the rationale for the fertilizer subsidy scheme, which aims at promoting access to inorganic fertilizers (Minot and Benson, 2009). This may also justify the political will among African leaders to reinstate or revitalize agricultural input subsidy schemes (Seck, 2106).

The positive relationship between expenditure (income) and the probability of using inorganic fertilizers is an indication that the probability of using inorganic fertilizers increases with an increase in farmers' incomes. This result also means that high-income farmers have a higher probability of using inorganic fertilizers than low-income farmers. Existing literature has found wealth to be a distinguishing factor associated with the probability of using inorganic fertilizers and accessing the inorganic fertilizer subsidy (Liverpool-Tasie, et al, 2010). The positive coefficient of the regional dummy implies that farmers in the Northern regions of Nigeria have a higher probability of using inorganic fertilizers than farmers in the Southern regions. This is because there is higher accessibility to inorganic fertilizers in the Northern regions

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[13] Fertilizer price is the combination of the price of organic and inorganic fertilizers, but the price of inorganic fertilizers represents 93 percent of total cost of fertilizers used by the surveyed farmers.

[14] Table 6 presents Probit IV (robust errors) estimation of the determinants of the probability of inorganic fertilizer use. The table shows that Wald Chi2 and Prob>Chi2 are 625.02 and 0.0000, respectively. This shows that the variables estimated in the model are major joint determinants of the probability of farmers using inorganic fertilizers. Comparing Probit IV (robust errors) estimation of the determinants of the probability of inorganic fertilizer use with Probit IV (standard errors) estimation reveals that all the variables that are significant in the Probit IV (robust errors) estimation are also significant in Probit IV (standard errors) estimation except expenditure (income). As expected, the major differences between the two models are the estimated standard errors. The Probit IV (standard errors) estimation of probability of using inorganic fertilizers with is presented in Appendix 6. The Newey's two-step option is reported in Appendix 7. Comparing Newey's two-step option with Probit IV (robust errors) estimation reveals that expenditure (income) is the only variable that is significant in Probit IV (robust errors) estimation that is not significant in the Newey's two-step option estimation.

than in the Southern regions (Olomola, 2015); Northern regions utilized 82 percent of inorganic fertilizers compared with 18 percent in the Southern regions (see Appendix 3).

The negative relationship between fertilizer transportation costs and the probability of inorganic fertilizer use suggests that an increase in the cost of transporting fertilizer will discourage its use among farmers. Since transportation costs increase with distance, this means that the farther the inorganic fertilizer supply unit is to the farmers, the lower the probability of farmers actually using those fertilizers. The transportation constraint has been identified as one of the reasons for the low use of inorganic fertilizers in rural Nigeria (Adesina, 2014).

The presence of children in the household may imply an increase in expenditure to provide for the need of those children. This may be a drain on the income that the farmers may otherwise use to purchase inorganic fertilizers (Onu, 2013) and could thus explain the negative relationship between the coefficient of child (dummy) and the probability of farmers using inorganic fertilizers.

As expected, the coefficient of fertilizer price is negative because an increase in the price of inorganic fertilizers will discourage farmers from using those fertilizers. This is the main reason for the introduction of the fertilizer subsidy in Nigeria - to reduce the price of inorganic fertilizers so that they will be affordable for the majority of the country's farmers (Kabir, 2014).

Table 5: Probability of Organic Fertilizer Use Model (Robust Errors)

Wald Chi^2 = 629.58* Prob > Chi^2 = 0.0000**				
	Coefficient	**Robust S.E**	**z**	**P>|z|**
Subsidy Amount	-0.0000942	4.19e-06	-22.50***	0.000
Expenditure	-1.98e-06	8.95e-07	-2.21***	0.027
Transportation Cost	0.015996	0.0027405	5.84***	0.000
Kids	0.1394763	0.0781948	1.78*	0.074
Gender	-0.0805725	0.0737016	-1.09	0.274
Region	-0.8829684	0.097154	-9.09***	0.000
Fertilizer Price	0.0000644	4.50e-06	14.31***	0.000
Constant	0.8979317	0.1565546	5.74***	0.000
/athrho	1.490759	.01545126	9.65***	0.000
/Insigma	9.283716	0.0423059	219.44***	0.000
Rho	0.9034644	0.028392		
Sigma	10761.35	455.269		
Wald Test of Exogeneity: Chi^2 = 93.09*** Prob > Chi^2 = 0.0000				

*** and * indicate Significance at 1% and 10% respectively
Source: Computed by the Authors

Table 6: Probability of Inorganic Fertilizer Use Model (Robust Errors)

Wald Chi^2 = 625.02***		**Prob > Chi^2 = 0.0000**		
	Coefficient	**Robust S.E**	**z**	**P>|z|**
Subsidy Amount	0.0000938	4.23e-06	22.16***	0.000
Expenditure	2.10e-06	9.44e-07	2.23***	0.026
Transportation Cost	-0.0158608	0.0027349	-5.80***	0.000
Kids	-0.1315767	0.078071	-1.69*	0.092
Gender	0.0902864	0.0741726	1.22	0.224
Region	0.879122	0.0969551	9.07***	0.000
Fertilizer Price	-0.0000642	4.49e-06	-14.31***	0.000
Constant	0.8898186	0.155843	5.71***	0.000
/athrho	-1.454321	0.1559455	-9.33***	0.000
/Insigma	9.283716	0.0423059	219.44***	0.000
Rho	-0.896544	0.0305979		
Sigma	10761.35	455.2685		
Wald Test of Exogeneity: Chi^2 = 86.97*** Prob > chi2 = 0.0000				

*** and * indicate Significance at 1% and 10% respectively
Source: Computed by the Authors

4.3 Determinants of Intensity of Organic and Inorganic Fertilizer Use

Table 7 reports Tobit IV (robust errors) estimation of the determinants of the intensity of organic fertilizer use. The Wald statistic of 52.06 and p-value of 0.0000 in the table indicate the variables estimated in the model are joint significant determinants of intensity of organic fertilizer use.[15] The Wald test of the exogeneity of the instrumented variables is presented at the bottom of Table 7. With P > 0.000, we reject the null hypothesis of no endogeneity. Since the test statistic is significant, so a regular Tobit regression may not be appropriate to use as the estimation model. This justifies the use of Tobit IV estimation model.

In Table 7, the coefficients of the fertilizer subsidy amount, expenditure, and region are negative but significant determinants of the intensity of organic fertilizer use, while transportation costs and fertilizer price are positive and significant determinants of the intensity of organic fertilizer use. The negative coefficient of the inorganic fertilizer subsidy amount indicates that an increase in the inorganic fertilizer subsidy amount will decrease the intensity of organic fertilizer use, implying that the inorganic fertilizer subsidy crowds out the intensity of organic fertilizer use. The negative coefficient of expenditure (income) suggests that an increase in farmers' expenditure (income) will decrease the intensity of organic fertilizer use, indicating that high-income farmers use organic fertilizers less intensively than low-income farmers.

[15] Comparing Tobit IV (robust errors) estimation with Tobit IV (standard errors) estimation reveals that all the variables that are significant in Tobit IV (robust errors) are also significant in Tobit IV (standard errors) except expenditure (income) coefficient. The Tobit IV (standard errors) estimation of intensity of organic fertilizer use is presented in Appendix 8. In addition, the Newey's (1987) two-step option Tobit IV of intensity of organic fertilizer use is reported in Appendix 9. All the variable coefficients that are significant in Tobit IV (robust errors) estimation are also significant in Probit IV with Newey's (1987) two-step option except expenditure coefficient. All these demonstrate that Tobit IV (robust errors) estimation is a better estimation model in this case.

The fact that the region coefficient is negative suggests that farmers in the Northern regions use organic fertilizers less intensively than those in the Southern regions. The low probability and intensity of organic fertilizer use in the Northern regions can be predicated on the low level of Northern farmers' awareness of how to convert the region's abundant livestock resources into organic fertilizers. Lawal-Adebowale (2012) reveals that Nigeria has a population of 35 million goats, 22 million sheep, and 14 million cattle. The larger proportion of these animals is largely concentrated in the Northern regions; according to Lawal-Adebowale, about 90 percent of the country's cattle population and 70 percent of the sheep and goat populations are concentrated in the Northern regions. Considering the fact that sheep and rams alone produce about 0.9 kg of waste per head per day in Nigeria (Abiola et al., 1999; Sridhar and Hammed, 2014), it is glaringly evident that the Northern regions are under-utilizing available animal waste which could be converted into organic fertilizers

The positive coefficient of inorganic fertilizer transportation costs demonstrates that an increase in the cost of transporting inorganic fertilizers will increase the intensity of organic fertilizer use. This suggests that as the price of inorganic fertilizers increases, the intensity of organic fertilizer use increases. This implies that inorganic fertilizer-using farming households in Nigeria view inorganic and organic fertilizers as substitutes instead of complements, underscoring the challenge of promoting integrated soil fertility management (Sheahan and Barrett, 2014).

In addition, the marginal effect of the estimated variables reported in Table 7 reveals that a 1 percent increase in the inorganic fertilizer subsidy amount will decrease organic fertilizer use intensity by 0.00031g/m2. This also means that if the subsidy amount increases by 100 percent, organic fertilizer use intensity will decrease by 0.031kg/ha[16]. The marginal effect of the regional dummy of -3.009 suggests that a farmers' organic fertilizer use intensity will decrease three times if that farmer moves from the Southern region to the Northern region.

Table 8 reports the determinants of the intensity of inorganic fertilizer use[17]. The coefficients of the fertilizer subsidy amount and fertilizer price are significant determinants of the intensity of inorganic fertilizer use. The positive coefficient of the inorganic fertilizer subsidy amount indicates that an increase in the subsidy amount will increase the intensity of inorganic fertilizer use. The negative coefficient of fertilizer price

[16] 1000g = 1kg and 10000m2=1ha

[17] Table 8 presents Tobit IV (robust errors) estimation of the determinants of the intensity of inorganic fertilizer use. The Wald statistic of 21.22 and p-value of 0.0035 reported in the table indicate the variables estimated in the model are joint significant determinants of intensity of inorganic fertilizer use. Comparing Tobit IV(standard errors) reported in Appendix 10, with Tobit IV (robust errors) estimation of the determinants of the intensity of inorganic fertilizer use reveals that only the coefficients of fertilizer subsidy amount and fertilizer price are significant in Tobit IV(standard errors). Tobit IV estimation using Newey's two-step option is also estimated to check the numbers of variables that are significant in the two-step option in comparison with Tobit IV (robust errors) estimation and this is presented in Appendix 11. When Newey's two-step option is compared with Tobit IV (robust errors), only fertilizer subsidy amount and fertilizer price are the two significant determinants of intensity of inorganic fertilizer use. This also confirmed that Tobit IV (robust errors) is adequate for our analysis of determinants of the intensity of inorganic fertilizer use.

suggests that an increase in the price of inorganic fertilizers will decrease those fertilizers' use intensity. A Wald test of the exogeneity of the instrumented variables is presented at the bottom of Table 8. With a P-value > 0.0001, we reject the null hypothesis of no endogeneity. Since the test statistic is significant, so a regular Tobit regression may be inappropriate to use as the estimation model of intensity of inorganic fertilizer use. This justifies the use of Tobit IV estimation model.

The marginal effects of the estimated variables reported in Table 8 shows the limited effect of the fertilizer subsidy in increasing inorganic fertilizer use intensity among the surveyed farmers. The estimated marginal effect reveals that a 1 percent increase in the fertilizer subsidy amount will increase inorganic fertilizer use intensity by 0.0000938g/m2. This also means that if the subsidy amount increase by 100 percent, inorganic fertilizer use intensity will increase by 0.09kg/ha. However, the marginal effects of transportation cost and regional dummy are -0.01586 and 0.8791, respectively. This implies that a 100 percent increase in transportation cost will reduce inorganic fertilizer use intensity by 15.86kg/ha. The regional dummy marginal effect of 0.8791 suggests that a farmer's inorganic fertilizer use intensity will increase by 0.88 if a farmer moves from the Southern region to the Northern region. There are various explanations for this regional disparity in the use of inorganic fertilizers. One explanation is that the large majority of the farmers in the Northern regions have more access to the inorganic fertilizer subsidy and to inorganic fertilizers than farmers in the Southern regions, hence the higher rate of inorganic fertilizer use in the Northern regions. Appendix 3 indicates that Northern regions used 82 percent and 85 percent of inorganic fertilizers and the inorganic fertilizer subsidy, respectively.

Aside from the fact that the inorganic fertilizer subsidy crowds out the probability and intensity of organic fertilizer use, this study also brings to fore some structural access constraints in stimulating inorganic fertilizer application among Nigerian farmers. Our results demonstrate that an increase in the cost of transporting fertilizers will completely offset the gains in inorganic fertilizer use intensity induced by the fertilizer subsidy. Regional disparity in inorganic fertilizer allocation also has a higher marginal effect in stimulating inorganic fertilizer use intensity than the application of the fertilizer subsidy. This is in consonance with the report of Zoe and Barreiro-Hurle (2012), which reveals that the fertilizer subsidy may not translate to application of more inorganic fertilizer if there are structural, market, credit, and capital constraints that hinder the purchase of that fertilizer.

Table 7: Organic Fertilizer Use Intensity Model (Robust Errors)

Wald Chi^2 = 52.06 Prob > Chi^2 = 0.0000								
	Estimates				**Marginal Effects**			
	Coefficient	**Robust S.E**	**z**	**P>|z|**	**dy/dx**	**S.E**	**z**	**P>|z|**
Subsidy Amount	-0.0002803	0.0000477	-5.88***	0.000	-.0003051	0.000054	-5.66***	0.000
Expenditure	-7.08e-06	3.17e-06	-2.23***	0.026	-6.35e-06	3.21e-06	-1.98**	0.048
Transportation Cost	0.0003128	.0001091	2.87***	0.004	.046394	0.0129053	3.59***	0.000
Kids	0.2444485	0.2446045	1.00	0.318	0.3992985	0.2440378	1.64*	0.102
Gender	-0.2045879	0.2355654	-0.87	0.385	-0.1677572	0.2430932	-0.69	0.490
Region	-3.275488	0.5016247	-6.53***	0.000	-3.009119	0.4559248	-6.60***	0.000
Fertilizer Cost	0.0002141	0.0000359	5.97***	0.000	0.000219	0.000036	6.09***	0.000
Constant	2.669689	0.5418483	4.93***	0.000				
/alpha	0.000229	0.0000445	5.15***	0.000				
/Ins	0.3826304	0.1087666	3.52***	0.000				
/Inv	9.36192	0.0467632	200.20***	0.000				
s	1.466136	0.1594667						
v	11636.71	544.1699						
Wald Test of Exogeneity : Chi^2 = 26.50*** Prob > Chi^2 = 0.0000								

***, ** and * indicate Significance at 1% and 10% respectively
Source: Computed by the Authors

Table 8 : Inorganic Fertilizer Use Intensity Model (Robust Errors)

Wald Chi^2 = 21.22* Prob > Chi^2 = 0.0035**								
Estimates					**Marginal Effects**			
	Coefficient	**Robust S.E**	**z**	**P>|z|**	**dy/dx**	**S.E**	**z**	**P>|z|**
Subsidy Amount	0.0003251	0.0000774	4.20***	0.000	0.0000938	4.23e-06	22.16***	0.000
Expenditure	-5.68e-06	3.87e-06	-1.47	0.142	2.10e-06	9.44e-07	2.23***	0.026
Transportation Cost	-0.0000951	0.0001134	-0.84	0.402	-0.0158608	0.0027349	-5.80***	0.000
Kids	0.0217841	.8127794	0.03	0.979	-0.1315767	0.078071	-1.69*	0.092
Gender	-0.1125111	0.7973408	-0.14	0.888	0.0902864	0.0741726	1.22	0.224
Region	-1.853331	1.276762	-1.45	0.147	0.879122	0.0969552	9.07***	0.000
Fertilizer Cost	-0.0003069	0.0000692	-4.43***	0.000	-0.0000642	4.49e-06	-14.31***	0.000
Constant	5.345489	2.334018	2.29***	0.022				
/alpha	-0.0002627	0.0000679	-3.87***	0.000				
/Ins	2.607022	0.1557483	16.74***	0.000				
/Inv	9.419262	0.0473612	198.88***	0.000				
s	13.55861	2.111731						
v	12323.49	583.6551						
Wald Test of Exogeneity : Chi^2 =14.96*** Prob > Chi2 = 0.0001								

***, ** and * indicate Significance at 1% and 10% respectively
Source: Computed by the Authors

5. Conclusion and Recommendations

The idea of integrated soil fertility management (ISFM) is built around the belief that both inorganic and organic fertilizers should be used together to improve the nutrient availability and absorption capacity of the soil. However, our findings reveal that only 6 percent of Nigerian farmers applied fertilizer of any type. The study shows that organic fertilizers are being used as an alternative to inorganic fertilizers and that farmers who are not able to access Nigeria's inorganic fertilizer subsidy rely on organic fertilizers. The study also reveals that the probability of the small-scale poorest farmers using organic fertilizers is higher than the probability of those farmers using inorganic fertilizers or the fertilizer subsidy.

We demonstrate that if the inorganic fertilizer subsidy amount doubles (increases by 100 percent), organic fertilizer use intensity will decrease by 0.31kg/ha. This will increase inorganic fertilizer use intensity by 0.09kg/ha. However, doubling the fertilizer transportation cost will reduce inorganic fertilizer use intensity by 15.86kg/ha. This indicates that an increase in the cost of transporting fertilizer will completely offset the gains in inorganic fertilizer use intensity induced by the fertilizer subsidy. The estimated regional dummy marginal effect of 0.8791 suggests that a farmer’s inorganic fertilizer use intensity will increase by 0.88 if a farmer moves from the Southern regions to the Northern regions, implying that regional disparity in inorganic fertilizer allocation also has a higher marginal effect in stimulating inorganic fertilizer use intensity than the application of the fertilizer subsidy. In other words, regional realignment in fertilizer allocation can exert a greater impact on inorganic fertilizer use intensity than the fertilizer subsidy scheme. Apart from revealing the crowding-out effect of the fertilizer subsidy on the use of organic fertilizers, our findings also bring to the fore the role of several transportation and regional constraints in stimulating inorganic fertilizer application among the farmers.

It may be a good idea to include organic fertilizers in the fertilizer subsidy scheme, as has been proposed by the Federal Government of Nigeria. However, the transportation constraints to fertilizer access should also be given priority in the fertilizer subsidy scenario, as these constraints may limit the impact of the scheme in stimulating fertilizer application (either inorganic or organic). In addition, farmers should be taught about integrated soil fertilizer management by extension agents and should be encouraged to view inorganic and organic fertilizers as complements instead of substitutes. Appendix 12 reveals that integrated soil fertility management is not among the information currently being disseminated by extension agencies to Nigerian farmers. Finally, application of large quantity of inorganic fertilizer may not be enough to fix the soil nutrient deficiency issues in the Northern regions of Nigeria (Morris et al, 2007). Thus, farmers in the Northern regions should be educated about how to convert their abundant livestock waste into simple organic fertilizers in order to address the region’s degraded land conditions.

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Appendix

Appendix 1A: INFORMATION IN THE QUESTIONNAIRE: POST-PLANTING VISIT.

Section	Topic	Respondent	Description
1	Roster	Household head or spouse	Roster of individuals living in the household, relationship to the household, gender, year of birth, age, marital status, spouse identification, parental status and place of birth.
2	Education	Individuals 5 years and above	Educational attainment, school characteristics and expenditures for 2009-10 academic year.
3	Labour	Individuals 5 years and above	Labour market participation during the last seven days, wage work and domestic activities within the home.
4	Credit and savings	Individuals 15 years and above	Savings made, loans or credit received, insurance and remittances by the household during the last six months and conditions of the transaction.
5	Household assets	Household head	Ownership of assets and value
6	Non-farm enterprises	Owner or manager of enterprise.	Enterprise ownership, status, labor, value of stock, sales, and business costs.
7A	Meals Away from Home	Most Knowledgeable person	Naira value of food consumed outside the home during the last seven days.
7B	Household food Expenditure	Person responsible for food purchases	Quantity and value of food consumed within the household during the last seven days.
8	Household Non-food Expenditures	Person responsible for household purchases	Non-food expenditure during the last week/last month/last six months/last 12 months
9	Food Security	Household head or eligible adult	Food security status of households in during the past 7 days/12 months.
10	Other Income	Household head or eligible adult	Other sources of household income since the new year.
Cover	Cover	To be completed by field staff. Household ID must be copy from Household to Agriculture Questionnaire	This section contains household location and identification data as well as administrative data as regards administering and managing the questionnaire.
11a	Plot Roster	Owner or manager of plot	Information on all post owned and/or managed by the Household. This section includes data on estimated area, GPS measured area and the GPS measured location of the plot.
11b	Land Inventory	Owner or manager of plot	Data on plot acquisition, tenure and use
11c	Input Costs	Owner or manager of plot	Use and cost of pesticide, herbicide, animal labor and use of machinery
11d	Fertilizer acquisition	Owner or manager of plot	Access to, use and cost of seeds used on the plot

11e	Seed acquisition	Owner or manager of plot	Data on source, quantity and costs of seeds used on the plot
11f	Planted field crops	Owner or manager of plot	Data on crops planted on the plot, amount of crops planted and expected harvest
11g	Planted tree crops	Owner or manager of plot	This section collects details on tree crops
11h	Marketing of agricultural Surplus	Owner or manager of plot	Marketing of agricultural Surplus. Quantities Sold, value and information on purchaser
11i	Animal holdings	Farmer or caretaker of animals	Data on farm animals owned by the household and commercial activity with these animals
11j	Animal Costs	Farmer or caretaker of animals	Livestock farmer caretaker activities and costs
11k	Agriculture by-product	Farmer or caretaker of animals	Trading activity in agricultural by-products
11l	Extension	Owner or manager of plot	Access to and utilization of technical support from various sources (government and non-government)
12	Network Roster	Farmer, owner or manager of plot	Roster of places or business where the household sells and purchases agricultural produce and /or supplies

Source: Compiled by the Authors

Appendix 1B: INFORMATION IN THE QUESTIONNAIRE: POST-HARVEST VISIT

Section	**Topic**	**Respondent**	**Description**
A1	Land and Dry Season planting	Farmer, owner or manager of plot	Follow-up on use of land for in post-planting visit and data on any subsequent planting or other use of the plot. Also information collected on new plots (I.e. added since post-planting visit.
A2	Harvest Labor	Farmer, owner or manager of plot	Data on labor that was used for crop harvesting, both from household and hired.
A3	Agricultural production Harvest of field and tree Crops	Farmer, owner or manager of plot	Quantity and value of field crops produced
A4	Agricultural Capital	Farmer, owner or manager of plot	Ownership and value of agricultural machinery and tools owned by the household
A5 (A and B)	Extension services	Farmer, owner or manager of plot	Access to and utilization of technical support from various sources (government and non-government)
A6	Animal Holdings	Owner or caretaker of animals	Data on farm animals owned by the household and commercial activity with these animals
A7	Animal costs	Owner or caretakers of Animals	Expenditure on livestock
A8	Other Agricultural Income	Farmer or caretaker of animals	Income from sale of Agricultural products and not capture, previous section under crops and livestock.
A9 (A and B)	Fishing, Capital and revenue	Owner of fishing operations	SectionA9a: Data on fishing activities, includes capture, harvesting and processing Section9b: Data on boat usage and the use of hired labor
A10	Network Roster	Farmer, owner or manager of plot	Roster of places or businesses where the household sells and purchases agricultural produce and/or supplies

Source: Compiled by the Authors

Appendix 2: Distribution of Number of Farm Plots by Farmers

Farm Plots	Frequency	Percent
1	3816	67.57
2	1271	22.50
3	386	6.84
4	113	2.00
5	32	0.57
6	12	0.21
7	14	0.25
8	2	0.04
9	1	0.02
Total	5647	100.00

Source: Computed by the Authors

Appendix 3: Share of Inorganic Fertilizer Subsidy Among the Farmers by Regions

	Regions	Subsidy Share (%)	Inorganic Share (%)	Organic Share (%)
Northern Regions	North Central	17.40	16.50	4.20
	North East	27.30	23.20	14.00
	North West	40.50	42.50	44.10
	Sub total	**85.20**	**82.20**	**62.30**
Southern Regions	South East	11.10	13.20	28.70
	South South	02.80	3.80	6.30
	South West	0.90	0.80	2.70
	Sub total	**14.80**	**17.80**	**37.70**
	Grand Total	**100.00**	**100.00**	**100.00**

Source: Computed by the Authors

Appendix 4: Probability of Organic Fertilizer Use Model (Normal Standard Errors)

Wald Chi^2 = 1314.39* Prob > Chi^2 = 0.0000**				
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	-0.0000942	2.76e-06	-34.11**	0.000
Expenditure	-1.98e-06	1.46e-06	-1.35	0.176
Transportation Cost	0.015996	0.0012319	12.98***	0.000
Kids	0.1394763	0.0779662	1.79*	0.074
Gender	-0.0805725	0.0746209	-1.08	0.280
Region	-0.8829684	0.0988935	-8.93***	0.000
Fertilizer Price	0.0000644	2.18e-06	29.58***	0.000
Constant	-0.8979317	0.1655379	-5.42***	0.000
/athrho	1.490759	0.1664296	8.96***	0.000
/Insigma	9.283716	0.0191883	483.82***	0.000
Rho	0.9034644	0.0305818		
Sigma	10761.35	206.4915		
Wald Test of Exogeneity: Chi^2 = 80.23*** Prob > Chi2 = 0.0000				

*** and * indicate significance at 1% and 10% respectively
Source: Computed by the Authors

Appendix 5: Probability of Organic Fertilizer Use Model (Two Step Option)

Wald Chi^2 = 61.03* Prob > Chi^2 = 0.0000**				
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	-0.0002198	0.0000358	-6.14***	0.000
Expenditure	-4.62e-06	3.31e-06	-1.40	0.163
Transportation Cost	0.0373163	0.0070642	5.28***	0.000
Kids	0.3253741	0.1752838	1.86*	0.063
Gender	-0.1879642	0.1769467	-1.06	0.288
Region	-2.059825	0.2907506	-7.08***	0.000
Fertilizer Price	0.0001503	0.0000232	6.47***	0.000
Constant	-2.094726	0.3699129	-5.66***	0.000
Wald Test of Exogeneity: Chi^2 = 55.59*** Prob > Chi2 = 0.0000				

*** and * indicate significance at 1% and 10% respectively
Source: Computed by the Authors

Appendix 6: Probability of Inorganic Fertilizer Use Model (Normal Standard Errors)

Wald Chi^2 = 1254.17***		Prob > Chi^2 = 0.0000		
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	0.0000938	2.85e-06	32.95***	0.000
Expenditure	2.10e-06	1.52e-06	1.39	0.166
Transportation Cost	-0.0158608	0.0012532	-12.66***	0.000
Kids	-0.1315767	0.0782163	-1.68*	0.093
Gender	0.0902864	0.0752271	1.20	0.230
Region	0.879122	0.0989075	8.89***	0.000
Fertilizer Price	-0.0000642	2.20e-06	-29.22***	0.000
Constant	0.8898186	0.1657816	5.37***	0.000
/athrho	-1.454321	0.1664166	-8.74***	0.000
/Insigma	9.283716	0.0191882	483.82***	0.000
Rho	-0.896544	0.0326524		
Sigma	10761.35	206.4915		
Wald Test of Exogeneity: Chi^2 = 76.37***		Prob > Chi^2 = 0.0000		

*** and * indicate significance at 1% and 10% respectively
Source: Computed by the Authors

Appendix 7: Probability of Inorganic Fertilizer Use Model (Two Step Option)

Wald Chi^2 = 61.01***		Prob > Chi^2 = 0.0000		
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	0.0002117	0.0000346	6.11***	0.000
Expenditure	4.75e-06	3.32e-06	1.43	0.153
Transportation Cost	-0.0358067	0.0068361	-5.24***	0.000
Kids	-0.2970434	0.1707623	-1.74*	0.082
Gender	0.2038273	0.1727412	1.18	0.238
Region	1.984675	0.2802344	7.08***	0.000
Fertilizer Price	-0.0001449	0.0000225	-6.45***	0.000
Constant	2.008826	0.3589779	5.60***	0.000
Wald Test of Exogeneity: Chi^2 = 54.03***		Prob > Chi^2 = 0.0000		

*** and * indicate significance at 1% and 10% respectively
Source: Computed by the Authors

Appendix 8: Organic Fertilizer Use Intensity Model (Normal Standard Errors)

Wald Chi^2 = 57.94***		**Prob > Chi2 = 0.0000**		
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	-0.0002803	0.0000478	-5.87***	0.000
Expenditure	-7.08e-06	4.86e-06	-1.46	0.145
Transportation Cost	0.0003128	0.0000687	4.55***	0.000
Kids	0.2444485	0.2448968	1.00	0.318
Gender	-.2045879	0.2471807	-0.83	0.408
Region	-3.275488	0.4968816	-6.59***	0.000
Fertilizer Price	0.0002141	0.0000339	6.32***	0.000
Constant	-2.669689	0.5152707	-5.18***	0.000
/alpha	0.000229	0.0000473	4.84***	0.000
/Ins	0.3826304	0.0765199	5.00***	0.000
/Inv	9.36192	0.0191882	487.90***	0.000
s	1.466136	0.1121886		
v	11636.71	223.2879		
Wald Test of Exogeneity: Chi^2 = 23.41*** Prob > Chi^2 = 0.0000				

*** indicates significance at 1%
Source: Computed by the Authors

Appendix 9: Organic Fertilizer Use Intensity Model (Two Step Option)

Wald Chi2 = 57.84***		**Prob > Chi2 = 0.0000**		
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	-0.0002803	0.0000478	-5.86***	0.000
Expenditure	-7.08e-06	4.86e-06	-1.46	0.145
Transportation Cost	0.0003128	0.0000688	4.55***	0.000
Kids	0.2444494	0.2451769	1.00	0.319
Gender	-0.2045855	0.2474485	-0.83	0.408
Region	-3.275468	0.4972256	-6.59***	0.000
Fertilizer Price	0.0002141	0.0000339	6.31***	0.000
Constant	-2.669679	0.5158076	-5.18***	0.000
Wald Test of Exogeneity: Chi^2 = 34.74*** Prob > Chi^2 = 0.0000				

*** indicates significance at 1%
Source: Computed by the Authors

Appendix 10: Inorganic Fertilizer Use Intensity Model (Normal Standard Errors)

Wald Chi^2 = 31.86***		Prob > Chi^2 = 0.0000		
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	0.0003251	0.0001293	2.51***	0.012
Expenditure	-5.68e-06	8.96e-06	-0.63	0.526
Transportation Cost	-0.0000951	0.0001429	-0.67	0.506
Kids	0.0217841	0.7939301	0.03	0.978
Gender	-0.1125111	0.7872509	-0.14	0.886
Region	-1.853331	1.269654	-1.46	0.144
Fertilizer Price	-0.0003069	0.0001089	-2.82***	0.005
Constant	5.345489	1.634455	3.27***	0.001
/alpha	-0.0002627	0.0001309	-2.01***	0.045
/Ins	2.607022	0.019903	130.99***	0.000
/Inv	9.419262	0.019139	492.15***	0.000
s	13.55861	0.2698576		
v	12323.49	235.8589		
Wald Test of Exogeneity: Chi^2 = 4.03*** Prob > Chi^2 = 0.0000				

*** and * indicates significance at 1% and 10% respectively
Source: Computed by the Authors

Appendix 11: Inorganic Fertilizer Use Intensity Model (Two Step Option)

Wald Chi^2 = 31.86***		Prob > Chi^2 = 0.0000		
	Coefficient	**Standard Error**	**z**	**P>|z|**
Subsidy Amount	0.0003251	0.0001293	2.51***	0.012
Expenditure	-5.68e-06	8.97e-06	-0.63	0.526
Transportation Cost	-0.0000951	0.000143	-0.66	0.506
Kids	0.0217854	0.7940524	0.03	0.978
Gender	-0.1125097	0.7873726	-0.14	0.886
Region	-1.853318	1.26985	-1.46	0.144
Fertilizer Price	-0.0003069	0.000109	-2.82***	0.005
Constant	5.345494	1.634706	3.27***	0.001
Wald Test of Exogeneity: Chi^2 = 4.24*** Prob > Chi^2 = 0.0396				

*** indicates significance at 1%
Source: Computed by the Authors

Appendix 12: Types of Extension Advice Given To Farmers in Nigeria

Advice On	**Percentage**
Fertilizer Use	24.87
New Seed Variety	19.17
Pest Control	13.21
Compositing Manure	9.20
Marketing/Sales of Crop	8.81
General Animal Care	8.55
Disease/Vaccination	7.25
Irrigation	3.71
Access to Credit	3.50
Forestry	1.17
Growing/Sales of Tobacco	0.52
Forestry Production	0.52
Others	0.13

Source: Computed by the Authors

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