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Decentralization, Agricultural Services and Determinants of Input Use in Nigeria

Kamiljon T. Akramov

Development Strategy and Governance Division

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AUTHORS

Kamiljon T. Akramov, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division
K.Akramov@CGIAR.org

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Contents

Acknowledgements		v
Abstract		vi
1.	Introduction	1
2.	Background on Decentralization and Agricultural Service Provision in Nigeria	3
3.	Analytical Framework and Empirical Methodology	7
4.	Data and Descriptive Findings	11
5.	Empirical Results	17
6.	Conclusions	20
References		21

List of Tables

1. Allocation of responsibilities for agricultural development across the federal, state and local governments 4

2. Descriptive summary of variables 11

3. Determinants of fertilizer use in Nigeria (Dependent variable = fertilizer use) 17

4. Heterogeneous impact of road access on fertilizer use in Nigeria (state-specific random slopes) 18

List of Figures

1. Share of households that use modern inputs by geopolitical zone 12

2. Share of communities in Nigerian states with at least one agricultural service project in the five years prior to the survey 13

3. Public-sector agricultural service projects and input use in Nigerian states 15

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ABSTRACT

Using a large household survey data, this study examines the impact of government involvement in agricultural service provision on the use of modern inputs by farmers in Nigeria. The empirical methodology used in this study is based on the multilevel (nested) mixed effects estimator and controls for systematic differences and unobserved heterogeneity across sub-national governments. The empirical findings suggest that government involvement in agricultural service provision positively influences the farmers' input use. However, wealthier farmers are more likely than poor farmers to benefit from such services. The likelihood of farmers' input use significantly varies across states and local government areas. Another important finding indicates that the impact of access to all-season roads on input use is heterogeneous across states; it is insignificant in states where the overall likelihood of fertilizer use is relatively high, but becomes significant and positive in states where the overall likelihood of fertilizer use is relatively low.

Keywords: decentralization, agricultural services, input use, Nigeria

1. INTRODUCTION

It is widely recognized that the use of modern inputs, particularly that of improved seeds and fertilizers, is closely linked to higher agricultural productivity and food security (Evanson and Gollin 2003; Crawford et al. 2003; Crawford, Jayne and Kelly 2006). It has been argued that the substantial differences in agricultural productivity and yields seen between Asia and Africa can be largely explained by differences in modern input use (Morris et al. 2007). The evidence suggests that better access to infrastructure (e.g., roads), irrigation, and agricultural services has given Asian farmers significantly better access to modern inputs (Johnson, Hazell, and Gulati 2003; Fan, Gulati, and Thorat 2008). In Sub-Saharan Africa, in contrast, farmers have been faced with inadequate infrastructure and lack of agricultural services, meaning that most of these farmers are unable to exploit the benefits of modern agricultural inputs (Crawford et al. 2003; Howard et al. 2003; Jayne et al. 2003). The need to improve farmers' access to infrastructure and agricultural services in Sub-Saharan Africa is a central challenge facing the region's governments and donors (World Bank 2007). Recent efforts of African governments in this direction have resulted in some important initiatives, including: the Comprehensive African Agricultural Development Programme (CAADP), which calls for 6 percent agricultural growth rates; the Maputo Declaration, which calls for 10 percent of total public spending to be used for agriculture; and the 2006 Abuja Declaration, which calls for a substantial increase in fertilizer use (Ehui and Okike 2007). Some recent success stories have stimulated renewed interest in government involvement in agriculture; one such notable success is that of the fertilizer and seed subsidy program initiated by the government of Malawi, which has been credited for significantly increasing the country's maize production (Denning et al. 2009).

The theoretical rationales for government involvement in agricultural service delivery are largely based on market failure, equity, and public goods considerations (Smith 2002). The absence of adequate institutions and markets in many developing countries makes the government involvement in agricultural service[1] provision almost a necessity (Hoff, Braverman, and Stiglitz 1993; Westlake 1994). In the past, the central governments in Africa have dominated in the provision of agricultural services and inputs. However, the government failures of the 1980s created the need for governance reforms, including decentralization. It is increasingly expected that the decentralization of responsibilities for agricultural service provision from central to sub-national governments will improve farmers' access to necessary services and modern inputs (World Bank 2007). Furthermore, decentralization involves not only the transfer of resources and responsibilities to lower levels of government, but also the transfer of decision-making and resources from the government to civil society and the private sector. This means that governments at both the central and local levels should build an enabling environment for effective decentralization (Smith 2002). Past experiences suggest that the provision of agricultural services (as for any services) can be disaggregated into four components: funding, physical production and delivery, regulation of delivery, and consumption[2]. As Smith (2002) suggests, it is not necessary for all of these components to be provided by the same level of government; some agricultural services can be funded by the central government while being produced and delivered by sub-national governments. At the same time, other services can be funded jointly by different levels of government while being regulated by the central government and provided by sub-national governments or parastatals. Finally, if the government can achieve its objectives through regulating or funding the provision of services, the actual provision could be delegated to community organizations and/or the private sector.

There are expectations that decentralization will ensure greater differentiation, efficiency, and equity in the provision of agricultural services, by bringing decision-making closer to the people. This reflects the belief that sub-national governments will have greater access to local information and will be better informed about the preferences and circumstances of their residents, with the result that the services

[1] Agricultural services include all non-tangible, non-storable items used by farmers to increase agricultural productivity. In this paper, the term "agricultural services" includes regulatory, financial, knowledge and information, research and extension, and input and output marketing services, all of which affect agricultural production.

[2] Ross (1988) uses this disaggregation, and Smith (2002) applies it to agricultural services.

provided by these sub-national governments will be better matched to the preferences of the local populace (World Bank 2007). However, the benefits of decentralization cannot be as clear as its proponents suggest. One potential risk is that decentralization may increase inter-jurisdictional disparities due to differences in the socioeconomic potentials and expenditure needs of various local governments (Prud'homme 1995). Other risks include possible inadequacies in the capacities of local governments, and the possibility of elite capture of local governments (Bardhan and Mookherjee 2006).

The recently renewed interest in government intervention in agriculture is important to Sub-Saharan Africa, where many governments have historically been involved in the provision of subsidized inputs and agricultural services to farmers. This past experience may help countries select appropriate mixes of policy instruments. In this regard, Nigeria, with its decentralized framework of agricultural service provision, provides an interesting example. There are three tiers of government in Nigeria, namely the federal, state, and local governments. These three levels of government share the authority and responsibility for the provision of agricultural services. The federal government is mainly responsible for regulating and funding agricultural research and development activities. It also provides subsidized inputs (fertilizer) and credit, and shares the responsibility for some agricultural services with the state governments. The state governments share the costs of agricultural subsidies with the federal government, and some of them provide additional fertilizer subsidies. The states are also responsible for providing agricultural extension and knowledge dissemination services. Finally, the local governments are mainly responsible for the actual delivery of various agricultural services, including subsidized fertilizer. Although the federal government provides subsidized credit, the state and local governments can also play important roles in channeling these resources to their constituencies (FMARD 2001).

This decentralized framework could conceivably give rise to varying institutional and policy environments, and different approaches to rural and agricultural service provision across states and local government areas (LGAs). As a result, farming households in different jurisdictions may face differences in agricultural service access and the incentive structures concerning modern input use. However, there are not clear, evidence-based answers to important questions, such as: Is there variations in access to services across states? How do these differences impact farmers' input use? Is there a relationship between agricultural service access and the use of modern inputs (fertilizer)? Do publicly funded agricultural services and input subsidies reach wealthy and poor farm households equally? Answering these and other related questions is critical for Nigeria, where policy-makers (with donor support) are currently promoting decentralization as a key governance reform capable of improving access to agricultural service and modern input use.

This paper explores the relationship between agricultural service provision and modern input use by farmers in Nigeria, with a focus on the differences among sub-national jurisdictions (states and LGAs). The discussion is organized around the possible role of decentralization in improving farmers' access to agricultural service and input use. The results indicate that there are differences in the use of agricultural services and inputs across the sub-national jurisdictions. A multilevel mixed effects logistic regression framework is used to examine the determinants of input use at the household level, while controlling for community characteristics and differences across sub-national jurisdictions. This inquiry is based on data from the 2006 Core Welfare Indicators Questionnaire Survey, which provides information on agricultural services and input use and is representative at both the national and sub-national (state) levels. The remainder of the paper is organized as follows: The next section provides a background on the institutional arrangements for agricultural service delivery in Nigeria. Section 3 discusses the analytical framework and empirical model specifications. Section 4 describes the data and provides some descriptive findings. Section 5 reports the empirical results, and Section 6 offers some conclusions.

2. BACKGROUND ON DECENTRALIZATION AND AGRICULTURAL SERVICE PROVISION IN NIGERIA

The issues surrounding decentralized agricultural service provision are particularly important for Nigeria. The country has a federal structure with three tiers of government: the federal government (first tier), 36 state and Federal Capital Territory (FCT) governments (second tier), and 774 local governments (third tier). The states are grouped into six geopolitical zones, including Northeast, Northwest, North Central, Southeast, Southwest, and South zones3. The existing fiscal decentralization arrangements4 among the three tiers of government in Nigeria are based on fiscal federalism principles, and are outlined in the second and fourth schedules of the 1999 constitution5. Based on the constitutional guidelines, various legal and policy documents lay out the specific policy and expenditure responsibilities of the different government tiers6. The constitution establishes that most federally raised revenues must flow to the federation account, from which they are then allocated (by formula) among the federal, state and local governments. The major concern regarding Nigeria's decentralization is the potential for a vertical fiscal imbalance, i.e., a mismatch of the revenue bases and expenditure needs of the state and local governments. Although the federal government collects more than 90 percent of the country's total government revenues, the state and local governments are responsible for more than 45 percent of total government expenditures. Hence, sub-national expenditures are largely financed with federal transfers7. This heavy dependence on federal transfers may lead to poor accountability, with sub-national governments potentially shifting the blame for poor service delivery to the federal government.

There are two types of revenue allocation in Nigeria: vertical allocation, which is the sharing of revenues among the three tiers of government; and horizontal allocation, which is the allocation of revenues among sub-national governments. According to the current vertical allocation formula, 55 percent of the total budget revenue is allocated to the federal government, 25 percent to the state governments, and 21 percent to the LGAs (Ekpo 2004). Funds allocated to the state and local governments are then distributed across the sub-national governments using a special formula that is based on five components: equality (40 percent); need, as defined by the population size (30 percent); land area (10 percent); social development factors (10 percent); and internal revenue generation efforts (10 percent). A critical element of Nigeria's fiscal arrangement is the principle of derivation (first charges), which allocates 13 percent of the oil revenues generated in each oil-producing state back to that state (Ekpo 2004; Ekpo and Englawa 2007).

According to the constitution, the responsibilities for providing rural infrastructure and agricultural services in Nigeria are shared among the three government tiers. At the federal level, the key institutions responsible for agriculture are the Federal Ministry of Agriculture and Water Resources (FMAWR), and the various agencies and parastatals gathered under the FMAWR. At the state level, the key institutions for agricultural development are the State Ministries of Agriculture (SMoAs) and the Agricultural Development Projects (ADPs), which form the implementing arms of the SMoAs. In some

[3] Nigeria's 36 states and FCT are grouped into six geopolitical zones as follows: Northeast— Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe; Northwest—Kaduna, Katsina, Kano, Kebbi, Sokoto, Jigawa, and Zamfara; North-central—Benue, FCT, Kogi, Kwara, Nasarawa, Niger, and Plateau; Southeast—Abia, Anambra, Ebonyi, Enugu, and Imo; Southwest—Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo; South—Akwa Ibom, Bayelsa, Cross-River, Delta, Edo, and Rivers.

[4] For a more detailed discussion of the political, economic and fiscal arrangements of decentralization in Nigeria, see Ekpo (1994; 2004) and Eboh, Amakom, and Oduh (2006).

[5] The evolution of the fiscal relationships among the different levels of government in Nigeria has been influenced by principles of fiscal federalism, oil revenues, and the centripetal forces of military governments.

[6] For more detailed discussions of the specific responsibilities of the three tiers of government in Nigeria, see Eboh, Amakom, and Oduh (2006).

[7] For example, in 2006, federal transfers accounted for 64 percent of the total revenue across all states. In fact, the internal revenues of most states cover less than 10 percent of their expenditures. Local governments rely even more heavily on federal transfers; in 2006, about 83 percent of local government revenues came from the Federation account.

states, the ADPs have a state-wide legal mandate as the Agricultural and Rural Development Authority (ARDA). At the local level, the key institutions are the local government councils and administrations.

The Nigerian Agricultural Policy (NAP) thrust, which was adopted in 2001 and revised thereafter, identified the specific agricultural development-related responsibilities of the different tiers of government. Overall, the federal government is responsible, either directly or indirectly (via fiscal transfers), for funding the provision of certain agricultural services. The state and local governments also have funding responsibilities for some services (e.g., extension). All three levels of government, along with the parastatals and some private companies, participate in the physical production and delivery of agricultural services. The specific responsibilities of the various levels of government are detailed in Table 1. According to NAP, the responsibilities of the federal government include: the provision of a stable and consistent policy environment; research and development for agricultural technologies; and direct interventions in areas considered to be of national importance. However, the responsibilities for some specific agricultural services have been decentralized to autonomous agencies and public corporations. For example, the agricultural research services have been decentralized to the National Agricultural Research Institutes network, which includes 15 agricultural research institutes distributed by agro-ecological zones and various enterprise development patterns. Similarly, the management of irrigation infrastructure has been decentralized through the River Basin Development Authorities network (FMARD 2001).

Table 1. Allocation of responsibilities for agricultural development across the federal, state and local governments

Level of Government		Responsibility
Federal	(i)	Ensure stable macroeconomic and trade policy environments and the flow of resources for agriculture and the rural economy
	(ii)	Support rural infrastructure development in collaboration with state and local governments
	(iii)	Support research and development for technologies aimed at agriculture
	(iv)	Provide support for the input supply, including the provision of improved seeds and quality control
	(v)	Support agricultural extension services
	(vi)	Manage and supervise large dams and irrigation infrastructure
	(vii)	Control of pests and diseases of national and international significance
	(viii)	Promote rural financial institutions and agricultural insurance
	(ix)	Support agricultural land management and control of land use
	(x)	Support training and manpower development
	(xi)	Participate in the mapping and development of interstate cattle grazing and watering routes
	(xii)	Promote agricultural commodity marketing institutions
	(xiii)	Maintain fishing terminals and other fisheries infrastructure
	(xiv)	Periodically review agreements on international agricultural trade
	(xv)	Coordinate agricultural data and information management systems
State	(i)	Provide effective agricultural extension services
	(ii)	Promote the production of inputs for crops, livestock, fish and forestry
	(iii)	Ensure land access for all those wishing to engage in farming
	(iv)	Develop and manage irrigation facilities and dams
	(v)	Develop pastures and create water access for livestock
	(vi)	Train and develop manpower
	(vii)	Promote the control of plant and animal pests/diseases
	(viii)	Promote rural financial services for smallholder farmers
	(ix)	Invest in rural infrastructure, including rural roads and water supplies, in collaboration with federal and local governments
	(x)	Manage and control forest estates held in trust for local communities

Table 1. Continued

Level of Government	Responsibility	
Local	(i)	Provide effective extension services
	(ii)	Provide rural infrastructure in collaboration with the federal and state governments
	(iii)	Manage irrigation infrastructure
	(iv)	Promote cooperatives and local community institutions
	(v)	Provide land for new entrants into farming, in accordance with the provisions of the Land Use Act
	(vi)	Coordinate data collection at the primary levels

Source: FMARD (2001).

The rest of this section summarizes the arrangements for the provision of three agricultural services in Nigeria: input supply, agricultural extension, and credit. As seen in Table 1, NAP determines the roles and responsibilities for the federal government, state governments, local governments, and the private sector in the supply and distribution of agricultural inputs (fertilizers, seeds, seedlings, fingerlings, etc.) to farmers. However, NAP's proposals concerning the roles and responsibilities of the various tiers of government have been inconsistent and at times contradictory. Historically, the promotion of agricultural input supply in Nigeria has focused on large-scale fertilizer distribution programs. Although these programs have been scaled back substantially since the mid-1990s due to budgetary pressure (Crawford, Jayne and Kelly 2006), fertilizer-related expenditures account for about 42 percent of federal-level agricultural expenditures in Nigeria (Mogues et al. 2008). Currently, the federal government of Nigeria distributes rather limited amounts of fertilizer to farmers with a 25 percent subsidy that is jointly financed by the federal and state governments. In addition to this federal-state subsidy of 25 percent, some state governments also provide fertilizer subsidies ranging up to 41 percent. The subsidized fertilizer program works as follows: The federal government purchases the fertilizer and then transfers it to the states. A state fertilizer allocation committee then distributes the fertilizer to local government areas; local government fertilizer allocation committees allocate the fertilizer to the wards; and ward committees distribute it to farmers (Mogues et al. 2008).

The main channel for disseminating knowledge and new agricultural technologies involves the public extension services of FMAWR, ADPs/ADRAs, and local governments. The ADPs, which were launched in the 1970s by the federal government, were funded with World Bank loans as part of an integrated rural development package (Oladele 2004). Based on a decision of the National Agricultural Council of Nigeria, all states agreed to unify their public extension services under ADPs/ADRAs. For the purpose of extension service provision, an ADP/ADRA divides the state into various cells, each of which is headed by an extension agent. The extension agent reports to a supervisor, who supervises a group of cells and reports to an extension officer of the local government. The extension officer reports to the state director of extension services (Mogues et al. 2008). Within this framework, an extension agent is backed by an appropriate extension supervisor and various subject-matter specialists, and is intended to be the farmers' principal contact for the dissemination of agricultural knowledge and technology. However, poor linkages between the federal and state agricultural institutions, insufficient numbers of trained staff members, and inadequate logistical support have limited the establishment of efficient unified extension services (ADF 2005). Although the ADPs are state-level institutions, they rely heavily on federal and (especially) external funds. Thus, the withdrawal of World Bank funding in 1990s had a significant negative impact on the funding and delivery of extension services in Nigeria (Oladele 2004).

Concerning rural credit in Nigeria, although the federal and state governments technically share the responsibilities for promoting agricultural financial services, only the federal government has institutions that promote such services. Three federal channels exist to promote the flow of credit

resources into the agricultural sector. Two of them are administered by the Central Bank of Nigeria: The first, the Agricultural Credit Guarantee Scheme Fund (ACGSF), was established in 1978 by the Federal Ministry of Finance (60 percent of equity) and the Central Bank of Nigeria (40 percent), and guarantees loans made by commercial banks to farmers[8]. The second, the Agricultural Credit Support Scheme (ACSS), is a joint initiative of the federal government and the Central Bank of Nigeria, and provides interest rate subsidies to farmers[9]. The third institution that provides credit to the agricultural sector is the Nigerian Agricultural Cooperative and Rural Development Bank (NACRDB), a public development finance corporation owned by the Federal Ministry of Finance (60 percent) and the Central Bank of Nigeria (40 percent). The NACRDB provides credit to farmers, agribusinesses, and other agricultural producers. It also provides equity financing, guarantees for agricultural ventures, and rural savings services (Mogues et al. 2008). The sub-national governments are expected to indirectly participate in the promotion of credit to farmers by interacting with the federal government agencies, spreading knowledge about existing schemes, and organizing the farmers into groups. Thus, an active sub-national government can positively influence farmers' access to credit. In fact, there is significant variation in credit access across sub-national jurisdictions in Nigeria[10] (for more detail, see Section 3).

As can be seen in this brief overview, the existing institutional arrangements in Nigeria assign the sub-national governments significant responsibilities in agricultural service provision. However, the reality may differ from the design, given that there may be tradeoffs between socio-economic potential and the capacity and/or performance of a given sub-national government. These factors, together with variations in the horizontal allocation of federal funds, might lead to between-state or -LGA variations in service delivery. As a result, farming households that have similar backgrounds and attributes might have significantly different likelihoods of input use.

[8] In addition, this scheme includes three innovative mechanisms: Self-Help Group Linkage Banking encourages group lending; the Trust Fund Model enhances the credit supply to agriculture by attracting resources from state governments, local governments, oil companies, and national government organizations (NGOs); and the Interest Drawback Program reduces the effective borrowing rate for farmers.

[9] At the commencement of project support, banks grant loans to qualified applicants at a 14 percent interest rate. Applicants who paid back their loans on schedule receive a rebate of 6 percent, thereby reducing the farmers' effective rate of interest to 8 percent.

[10] Overall, the ratio of agricultural credit to agricultural GDP remains at very low levels (4-6 percent). This suggests that very few Nigerian farmers have access to credit.

3. ANALYTICAL FRAMEWORK AND EMPIRICAL METHODOLOGY

The present analysis of the relationship between decentralized agricultural service provision and modern input (fertilizer) use by farmers in Nigeria draws from existing theoretical models in which farm households maximize their utility derived from net revenue, which is affected by the transaction costs of input use (Jayne et al. 2003; Winter-Nelson and Temu 2005). These models assume that, in developing countries, imperfect markets, inadequate institutions, and credit constraints may lead to higher transaction costs. The model implies that farmers' decisions to use a given input are affected by input price, variable transaction costs, and fixed transaction costs. The relative magnitudes of these transaction costs depend on the farmers' accesses to infrastructure (roads) and agricultural services. For example, subsidized input supply services, if appropriately targeted, can help increase input use among poor farmers, while agricultural extension services might positively influence input use by improving the farmers' knowledge of the benefits of modern inputs. Similarly, access to all-season roads can reduce farmers' travel costs, thereby positively influencing input use. Furthermore, access to credit is likely to ease the farmers' financial constraints, consequently increasing input use (World Bank 2007). However, in Nigeria, as in many other developing countries, many farmers lack access to such important services due to inadequate institutions and imperfect markets. This makes the government involvement in the provision of such services desirable (Hoff, Braverman, and Stiglitz 1993; Westlake 1994), as the government can improve input use by fixing market failures and reducing the transaction costs associated with input use (Kelly 2006; Gregory and Bumb 2006; Morris et al. 2007).

The actual impact of government involvement in agricultural service provision depends on the effectiveness of the institutional arrangements for the provision of such services. In this regard, decentralization can have important implications. By bringing decision-making closer to the people, decentralization may ensure greater differentiation, efficiency and equity in the provision of agricultural services. This could happen if the sub-national governments have greater access to local information regarding the preferences and needs of their residents (World Bank 2007). At the same time, however, decentralization may engender different enabling environments across sub-national jurisdictions, due to differences in the socio-economic potential and capacity of each sub-national government. These variations across the sub-national governments' potentials and capacities are likely to have important implications for agricultural service provision and input use.

Household-level analyses of modern input use in developing countries, which must address the circumstances mentioned above, often employ one of three approaches. Some authors use binary response (often, probit or logit) models to explain whether or not farmers use a given input without analyzing their intensity of use (e.g., Kaliba Verkuijl, and Mwangi 2000). Others use a tobit model, which assumes that the same factors determine both decisions (e.g., Nkonya, Schroeder, and Norman 1997). Finally, a third group of studies make use of a two-stage approach, which assumes that decisions on input use and intensity of use are affected by different underlying processes (e.g., Winter-Nelson and Temu 2005).

The available data on farm households in Nigeria only allow us to explore whether or not the farmers use modern inputs. Thus, the dependent variable can be categorized simply as "input use" or "no input use." The main goal here is to explain the likelihood of farm households in Nigeria using modern inputs such as fertilizer. Let Y_i be a binary random variable representing the input use by a given farm household. A natural model to consider here is a binary response model with either a probit or a logit link function11. Here, a binary response model with a logit link function is specified. The standard logit model estimates the expectation (mean) of modern input use as a function of various determinants, including the availability of agricultural service provision (by both the government and the private sector) in the community, infrastructure (roads), household characteristics, and other controls (e.g., agro-ecological factors). The empirical model may be specified as follows:

[11] As conventional wisdom states that in most cases these two models provide very similar substantive conclusions (Cameron and Trivedi 2005), the choice of the link function is largely a matter of taste. However, in the presence of extreme independent variable levels, the logit link seems to provide a better fit (Hahn and Soyer 2007).

$$Prob(Y_{ijkh} = 1) = \alpha + \beta_h HH_{ijkh} + \beta_g GASP_{ijk} + \beta_p PASP_{ijk} + \beta_r RD_{ijk} + \varepsilon_{ijkh} \quad (1)$$

where

- Y_{ijkh} is a binary variable for the input use for household i, which is nested in community j, local government area k, and state h;
- HH_{ijkh} is a matrix containing household characteristics;
- $GASP_{ijk}$, $PASP_{ijk}$, and RD_{ijk} are measured at the community level; $GASP_{ijk}$ and $PASP_{ijk}$ show whether a given community received at least one agricultural service project during the five years prior to the survey, provided by public and private sources, respectively, while RD_{ijk} shows whether a given community has access to all-season roads; and
- ε_{ijkh} is an error term that has a logistic distribution.

The standard logistic regression model usually assumes that the residuals, ε_{ijkh}, have a zero mean with a variance of $\pi^2/3$ and are mutually independent. However, this appears unlikely if the differences in the socio-economic potentials and capacities of the sub-national governments on the one hand, and the importance of such governments in agricultural service provision on the other. In a hierarchical structure where units (households) are nested in clusters (local governments) and clusters are nested in superclusters (states), one would expect that errors within the same state would be correlated, and that errors within the same LGA would be even more highly correlated. This violates the basic assumptions of the standard logistic regression, with the result that the (omitted) state and local government effects will lead to biased estimates, and the estimated standard errors of the regression coefficients will not be valid.

Therefore, this type of data structure requires the use of a multilevel regression framework, in which a nested random effects estimator is used to explicitly model the dependence in the error term (Rabe-Hasketh and Skrondal 2004; Rabe-Hasketh, Skrondal, and Pickles 2005). This method decomposes the error term into error components. Here, the error term in equation (1), ε_{ijkh}, is assumed to have three components:

$$\varepsilon_{ijkh} = \nu_h + \eta_{kh} + \xi_{ijkh} \quad (2)$$

where ν_h represents the state effects, η_{kh} stands for the LGA effects, and ξ_{ijkh} is a mutually independent error term that has a logistic distribution with a variance of $\pi^2/3$. The error component for state effects (which is invariant across all farm households within a given state) can be considered to be the combined effect of the omitted covariates and/or the unobserved heterogeneity at the state level. Similarly, the error component for LGA effects (which is invariant across all farm households within a given LGA) can be considered to be the combined effect of the omitted variables and/or the unobserved heterogeneity at the local-government level within a given state. Theoretically, the error terms, ε_{ijkh}, may have one additional component for community effects. However, the present work assumes that community-level differences are controlled for by the three community-level variables included in equation (1).

Inserting equation (2) into equation (1) yields the following specification for a three-level mixed effects logistic regression model for input use by farm household i, which is nested in local government area k within state h:

$$Prob(Y_{ijkh} = 1) = \alpha + \beta_h HH_{ijkh} + \beta_g GASP_{ijk} + \beta_p PASP_{ijk} + \beta_r RD_{ijk} + \nu_h + \eta_{kh} + \xi_{ijkh} \quad (3)$$

This is a generalized mixed-model specification with both fixed effects (regression coefficients for household- and community-level covariates) and random effects. The random effects in equation (3) include η_{kh} and ν_h, which represent deviations of local-government specific (level 2) and state-specific (level 3) random intercepts from the mean intercept α, respectively. Thus, equation (3) estimates the impact of access to all-season road and public- and private-sector agricultural service provision on the

farmers' modern input use, while controlling for household characteristics and LGA- and state-specific latent effects.

The estimates derived using equation (3), which are presented below in Section 5, suggest that access to all-season roads has an insignificant impact on input (fertilizer) use. One hypothesis that could account for this finding is that the effect of all-season road access on input use may be heterogeneous and therefore varies across states. This hypothesis can be tested by specifying a random coefficient (slope) for all-season road access at the state level, as follows:

$$Prob(Y_{ijkh} = 1) = \alpha + \beta_h HH_{ijkh} + \beta_g GASP_{ijk} + \beta_p PASP_{ijk} + (\beta_r + \lambda_h)RD_{ijk} + \nu_h + \eta_{kh} + \xi_{ijkh} \quad (4)$$

Here, λ_h is the deviation of state h's slope from the mean slope β_r of the all-season road access variable. The parameters of equations (3) and (4) can be estimated using the nested random effects estimator proposed by Rabe-Hasketh and Skrondal (2005). The results of the econometric estimations are provided in Section 5. As a prelude to this econometric estimation, the next section describes the basic features of the data and discusses some descriptive findings.

4. DATA AND DESCRIPTIVE FINDINGS

The data for this empirical inquiry come from the 2006 Core Welfare Indicators Questionnaire (CWIQ) survey conducted by the National Bureau of Statistics of Nigeria (NBSN 2006). The survey, which was framed with help from the World Bank, used LGAs as the reporting domains. In general, a two-stage cluster sample design was adopted in each LGA: first, enumeration areas were selected; and then 10 household units were randomly selected from each enumeration area. The survey is representative at the national and state levels; it covers more than 75,000 households and 7,700 communities in all LGAs and states of Nigeria, and includes data on the demographic and socioeconomic attributes of the surveyed households, as well as their access to and use of various social and economic services. The survey further includes information on agricultural input use and the sources of these inputs, along with community-level information on various social and economic projects. The survey design allows indirect assessment of the efficiency of agricultural service provision by the public sector. For the present study non-agricultural households were excluded, resulting in a sample size of 53,694 households nested within 774 LGAs and 37 states (including the FCT). The definitions and descriptive summaries of the variables used in this analysis are provided in Table 2.

Table 2. Descriptive summary of variables

Variable	Mean	Standard deviation	Number of observations
Dependent variable			
Fertilizer use (1 if farmer uses chemical fertilizer, 0 otherwise)	42.8	49.5	56643
Independent variables			
Community-level			
Has access to all-season roads (1 if yes, 0 otherwise)	0.54	0.50	7489
Had at least one agricultural service project in the prior five years			
Public (GASP = 1 if yes, 0 otherwise)	0.21	0.40	7497
Private (PASP = 1 if yes, 0 otherwise)	0.40	0.49	7497
Household characteristics			
Household size (number of people in the household)	5.3	2.9	56643
Marital status of household head (1 if married, 0 otherwise)	0.84	0.37	56641
Household head's gender (1 if male, 0 otherwise)	0.90	0.30	56643
Age of the household head, years	48.2	15.3	56643
Household head's education (1 if at least primary school, 0	0.43	0.49	55777
otherwise)	0.08		
Household member is government employee (1 if yes, 0 otherwise)		0.28	56643
Income quintiles			
First	0.26	0.44	56643
Second	0.22	0.41	56643
Third	0.20	0.40	56643
Fourth	0.17	0.38	56643
Fifth	0.15	0.36	56643
Agriculture is main activity (1 if yes, 0 otherwise)	0.57	0.49	56643
Land holdings (hectares)	3.7	6.8	56643
Of land holdings, amount owned (hectares)	3.3	6.5	56643
Access to agricultural services			
Credit access (1 if yes, 0 otherwise)	0.18	0.39	55502
Agricultural extension (1 if yes, 0 otherwise)	0.013	0.11	56643

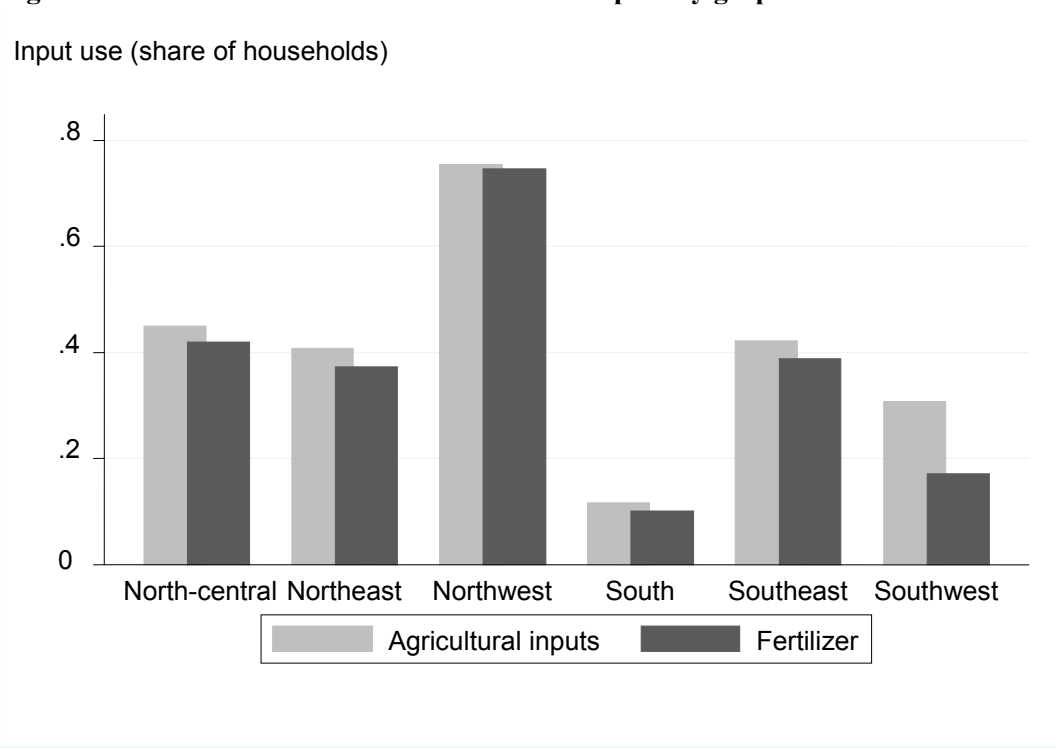
Table 2. Continued

Variable	Mean	Standard deviation	Number of observations
Agro-ecological zone			
Sudan savanna (1 if yes, 0 otherwise)	0.43	0.49	56643
Guinea savanna (1 if yes, 0 otherwise)	0.12	0.33	56643
Derived savanna (1 if yes, 0 otherwise	0.18	0.39	56643
Rainforest (1 if yes, 0 otherwise)	0.27	0.44	56643

Source: NBSN (2006).
Note: The means for the binary variables show the share of positive responses.

The data suggest that only 46.4 percent of all farm households in Nigeria use modern agricultural inputs such as improved seeds, chemical fertilizers and pesticides. Most of the input-utilizing farm households use chemical fertilizers (42.8 percent of all farmers), while only a few farm households use improved seeds (7 percent) or pesticides (10.5 percent). The majority (87.5 percent) of the farmers that use modern agricultural inputs buy them in the open market, while the remainder purchase their inputs through the public sector. Significant variations in modern input use are seen across the various sub-national regions. For example, about 80 percent of all farm households in the Northwest zone use modern inputs, while only 16 percent in the South zone use such inputs (Figure 1).

Figure 1. Share of households that use modern inputs by geopolitical zone



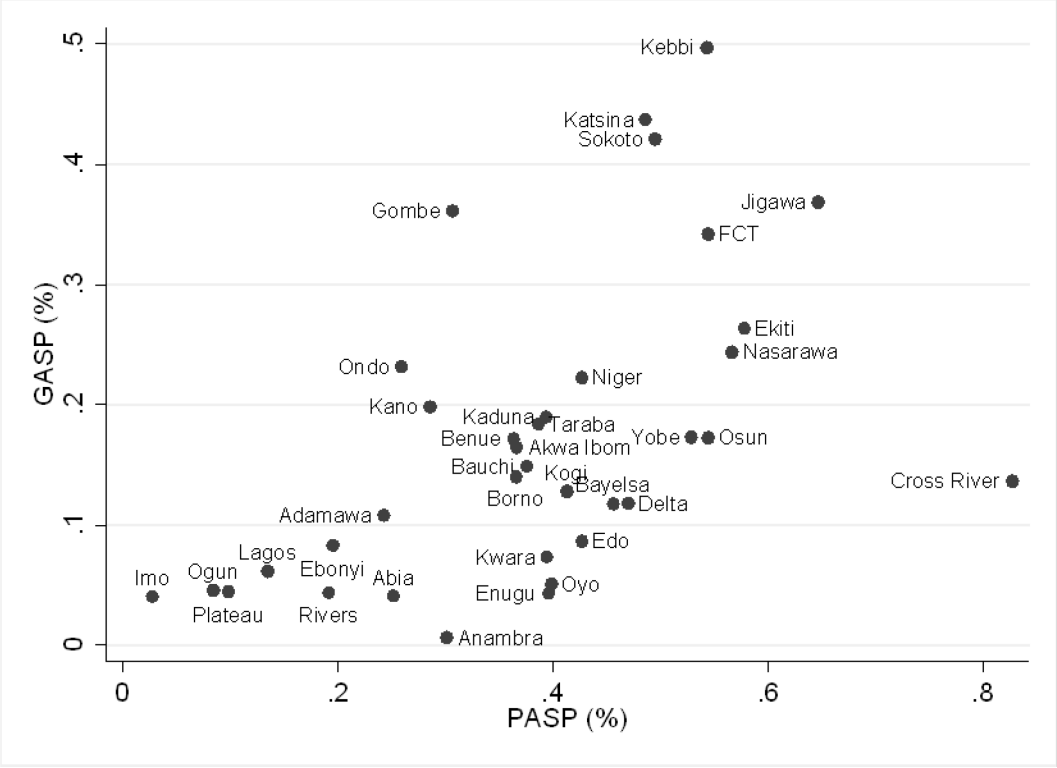
Source: Author's calculations based on NBSN (2006)
Note: Agricultural inputs include fertilizer, improved seeds, and pesticides. For definitions of geopolitical zones see page 6.

Two key independent community-level variables measure whether a given community received an agricultural service project during the five years prior to the survey; these projects were divided into those provided by the public (GASP) and private (PASP) sectors. The survey results suggest that the

public sector (which includes all government levels and donors) mainly funds projects that provide subsidized inputs to credit and extension services, whereas the private-sector projects mainly focus on agricultural input and output markets. The data show that approximately 42 percent of the surveyed communities received at least one agricultural service project over the five-year period prior to the survey. About 45 percent of the surveyed farm households reside within a community that received at least one agricultural service project. The breakdown by service providers reveals that only 18.8 percent of the surveyed communities (encompassing 21 percent of the surveyed households) received agricultural service projects provided by the public sector, while about 38 percent (encompassing 40 percent of the surveyed households) received such projects provided by the private sector.

When considering the allocation of agricultural service projects across states, the data show significant variations (coefficient of variation = 0.42). For example, only 7 percent of the surveyed communities in Imo state received at least one agricultural service project, while more than 70 percent of the communities in Kebbi state received such projects[12]. There is a considerable correlation (0.56) between the provision of public- and private-sector agricultural service projects across states (Figure 2), but this correlation is considerably lower (0.34) when measured at the community level. Substantial correlation (0.57) is seen between public agricultural service provision and input use at the state level. Figure 3 shows that states with higher public agricultural service provision are more likely to have higher rates of input use. This correlation, however, becomes substantially smaller (0.17) when measured at the household level. Overall, all other factors being equal, farmers who live in communities that received agricultural service projects are more likely to use modern inputs.

Figure 2. Share of communities in Nigerian states with at least one agricultural service project in the five years prior to the survey



Source: Author's computations using data from the CWIQ survey (NBSN 2006).
Note: Y (or X) axis represents the share of communities that received at least one agricultural service projects provided by the public (or private) sector.

[12] In this regard, Zamfara state, where more than 90 percent of communities received at least one agricultural service project, appears to be an absolute outlier.

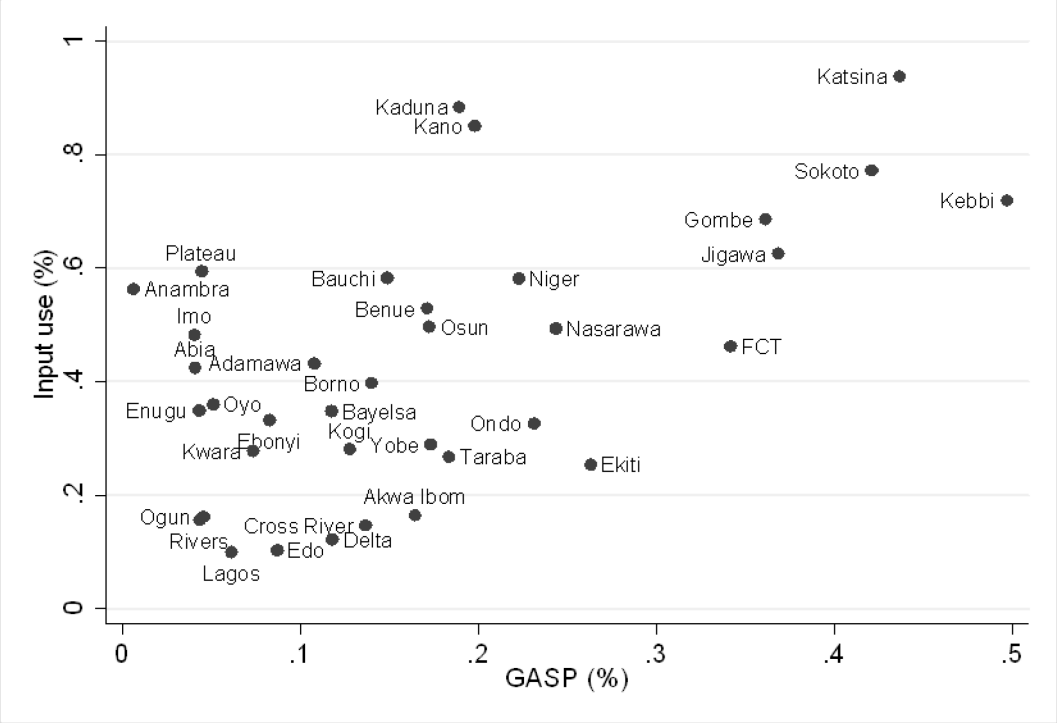
Access to all-season roads is another important community-level independent variable, and it is expected to correlate positively with input use. The data suggest that about 54 percent of the surveyed communities have access to all-season roads. However, the simple descriptive analysis shows no significant correlation between access to all-season roads and agricultural service provision. For example, the pairwise correlation between access to all-season roads (RD) and agricultural service projects provided by public sector (GASP) is equal to 0.09.

The HH_{ijkh} matrix includes important household attributes, such as the use of agricultural extension and credit. The data indicate that very few farmers (1.3 percent) in Nigeria use extension services13. This is very low compared to the rates found in many other countries in the region, and seems to support the idea that the withdrawal of World Bank loans has negatively impacted the performance of agricultural extension in Nigeria (Oladele 2004). About 18 percent of the sampled farm households report using credit facilities. However, only 6.8 percent of them use formal or semi-formal credit facilities (e.g., banks, microfinance institutions, and credit cooperatives), while 11.2 percent use informal credit facilities, such as esusu14. The descriptive analysis shows that there is considerable variation in access to credit across the geopolitical zones and states of Nigeria. The highest level of credit use is seen in the Southwest (28 percent) and North-central (26 percent) zones, while the Northeast (9 percent) zone has the lowest level of credit use by agricultural households. The ceteris paribus effects of these variables on input use are expected to be positive based on previous research (World Bank 2007). However, in the present study, the simple descriptive analysis shows no significant correlation between the use of credit/extension services and modern inputs in Nigeria. Also, no significant correlation is seen between these household-level variables and the community-level variables discussed above.

[13] This is the share of surveyed farmers who report using an agricultural extension service.

[14] These are unorganized and unregulated, in contrast to the legalized financial institutions found in Nigeria. Informal credit facilities bring together a number of people (~ 200) to help one another financially. These organizations have different names in various parts of the country. For example, they are called "esusu" in Yoruba and "etibe" in Ibibio (Iganiga and Asemota 2008). Similar institutions are found in other Sub-Saharan African countries, such as the "iddirs*"* of Ethiopia, the "susu" or "olu" in Ghana, the "upatu" or "mchezo" in Tanzania, and the chilemba or chiperegani in Malawi (Steel et al. 1997).

Figure 3. Public-sector agricultural service projects and input use in Nigerian states



Source: Author's computations using data from the CWIQ survey (NBSN 2006).
Notes: Y axis represents the share of households in a given state that use modern input. X axis represents the share of households in a given state that received at least one agricultural service project provided by the public sector.

Based on previous studies regarding input use (Reardon et al. 1999; Minot, Kherallah, and Berry 2000; Winter-Nelson and Temu 2005; etc.), the following household attributes are also included in HH_{ijkh} : household size; income quintile; landholding size; the age, gender, marital status, and education of the household head; whether agriculture is the main activity of the household head; and whether any household member is a civil servant. As Table 2 shows, the average size of the operational land holdings for the sampled households is 3.7 hectares, while the average size of privately owned land holdings is 3.3 hectares. The data show that land distribution in Nigeria is highly skewed. About 25 percent of the sampled households cultivate less than 0.5 hectares of land, and their share in the total cultivated area is less than 2 percent. At the other extreme, only 6.2 percent of the sampled households cultivate more than 10 hectares, but these households control almost 40 percent of the total operational land. Given such a skewed distribution of land holdings, the relationship between land holding size and input use cannot possibly be linear. It has long been recognized that misspecification of the nonlinearity in a relationship not only leads to inconsistent and vague parameter estimates, it can also severely bias such estimates. Thus, the land holding size is transformed into logs[15]. The descriptive analysis also reveals that nearly half of the sampled households belong to the first and second income quintiles; only 43 percent of the household heads had completed at least primary school; and about 90 percent of the sampled households are male headed. Holding all other factors constant, landholding size, income, and the education level of the household head are expected to positively impact modern input use.

With respect to agro-ecological conditions, the incentives for modern input use are expected to be higher for certain soil, rainfall and crop combinations (because some of these combinations will respond better to modern inputs). This study differentiates among four agro-ecological zones in Nigeria, namely Sudan savannah, Guinea savannah, Derived savanna, and Rainforest. Ideally, the empirical model should

[15]Based on similar considerations, the remaining continuous variables (age and households size) are also log transformed.

also control for the impact of other important factors (e.g., irrigation), but the survey data do not include such information at either the community or household level. However, this should not be a major problem in the present study. According to the World Resource Institute's Earth Trends database, while about 5 percent of arable land is suitable for irrigated agriculture in Nigeria, currently less than 1 percent of Nigerian cropland is actually irrigated16. Moreover, most of the irrigated cropland belongs to plantations and large-scale projects owned by private commercial interests (Johnson and Vermillion 1995).

[16] Available at http://earthtrends.wri.org/pdf_library/country_profiles/agr_cou_566.pdf

5. EMPIRICAL RESULTS

The descriptive findings presented in the previous section show that only a fraction of Nigerian farmers use improved seeds (7 percent) and chemical pesticides (10.5 percent). Moreover, the data indicate that most of the farmers who use improved seeds and pesticides also use fertilizer. Therefore, it is logical to focus on examining the impact of agricultural service provision on fertilizer use. Table 3 shows the maximum likelihood estimates from nested two- and three-level mixed effects (random-intercept and random-coefficient) models, along with those from the standard logit model of fertilizer use. The two-level mixed effects models assume that the households are nested in states, and do not control for deviations across LGAs.

Variations Across States and LGAs

Overall, the estimated nested models reveal significant heterogeneity in the likelihood of fertilizer use across states and LGAs. The two-level (households nested in states) random-coefficient (F3) model suggests that states vary in their intercepts, with an estimated random-intercept standard deviation of 1. The three-level (households nested in LGAs, which are nested in states) random-intercept model (F4) has an estimated random-intercept standard deviation of 1.05, suggesting that its deviations from the mean intercept are even larger. The state-specific random-intercepts (data not shown) are both statistically and practically significant for almost all of the states. The state-specific intercepts suggest that households residing in states such as Kano (with an estimated odds ratio of 0.3.6), Kaduna (9.5), Katsina (5.3), Zamfara (4.7), and Anambra (3.0) have significantly higher likelihoods of using fertilizer, ceteris paribus. In contrast, households residing in such states as Borno (with an estimated odds ratio of 0.31), Ekiti (0.15), Cross River (0.51), Delta (0.44), Yobe (0.14) and Taraba (0.29) have significantly lower probabilities of fertilizer use, all other things being equal.

The three-level models also reveal significant variances among LGAs in the farmers' likelihood of fertilizer use; the LGAs vary in their intercepts, with an estimated random intercept standard deviation of 1.25. Overall, the regression diagnostics suggests that the three-level mixed effects logit model fits better than the standard and two-level mixed effects logit models at the 1 percent significance level (using a conservative likelihood ratio test). Furthermore, the same test indicates that the three-level random-coefficient (F5) model fits better than the three-level random-intercept (F4) model at the 5 percent significance level. Thus, the discussion of the findings provided below is mainly based on the results estimated using the three-level random-coefficient (F5) model.

Table 3. Determinants of fertilizer use in Nigeria (Dependent variable = fertilizer use)

Variable	F1	F2	F3	F4	F5
Household size (log)	0.30**	0.31**	0.31**	0.30**	0.30**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Married	0.07	-0.02	-0.01	0.02	0.02
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Primary school	0.12**	0.10**	0.10**	0.08**	0.08**
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Income quintile 1	-1.06**	-0.76**	-0.79**	-1.02**	-1.04**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
Income quintile 2	-0.63**	-0.47**	-0.50**	-0.67**	-0.69**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
Income quintile 3	-0.28**	-0.22**	-0.25**	-0.38**	-0.41**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
Income quintile 4	-0.03	-0.05	-0.07	-0.16**	-0.17**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)

Table 3. (Continued)

Variable	F1	F2	F3	F4	F5
Gender	0.01	-0.10	0.09	0.12	0.12
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
Age (log)	-0.26**	-0.28**	-0.29**	-0.29**	-0.30**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
Land holding size (log)	0.14**	0.15**	0.15**	0.18**	0.18**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Credit	0.21	0.27**	0.27**	0.26**	0.25**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Extension	0.45**	0.28**	0.28**	0.44**	0.45**
	(0.09)	(0.10)	(0.10)	(0.11)	(0.11)
GASP	0.43**	0.31**	0.30**	0.29**	0.29**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
GASP *POOR	0.04	-0.09	-0.09	-0.13*	-0.14*
	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
PASP	-0.12**	0.11**	0.12**	0.09**	0.08*
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Civil servant	-0.11**	0.10*	0.10**	0.13**	0.13**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
Agric. as main activity	0.24**	0.22**	0.23**	0.31**	0.32**
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
All-season road access	-0.24**	-0.08**	-0.14	-0.02	-0.10
	(0.02)	(0.02)	(0.08)	(0.03)	(0.07)
Sudan savanna	0.43**	0.64	0.57	0.78	0.65
	(0.03)	(0.50)	(0.53)	(0.79)	(0.61)
Derived savanna	-0.60**	0.67	-0.61	-0.88	-0.93
	(0.04)	(0.56)	(0.59)	(0.67)	(0.68)
Rainforest	-1.25**	-1.54**	-1.54*	-2.07**	-2.10**
	(0.04)	(0.50)	(0.53)	(0.61)	(0.61)
Constant	0.67	0.19	0.28	0.20	0.37
	(0.14)	(0.44)	(0.46)	(0.52)	(0.53)
Random-effects parameters					
State (random intercept)		1.00**	1.05**	1.15**	1.17**
		(0.12)	(0.13)	(0.14)	(0.15)
State (random coefficient for road access)			0.42**		0.37**
			(0.06)		(0.06)
LGA				1.25**	1.25**
				(0.04)	(0.04)
N	53,694	53,694	53,694	53,694	53,694
No. of states		37	37	37	37
No. of LGAs				774	774
Log likelihood	-31425.9	-27421.6	-27315.8	-23781.2	-23729.8
Pseudo R squared	0.14	0.25	0.25	0.35	0.35

Source: Authors' own estimations.

Notes: Standard errors are given in parentheses; ** $p < 0.01$, * $p < 0.05$.

The reference category for the income quintiles is income quintile 5; the reference category for the agro-ecological zones is the Guinea savanna zone.

F1 shows the results from a standard logistic regression model with robust standard errors.

F2 shows the maximum likelihood estimates for a two-level (households nested in states) random-intercept model.

F3 shows the maximum likelihood estimates for a two-level (households nested in states) random coefficients (for access to roads) model.

F4 shows the maximum likelihood estimates for a three-level (households nested in LGAs and LGAs nested in states) random-intercept model.

F5 shows the maximum likelihood estimates for a three-level (households nested in LGAs and LGAs nested in states) random-coefficients (for access to roads) model.

Agricultural Services and Fertilizer Use

The estimation results indicate that the provision of agricultural service projects by the public sector positively influences fertilizer use by farm households in Nigeria. Farm households in communities that had at least one agricultural service project provided by the public sector are about 1.33 times more likely to use fertilizer compared to households in communities that did not receive such projects. However, there is a negative and statistically significant coefficient for the interaction of this variable with the "poor farmer" dummy (representing households in the first and second income quintiles), indicating that poor households are less likely to be targeted. Together, these results suggest that wealthier households are more likely to benefit from agricultural service projects provided by the public sector. This finding has two important implications. First, the differences in the odds ratios of fertilizer use between wealthier and poorer households are much greater in communities that received at least one agricultural service project. Second, all other things being equal, poor households in communities with at least one agricultural service project are likely to have a lower odds ratio of fertilizer use compared to their counterparts in communities without any agricultural service project. Given that these projects mainly focus on the provision of subsidized fertilizer to farmers, one can expect that such projects might have crowded out the private sector, and thus could actually lower the likelihood of fertilizer use by poor farmers. This finding is consistent with previous reports indicating that public-sector efforts at improving input supply can crowd out the private sector and reduce overall fertilizer use in some areas (Xu et al. 2009; Kelly, Adesina, and Gordon 2003).

The estimation results indicate that the impact of private-sector-provided agricultural service projects on fertilizer use is relatively small. Note that the results also suggest that uses of credit and agricultural extension services positively correlate with fertilizer use. The estimates from the three-level random coefficient model suggest that households that report using credit and extension services are about 1.3 times more likely to use fertilizer. These results are in line with the findings and conclusions of previous research (e.g., World Bank 2007).

Access to All-Season Roads and Fertilizer Use

The overall impact of access to all-season roads on fertilizer use appears to be insignificant, which is surprising given previous reports suggesting that access to roads can drastically reduce the cost (and thus increase the use) of modern inputs (Gregory and Bumb 2008; Dercon et al. 2008). However, the results from the two- and three-level random coefficient models suggest that the relationship between road access and fertilizer use is heterogeneous across states. The standard deviation of the slope of access to roads, which can be interpreted as the residual variability in the impact of road access on fertilizer use across states, is estimated at 0.42 (model F3). This deviation slightly decreases to 0.37 when the three-level model is estimated. These findings suggest that although the mean slope for access to all season roads is statistically insignificant, the state-specific slopes vary significantly.

Table 4 gives the state-specific slopes estimated using the two- and three-level random coefficient models. The impact of road access on fertilizer use is positive in six states (Adamawa, Bauchi, Borno, Nasarawa, Oyo, and Yobe), negative in eight states (Anambra, Edo, Enugu, Kaduna, Plateau, Rivers, Zamfara, and FCT), and statistically insignificant in the remaining 23 states. The estimated correlation between the state-specific intercepts and slopes is negative (-0.39). This suggests that for the given covariate values, the impact of road access on fertilizer use is insignificant or negative in states where the likelihood of fertilizer use is relatively high, while the impact is significant and positive in states where the likelihood of fertilizer use is relatively low. Arguably, this heterogeneity might be due to differences in the development of road networks, in that some states may have developed roads in areas of high agricultural potential, while other states may have built roads away from such areas.

Table 4. Heterogeneous impact of road access on fertilizer use in Nigeria (state-specific random slopes)

	F3	F5
Abia	-0.03	NA
Adamawa	0.44*	0.38*
Akwa Ibom	0.10	0.14
Anambra	-0.36*	-0.38*
Bauchi	0.52*	0.61*
Bayelsa	0.08	-0.01
Benue	-0.47*	-0.10
Borno	0.39*	0.43*
Cross River	0.41*	0.25
Delta	0.15	-0.13
Ebonyi	-0.50*	-0.10
Edo	-0.97*	-0.60*
Ekiti	-0.39	-0.25
Enugu	-0.44*	-0.34*
Gombe	-0.34	-0.07
Imo	-0.52*	NA
Jigawa	-0.19	-0.07
Kaduna	-0.39*	-0.37*
Kano	-0.30	-0.23
Katsina	-0.02	-0.11
Kebbi	0.09	0.01
Kogi	-0.24	-0.25
Kwara	-0.58*	-0.45
Lagos	-0.62	-0.49
Nasarawa	0.33*	0.20*
Niger	0.00	-0.20
Ogun	-0.10	0.01
Ondo	0.18	NA
Osun	-0.19	NA
Oyo	0.31*	0.35*
Plateau	-0.07	-0.48*
Rivers	-0.62*	-0.60*
Sokoto	-0.32*	-0.16
Taraba	0.38*	0.23
Yobe	0.45*	0.36*
Zamfara	-0.72*	-0.63*
FCT	-0.68*	-0.63*

Notes: The slope predictions are based on two-level (F3) and three-level (F5) random coefficient logistic regression models.
* $p < 0.05$

Other Results

With respect to household characteristics, the model results show that household size and the household head's level of education have positive impacts on fertilizer use, while the household head's age has a negative impact on fertilizer use. In addition, the household income has a positive impact on input use, with the estimated coefficients suggesting that households in the lower income quintiles are significantly less likely to use fertilizer compared to households in the upper income quintiles. For example, all other things being equal, the farm households in the lowest quintile are about three times less likely to use fertilizer compared to farm households in the fifth income quintile. The analysis also reveals that households whose heads practice agriculture as a main activity are 1.4 times more likely to use fertilizer than other households. Households with a civil servant in residence are also more likely to use fertilizer.

Furthermore, the operational land holding size is found to positively affect fertilizer use; a unit change in the log of operational land holdings, conditional on the mean values of the other regressors, increases the likelihood of fertilizer use by 1.2 times. Finally, the results also indicate that farmers in the Rainforest zone are less likely to use fertilizer compared to farmers in the other agro-ecological zones. These results are robust and consistent across all five estimated models.

6. CONCLUSIONS

The recent renewal of interest in government intervention in agriculture is of significant importance to Sub-Saharan Africa, where most governments are involved in providing subsidized inputs and agricultural services to farmers. This study examines the relationship between government involvement in agricultural service provision and modern input use by farmers in Nigeria. The brief overview of the decentralized institutional arrangements for agricultural service delivery in Nigeria shows that the sub-national governments play important roles in the funding and delivery of such services. Next, the effects of agricultural service provision on farmers' fertilizer use are examined using a large set of household survey data (representative at both the national and sub-national levels) in a multilevel nested modeling framework, which distinguishes among the three levels of organization (states, LGAs, and households).

The empirical analyses described herein reveal that there are significant variations in agricultural service provision and fertilizer use across the sub-national jurisdictions in Nigeria. The results further indicate that government involvement in agricultural service provision positively influences fertilizer use. Households in communities that had received at least one agricultural service project provided by the public sector (in the five years prior to the survey) are more likely to use fertilizer (odds ratio 1.33). However, the findings also suggest that wealthier farmers are more likely to benefit from such public services, compared to poorer farmers. This lowers the likelihood of fertilizer use among poor farmers in communities that received public agricultural service projects. When considering between-state differences, the results suggest that (all other things being equal) the likelihood of farmers' fertilizer use varies across states, with an estimated standard deviation of 1.05. Similarly, three-level model results suggest that the likelihood of farmers' fertilizer use varies across LGAs, with an estimated standard deviation of 1.25. Another important finding concerns the impact of access to all-season roads on fertilizer use. Although the overall impact of road access on fertilizer use is statistically insignificant, the findings from the random-coefficient models suggest that this impact is heterogeneous across states. The impact is insignificant or negative in states where the likelihood of fertilizer use is relatively high, but it becomes significant and positive in states where the likelihood of fertilizer use is relatively low.

The empirical methodology used in this study controls for systematic differences and unobserved heterogeneity across the sub-national jurisdictions (states and LGAs). This approach removes concerns about potential endogeneity due to the combined effect of omitted covariates and unobserved heterogeneity at the state and local government levels. The present study does not directly explore the sources of the observed differences across states and LGAs, due to the scarcity of data at these levels. Future studies should investigate potential sources for the differences in agricultural service provision and input use between various states and LGAs. The present study also observes the availability of agricultural service projects and road access at the community level. Although this approach produces unbiased estimates to the extent that there are not systematic differences between communities, biased estimates may arise if inter-community differences in the explanatory variables are correlated with the residuals. For example, because the utilized data come from the same survey, common measurement errors in the community-specific variables could potentially introduce bias. Dealing with this and other possible types of endogeneity would require the identification and use of suitable instrumental variables (IVs); although it is not clear that such IVs exist at present, this avenue warrants future research.

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P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
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CG Block, NASC Complex, PUSA
New Delhi 110-012 India
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