Do new delivery systems improve extension access?

Evidence from rural Uganda

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Abstract: The literature has long identified lack of rural diversification and low intensity of input use as two key constraints to sustainable and pro-poor growth in Uganda. We use data from a large nationally representative survey to demonstrate that broader access to agricultural extension could increase diversification and input use and that a surprisingly high level of farmers (more than are actually reached) would be willing to pay for such services. Although willingness to pay increases with wealth, illustrative simulations suggest that, due to knowledge spillovers, policies to respond more effectively to the demand for extension services would also benefit the poor.

1. Introduction

Despite significant advances in efforts to reduce rural poverty, it is now widely recognized that reaching the Millenium Development Goals with respect to poverty reduction will remain a considerable challenge, especially in Africa where the incidence of poverty rose between 1990 and 2001, and almost half of the region's population lives on less than US $1 a day. As the majority of the world´s, and particularly Africa's poor remains concentrated in rural areas, poverty reduction and sustained increases in living standards are unlikely to be possible without significant increases in agricultural productivity. This is specifically true for Africa, where in most cases the scope for expansion of cultivated area, which formed the basis for agricultural growth in the past, is no longer feasible and where opportunities for non-farm income that are not related to agriculture are more scant than in other regions. While this will require sustained efforts to expanding the frontiers of science, the majority of farmers produce at a level that falls far short of existing possibilities. Recent steps to improve incentives and liberalize marketing were associated with considerable one-off gains and helped to create a more enabling environment for agricultural production. This suggests that adoption of improved technology may become of importance again.

Agricultural extension gained much attention over these last decades pertaining certainly to the fact that, even though, policies related to area expansion, liberalization (regime and reducing marketing margins as well as agricultural commodity markets functioning) helped to create growth-nuturing environment, they was of *one-shot* nature and not able to provide, as can be done with agricultural extension services, a sustained impetus for continuous growth in agriculture. Thus, by displaying the potential to provide farmers with human capital which increases agricultural productivity and allows to shift from "low input/low output" agriculture into a modern science-based agriculture capable of sustaining growth, agricultural extension services still being one of the paramount issues in the contemporary development dialogue. This is acknowledged by the growing and steady interest of the international community

regarding extension services and the large amounts of resources that donor agencies have been spending on programs aiming to improve the use of existing technology. However, even though a few studies point towards high potential returns from extension, traditional approaches have often failed to deliver on their promise. As an alternative, decentralized and demand-driven approaches, in some cases with partial cost sharing by beneficiaries, which may increase over time, have been embarked upon.

The example of Uganda is of interest in this respect for a number of reasons. The country's economy remains characterized by high reliance on the agricultural sector which employs about 60% of the economically active population. At the same time, levels of technology adoption and modern input use are considered to be among the lowest in Africa. While liberalization of trade and marketing provided significant benefits to coffee producers, diversification of cropping patterns was more limited than expected, implying continued high levels of dependence on coffee which led to reductions in producers' income as international prices collapsed.[1] This has implications for regional patterns of growth, the scope for poverty reduction, and for sustainability of land use patterns in the longer term. In fact, after an impressive decline in the poverty headcount between 1992 and 2000, recent household survey data suggest that this trend has been reversed, mainly because of an increase in rural poverty that can be attributed to the low growth of agricultural productivity. In recognition of the importance of this issue, the country has recently embarked on the National Agricultural Advisory System (NAADS) as an innovative, decentralized approach to extension delivery that aims to better disseminate existing technolgy and improve agricultural diversification adoption of existing technology.

In this paper, we use data from the 2004 National Service Delivery Survey (NSDS) which covered households and providers of public services (including extension agents) in a sample of 700 rural villages covering all of Uganda´s 56 districts. These data are used to gain insight into three sets of issues, namely (i) demand for agricultural extension; (ii) the effectiveness of traditional and "new" approaches to the delivery of technical assistance; and (iii) the impact of better extension access on crop diversification and productivity, including an illustrative simulation of the potential impact of increasing coverage with such services.

Our findings are very appealing. They give the evidence that supply-side and political environment or democratization variables are critical when one is interested in investigating determinants of extension demand. The political related variables gives support to the strand of the literature advocating the thought that local government institutions or local government related systems may fail to make services work for the poor due to incomplete or ill-designed decentralization process. While the supply side variables

[1] The low level of diversification in spite of the market and trade liberalization reforms, suggest that diversification is may be exclusively considered as a strategy geared towards coping with idiosyncratic shocks. This implies that there is a great potential for extension service providers to bring Ugandan farmers position to evolve regarding the potential benefits of diversification.

contributes to the debate around the effectiveness of new extension delivery systems. The impacts of such variables on access to extension, the low level of access to extension observed and the reported willingness to pay for extension by farmers cast a doubt on the effectiveness of the new service delivery systems, including the NAADS program. As one can expect, access to extension have a strong impact on technology adoption and diversification, which is far greater when one takes into account its spillover effects. This result corroborates the idea raised in the literature and which highlights the critical role play by such externalities in technical changes. Herein, we find that such spillover effects highly contributes to making pro-poor a policy geared towards responding more effectively to the demand for extension services, expressed through farmers willingness to pay.

The paper is structured as follows. Section two discusses the importance of technology for growth of the rural sector and reviews global experience with innovative mechanisms to deliver such services before presenting some of the specifics of the Ugandan situation and introducing the framework for empirical estimation. Section three describes the data used and provides descriptive statistics on household characteristics, demand for extension, and differences in cropping patterns and input use between those with and without access to extension services. Section four provides econometric estimates of access to extension, the impact of such access, and simlations of the potential impact under a number of scenarios. Section five concludes by drawing out policy recommendations and implications for future research.

2. Background and conceptual framework

Even though the share of population living in rural areas will decline over time and is expected to reach 50% around 2020, the share of the poor living in those areas will remain well above that for urban ones for the foreseeable future. Where data are available, as in the case of China and India, growth in the agricultural sector had a much bigger impact on poverty reduction than in other sectors. Africa is characterized not only by a higher share of the population in rural areas but also high potential payoffs from investment in agricultural research as well as the transfer of results from such research to farmers, and a willingness to adopt new approaches.

2.1 Importance of agricultural technology for pro-poor growth

Even though the MDG of halving poverty by 2015 may be achieved due to sustained reductions of poverty in China and India, Africa is lagging behind badly (World Bank IMF Development Committee 2005). While UN projections suggest that the share of population in developing countries who live in rural areas will start to be lower than in urban areas shortly after the year 2020, poverty remains disproportionately concentrated in rural areas. Currently: about 70% of the world's poor currently live in

rural areas, and even once the cross-over point has been reached, around 60% of the poor will continue to live in rural areas (Ravallion 2002). About 70% of China's remarkable progress in reducing poverty reduction can be attributed to growth in the rural economy (Ravallion and Chen 2004). Benefits from agricultural research and technology will also provide significant benefits to the urban population (Fan *et al.* 2003b). A similarly important role has been played by the rural sector in the case of India (Fan and Hazell 2001, Ravallion and Datt 2002).

Compared to other continents, Africa is not only characterized by a much higher share of the population still in rural areas (70% as compared to 59% globally) but also by a rich endowment with agricultural land (15 ha per worker compared to a global average of 10.5). However, much of the region's rich endowment and potential has remained underexploited. While macro-economic reforms as well as liberalization of marketing channels have helped many African countries to create an environment in which incentives for productivity-led agricultural growth will be higher (Kayizzi-Mugerwa 1998). In fact, recent studies show that there is considerable potential for poverty reduction through agricultural growth; a 1% increase in yields is estimated to have the potential of lifting more than 2 million Africans out of poverty, at a cost of only $144 per person (Thirtle *et al.* 2003). Increases in public funding for research are needed (Pardey *et al.* 1992) and (Fan *et al.* 2003a) has shown that in the Ugandan context, agricultural research and extension spending have an important impact on agricultural production and poverty reduction The general role of agricultural research in marginal areas is demonstrated in (Otsuka 2000).

Case studies of successful interventions confirm that advances in agricultural productivity, together with expansion of the rural non-farm sector, offer considerable opportunities to bring about sustainable reduction of poverty (Gabre-Madhin and Haggblade 2004). There is also still considerable scope to re-orient the quality of public expenditure, for example by re-directing government spending from input programs to provision of public goods to stimulate intensification of input use (Kelly *et al.* 2003). A strong focus on agricultural technology, as well as other associated services, will be even more critical in an international environment where emphasis has shifted towards commodities with higher value added, more integrated supply chains, and standardization of quality (Pray 2001). The importance of these considerations is supported by recent suggestions of innovative mechanisms to provide greater incentives for creation of agricultural technology that take into account the need for adoption of innovations with a special focus on Africa (Masters 2003, Kremer and Zwane 2005). This will also require that the extension system is geared up to assist in dissemination of new technology and make sure it is actually implemented.

2.2 Modalities of technology delivery

While some agricultural techniques such as (e.g. hybrid seeds) are rival and excludable in the sense that their benefits only accrue to their direct user, others (e.g. knowledge about management techniques and how to apply them in a specific context) are public goods. In between these two extremes fall a significant number of technologies that combine elements of both (Umali and Schwartz 1994) and that are commonly referred to as club or toll goods. In all but the first group, supply or demand by private entrepreneurs will fail to account for external effects and thus be sub-optimal from a social point of view. This has long provided the rationale for public support for systems aiming to generate agricultural technologies (Traxler and Byerlee 2001). Considerations related to poverty reduction and the inability of the poor to express demands in a way will be effective in the market, further strengthens the case for public support (Pardey *et al.* 1997).

Even if technology is readily available or effectively generated by a national agricultural research system, the spatial diversity of agricultural production implies that its dissemination to producers can not be taken for granted and special efforts to disseminate them may be justified (Feder *et al.* 1985, Anderson and Feder 2004). Together with evidence from a number of studies that pointed towards very high social returns from well-implemented extension programs (Birkhaeuser *et al.* 1991, Bindlish and Evenson 1997, Evenson and Mwabu 2001, Evenson 2001), this has led multi- and bilateral agencies to allocate large amounts of resources to such programs, the majority under the "training and visit" (T&V). Enthusiasm for this type of approach has, however, been reduced by studies that show that high returns are by no means universal and often quite sensitive to data issues and specification (Gautam and Anderson 1999), together with field evidence that giving the public sector an effective monopoly on provision of such services may encourage corruptoin and inefficiency rather than efficient service provision.

While this suggests that there can be a sound economic justification for public provision of technical advice, past experience also suggests that the most appropriate form of doing so will have to be chosen depending on the specific circumstances. Four difficulties are of particular relevance, namely (i) dealing with the scale, complexity and spatial dispersion of the associated operations; (ii) ensuring continuing interaction and feedback with the knowledge generation system; (iii) measuring impact and establishing channels of accountability; and (iv) delivering services in a fiscally sustainable way (Anderson and Feder 2004). The general consensus is that this calls for models where public and private sector coooperate (Umali-Deininger 1997), based on a number of general principles (Hanson and Just 2001).

Studies demonstrate that there are many situations where the private benefits exceed the cost of providing extension services (Holloway and Ehui 2001), thus making partial or full cost recovery feasible for at least a segment of the population and thus reduce the burden on the public purse (Keynan *et al.* 1997,

Dinar and Keynan 2001), that farmers are able to effectively express their demand (Frisvold *et al.* 2001), that new approaches can have a positive impact on farmers' knowledge while at the same time allowing them to monitor providers better (Godtland *et al.* 2004). As a consequence, the past decade has seen a large number of initiatives that aimed to make public systems more responsive by increasing private sector involvement either through privatizing parts of the extension system, introducing competitive elements such as subcontracting in publicly funded systems, or by carrying out far-reaching structural reforms (Rivera and Alex 2004).

2.3 The Ugandan context

Not unlike other African countries, Uganda is characterized by signficant reliance on the agricultural sector which employs about 60% of the population and, with 42% of GDP and about 40% of total exports, constitues a mainstay of the economy. A rich natural resource base provides auspcious conditions for poverty-reducing technical progress in agriculture.

Price gains associated with liberalization of agricultural markets in the late 1980s put the country on a path of rapid recovery after a prolonged civil war. Growth in food crops was, with 7.5% per year, very high. Sustained gains in output prices facilitate significant gains in poverty reduction during the 1992-2000 period (Deininger and Okidi 2003). In the longer term, however, slow progress with institutional reforms implied that the buoyant prices in the 1990s contributed less towards the urgently needed diversification of the economy than could have been hoped, leaving the economy highly dependent on coffee exports (Belshaw *et al.* 1999). Ineed, inability to maintain the high levels of agricultural growth after the world-wide drop in coffee prices has been identified as one of the key reasons why, despite continuing high levels of growth, the 1999/2000-2002/03 period has witnessed a slowdown in poverty reduction and even an increase in poverty as well as a rise in inequality (Kappel *et al.* 2005).

In fact, while the traditional extension service delivery approach failed to meet its promises due mainly to institutional constraints: uncoordinated and non-participatory extension services; weak research-extension-farmer linkages; high level of bureaucracy during service provision; low responsiveness to farmers' needs; and lack of financial and performance accountability, a number of studies point towards Uganda's significant potential to realize productivity increases from better use of existing as well as from the the generation of new technologies. One study estimated a rate of return of 50% on agricultural research in Uganda (Thirtle *et al.* 2003) and another one finds that "agricultural R&D was the most effective investment to cut poverty"; albeit over an unspecified time horizon, it finds that an additional shilling spent on agricultural R&D in Uganda would generate more than 20 times this amount, at least in

some regions. In fact, an agricultural R&D investment of about US $ 9 (or about US $ 3 for the Northern part of the country) would be enough to lift an adidtional person out of poverty (Fan and Chan-Kang 2004).[2] Even if they constitute an upper bound, these figures clearly illustrate that there is considerable potential.

To realize this potential, the Government launched an ambitious Plan for Modernization of Agriculture (Government of Uganda 2001) which puts agricultural growth at the heart of its fight against poverty under the Poverty Eradication Action Plan (PEAP).[3] In addition to providing a mechanism whereby local communities could access central government grants, it envisaged implementation of a new agricultural service delivery system, the National Agricultural Advisory Services (NAADS).[4] Under this system, users would receive, on a gradually declining scale, a grant that would allow them to contract private service providers to advise them on technology, thereby replacing the bureaucratic culture of the government-sponsored extension system with a program that would have a much greater level of ownership and accountability to the needs of ultimate users. The program, which was started in 2001, was initially implemented in a set of pilot districts. In accordance with Uganda's decentralization policies, districts will implement NAADS through the existing political and technical structures. Districts councils will be responsible for coordination and implementation of NAADS and publicly accountable for NAADS performance in their respective districts. The Councils will also be accountable to the NAADS Board and Ministries (agriculture, local governance, and finance). Although the limited time that has been passed since its initiation may make it difficult to observe real impacts, at least one study, finds that NAADS has been quite successful (Nkonya *et al.* 2004),

2.4 Estimation framework and strategy

We aim to use the data from the NSDS to test whether NAADS has had a significant impact on improving access to advice on agricultural technology, in addition to determining the actual or potential impact of such access on diversification, input use, and productivity. Before discussing how we implement this, we discuss two methodological issues, namely the potentially endogenous nature of participation in extension

[2] The figure can be computed from their table 4 (p. 441) using an exchange rate of USh 1914 to the US$.

[3] This is in the context of the country embarking on an ambitious program of political and administrative decentralization. Observers note that the multitude of often rather uncoordinated policies and taxation regimes may not have been the most conducive to broader growth{ (Bahiigwa *et al.* 2005); (Ellis and Freeman 2004); (Ellis and Bahiigwa 2003)} , in addition to the fact that this program may have been subject to political interference(Francis and James 2003). Also reference (Craig and Porter 2003). This is important since there has been persistent concern that very limited use of purchased inputs might jeopardize performance of Uganda's agricultural sector(Pender *et al.* 2004).

[4] NAADS is envisioned to become a decentralized, farmer owned and private sector serviced extension system contributing to the realization of the agricultural sector development objectives by increasing farmers' access to information, knowledge and technology for profitable agricultural development. To do so, it aims to (i) promote market oriented commercial farming; empower subsistence farmers to access private extension services, technologies and market information; (iii) create options for financing and the delivery of appropriate advisory and technical services for different types of farmers; shift from public to private delivery of advisory services; develop private sector capacity and professional capability to supply agricultural advisory services; and (v) stimulate private sector funding for agricultural advisory services.

and the use of data from the 1999/00 Uganda national household survey to obtain estimates of producers' technical efficiency that allow us to establish a link between their level of diversification and productivity.

Endogeneity: It is well known that, to the extent that there is an overestimate. To deal with this, we use instrumental variable techniques. Appropriate instrument need to be highly correlated with the variable of interest (i.e. access to extension) while not having any correlation with productive outcomes, therefore affecting productivity only through their impact on extension access. We use attributes of the supply of extension services as well as the households' standing in the social hierarchy at the local level as instruments. The former include the level of spending by the local government, whether the local extension agent received training during the 12 month preceding the survey, whether funding or long distances (i.e. transport) are perceived as a problem to provide adequate services, and whether the local government, rather than a technical specialist from the line ministry, is responsible for supervising provision of technical advice. Variables to capture the latter are whether a member of the household is part of the LC1 committee and whether the household is aware of the way in which graduated tax is spent by local government.

Link to productivity: The large sample of the NSDS made it impossible to administer a detailed module on agricultural production that would have been needed to make inferences on households' level of agricultural productivity. To overcome this shortcoming, we use the level of diversification as our key variable of interest and rely on the 1999/00 Uganda national household survey to obtain estimates of producers' technical efficiency through estimation of a frontier production function. Inspection of these data confirms not only that diversification is indeed highly correlated with higher levels of productivity but also allows us to conduct illustrative simulations on the potential impact of expanding access to extension.

2.5 Empirical implementation

To identify determinants of households' extension access, we index agricultural producers by *i* and run a regression of the form

$$A_i = \alpha_0 + \alpha_1 \boldsymbol{H}_i + \alpha_2 \boldsymbol{I}_i + v_i \qquad (1)$$

where A_i is a zero-one dummy for whether a producer was visited by an extension worker during the 12 months preceding the survey, $\boldsymbol{H}_i$ is a vector of standard household characteristics including female headship, age and education of the head, and land and non-land asset endowments, $\boldsymbol{I}_i$ is a vector of instruments as discussed above, v_i is an iid error term, and α_0, α_1, and α_2, are coefficient vectors to be estimated. We expect higher levels of human capital, experience (age), and assets to have a positive

impact on extension access. Similarly, higher levels of per capita spending by local government as well as a household being located in a NAADS district and the extension worker having received training in the recent past are all expected to increase the likelihood of having access to extension. For instrumental variables, we expect levels of spending as well as location in a NAADS district and training of extension workers to be positive, problems with funding or facilities and long distances, to be negative, and membership in local government or knowledge about its finances positive.

In the absence of data on productivity, we use as proxies information on production practices, i.e. whether farmers produce "cash crops" such as coffee, fruit, vegetables, milk, or beef, or use seeds or chemicals as inputs into production.[5] Defining I_{ij} as a dummy that equals one if household i has adopted production practice j, this gives rise to an estimable reduced form equation

$$I_{ij} = \beta_0 + \beta_1 \boldsymbol{E}_i + \beta_2 \boldsymbol{H}_i + v_i \qquad (2)$$

where $\boldsymbol{E}_i$ is a vector containing the predicted value of household i's access to extension from equation (1) as well as the mean level of extension access in the village, $\boldsymbol{H}_i$ is a vector of household characteristics as defined in (1), and v_i is an iid error term.[6] The hypothesis that extenion will increase farmers' propensity to diversify or adopt advanced production practices both directly and indirectly translates into the prediction that both elements of $\beta_1 > 0$. Higher levels of education and better access to infrastructure are expected to increase the propensity to adopt new production practices. A similarly positive sign would be expected for hosueholds' endowments with other factors that will be intensively used by new practices. Similarly, we regress the number of cash crop grown items produced over the same set of explanatory variables to analyze the impact on diversification.

To obtain a measure of productive efficiency in the absence of detailed data on output quantities, prices, and inputs that would be needed to obtain such a measure, we use an earlier survey for which such data were available to estimate a stochastic production frontier. The latter, which has been used widely in the literature, is based on the assumption that, in a regular production function, the disturbance term can be decomposed into two parts, a one-sided non-positive component that represents the degree of inefficiency for any given producer and a symmetric *iid* error term (Flinn *et al.* 1982, Battese and Coelli 1992). Choosing the translog functional form,[7] we estimate

[5] Unfortunately, no information on fertilizer use was collected in the survey.

[6] We used the a two-stage method inspired by (Rivers and Vuong 1988) and highly recommended by (Wooldridge 2002) in order to instrument the access variable variable suspected for endogeneity in our impact regression. It has several advantages: Monte-Carlo evidence suggests that it performs favorably relative to its alternatives, it is easier to compute and can be carry out using standard regressions and probit programs; and incorporates a simple and asymptotically optimal test of exogeneity. The method

[7] The literature suggests that, in general, use of a non-homothetic functional form such as the translog is often preferable to simpler specifications such as the Cobb-Douglas which corresponds to the special case where coefficients on the interaction terms (i.e. the βs in (3)) all equal 0, a proposition that can be tested statistically.

$$\ln Y_i = \alpha_0 + \sum \alpha_i (\ln X_i) + \sum \beta_{ii} (\ln X_i)^2 + \sum \sum_{i>j} \beta_{ij} (\ln X_i)(\ln X_j) + \varepsilon_i \qquad (3)$$

where Y_i is the value of output produced by producer *i*, X_i is a vector of inputs used by the same producer that includes area of land operated, the amount of family and hired labor used, the cost of capital services, and the amount of fertilizer, pesticide, and seeds used, and $\varepsilon_i = \zeta_i - \eta_i$ the composite error composed of the productivity measure (η_i) that can be interpreted as the farmer's distance from the frontier and a white noise error term ζ_i.

Even though the productivity measure will be measured with some error, linking it to adoption of advanced methods of production and the impact of having access to extension on the latter allows us to derive at least an approximate measure of the impact of extension access on the level of productivity that can be used to perform illustrative simulations of the impact of expanding such access to parts of the population who may have lacked it earlier. Formally, the gain in productivity from shifting from regime 0 to regime 1 in the provision of extension services, $\Delta\kappa_i$ can be defined as

$$\Delta\kappa_i = (\hat{d}_i - d_i)\theta \qquad (4)$$

Where $\hat{d}_i$ is the predicted level of diversification by producer *i* under regime 1 whereas d_i is the actual diversification level under regime 0 and θ is the productivity gain associated with adopting higher levels of diversification.

3. Data and descriptive statistics

Descriptive analysis of the 2004 NSDS confirms that (i) the poor are concentrated in the rural sector and higher agricultural productivity can have a significant impact on improving their livelihood; (ii) even though, at 14%, the level of extension coverage is quite low, having had access to extension, in contrast to being located in a NAADS district, are associated with diversified patterns of production, higher levels of input use, and improved knowledge on agricultural production practices and market access; (iii) neither extension coverage nor the training received by extension providers are higher in NAADS as compared to non-NAADS districts; and (iv) with 29%, a surprisingly large share of producers report to be willing to pay for extension visits, with a reported willingness to pay of almost US $ 2 per visit.

3.1 Household characteristics and extension access/demand

To make inferences about the issues at hand, we use data from the household and service provider schedule of the 2004 National Service Delivery Survey (NSDS). The sample consisted of about 18,000

households nation-wide (12,000 of them agricultural producers), complemented by a range of service providers at the village level in a sample representative of all of Uganda´s 56 districts. In addition to standard household characteristics, the survey contains information on households' production practices and their actual and desired access to extension (including potential willingness to pay). Providers were asked about delivery targets, training received, and perceived constraints to effective service delivery.

Main household characteristics for the whole sample, by quintile of per capita expenditure, by region, and by the head's occupation, are summarized in table 1. Poverty is disproportionately concentrated in rural areas; compared to an average of 75% of households in rural areas, 91% of the poorest quintile and only 47% of the richest quintile being rural. Households in the top quintile have significantly more education (9.2 years as compared to 3.5 years for the bottom 20%) and are also slightly younger (with the head's age being 38 as compared to 43 for the bottom quintile). Land ownership and cultivation, which are almost constant for the bottom three quintiles, are sharply lower for the top 40% hose higher endowment with iron sheet roofs (a good indicator of wealth in rural Uganda) and closer location to infrastructure are not surprising. Across regions, we find higher levels of education (6.8 years compared to 5.7 at the national average) in the Center and lower levels of farming (53% and 54%, respectively) and male headship in the Center and the North (25% and 27%, respectively), although the reasons for the latter are likely to differ between the two - a more active non-farm economy in the Center and violence in the North. We also note that those engaged in agriculture have lower levels of education (4.9 years), larger households (5.7 vs. 4.3 members), and less favorable access to infrastructure (30 as compared to 20 kms to the district headquarters).

Table 2 highlights that awareness of the PMA remains rather low and wealth-biased; 38% of producers, 50% in the top and 25% in the lowest quintile indicated to have heard about the program. With 14%, ranging from 10.6% in the lowest quintile to 20.5% in the highest, the share of producers visited by an extension worker during the last 12 months is even lower. Two thirds of these was visited by government staff, about 40% at monthly and 33% quarterly to half-yearly intervals, 46% indicated to have paid for the visit, and the vast majority (88%) were satisfied with the services received. What is more surprising is that, 28.8% of producers, more than double those who report to have had access to advice report, to be willing to pay for such visits. Even though this share obviously increases with wealth (from 22.5% in the lowest to 38.3% in the highest quintile), the mean amounts which producers report to be willing to pay are by no means trivial and range from US $ 1.70 to US $ 2.83 in the lowest and highest quintile respectively, with US $ 1.92 on average.

3.2 Production patterns

Given the appreciation of extension expressed in these valuations, it is of interest to asses whether levels of knowledge on specific practices, diversification, and input use, are indeed higher for producers with access to outside advice as compared to those without. Information on these variables, compared to values for producers who are located in NAADS districts, is given in table 3. The first panel suggests that those with extension access are significantly more likely to engage in animal farming as a primary or secondary activity and thus significantly less likely to be engaged in crop farming while the reverse is true for those in NAADS districts. The second panel illustrates that producers with access to extension are more likely to be diversified; they produce on average 2 cash crops as compared to 1.4 for those not benefiting from extension, a distinction that is particularly significant given that, with 1.4 compared to 1.5 cash crops, those in NAADS districts seem to be statistically significantly less likely to diversify. Figures for individual crops support this; beneficiaries from extension are significantly more likely to produce coffee, vegetables, fruit, milk and livestock, but not traditional staples such as maize and matooke while those in NAADS districts are, with the exception of vegetables where the difference is insignificant, uniformly *less* likely to produce these crops.

To be able to identify potential reasons, producers were asked not only about their use of certain inputs but also about whether their knowledge of the best way to use certain types of inputs improved during the last 3 years (i.e. from 2000 to 2003). The third panel of table 3 illustrates that the proportion of those whose knowledge improved is consistently and significantly larger among producers visited by extension workers compared to those who were not (44% vs. 22% for hybrid seeds; 30% vs. 15% for chemicals, and 38% vs. 15% for animal drugs). Although establishing a direct causality is difficult, better knowledge and the associated higher demand is likely to be one of the key factors underlying the fact that access to such inputs improved (by 38 vs. 18% for seeds, 26 vs. 11% for chemicals, and 34 vs. 12% for animal drugs) and the much higher intensity of use (51 vs. 26%; 31 vs 13%; and 51 vs. 17%). The fact that, with the exception of chemicals which is likely to be specific to cotton and where the magnitudes are much smaller, no such differences are observed for producers in NAADS districts, suggests that there remains considerable scope to improve the performance of NAADS.[8]

3.3 Supply of technical advisory services

To check whether, as one might argue, NAADS has started to reorganize the system through which technical advice is delivered but that not sufficient time had passed for such a reorganization to make an

[8] Note that livestock drugs are for livestock holders only.

impact on production practices, table 4 compares supply-side characteristics between NAADS districts and the rest of the country. There was indeed a marked shift in patterns of supervision; in NAADS districts, about 50% of service providers in NAADS districts are accountable to local government, 40% to the district agric. office, and 10% to the line ministry, compared to 25%, 71%, and 4%, respectively, in the country as a whole. However, there is little difference in overall levels of public spending, and only a minor difference in spending on production and marketing, between the two types of districts.

The latter may be one of the reasons for the finding that only one third of providers in NAADS districts as compared to 45% in non-NAADS ones identified funding as a key constraint to effective extension delivery. At the same time, more providers in NAADS districts point towards inadequate facilities or staffing as a main constraint (45 vs. 32%). Note that, while there is little difference in the share of those pointing to long distances as a key problem, problems of insecurity have emerged as a significant bottleneck to effective production and transfer of knowledge in the North where 18% of service providers point towards this issue as their main concern. Moreover, while there is little difference in the incidence of technical refresher and communication courses, NAADS providers seem to have received significantly less training of trainers courses and, while they cover a slightly higher number of producers on crop production, seem to have limited outreach regarding livestock production issues as illustrated by the fact that they reach on average less than 500 producers, compared to more than 750 at the national average.

4. Econometric evidence

Our data suggest that public spending and other supply side variables such as whether extension workers received training, constraints faced by extension providers as well as households' participation in local government matters are indeed very significant determinants of households' access to extension and can thus be used as instruments. We tests the robustness of our findings using different specifications (probit, tobit and OLS) as shown in Table 5, but the results do not change significantly. Access to extension, adequately instrumented following the Rivers and Vuong method, has a significant *direct* impact on farmers' use of "advanced" inputs and diversification of output while its *indirect* impact channelled through the share of households having access to extension at the district level, measuring spillovers or externality effects, is likely to be significant only for households using improved/hybrid inputs and veterinary drugs and those engaged in animal husbandry farming (cattle and milk), as well as the HVP diversification. Using estimates of the productivity impact of diversification from the 1999/00 UNHS suggests that merely providing access to those who are willing to pay (a measure that should be revenue neutral), would be expected to raise productivity by 4.5%, whereas a program to effectively target the bottom 40% in addition would yield productivity gains of 5.7% and a program mixing both policies

would increase productivity by 8.7%. Even though the first type of program would directly target the better-off, we demonstrate that, largely due to the presence of spillover effects, the benefits would be distributed in a pro-poor manner.

4.1 Determinants of extension access

Results for the instrumental regressions (1) are reported in table 5.[9] Higher endowments with land and labor as well as education and assets increase households' propensity to access extension services. Better-off households (as indicated by having a roof covered with iron sheets) are 3.8 to 4.0 points more likely to have been visited by an extension worker. One additional family worker increases this probability by 1.4 to 1.6%, and the fact of acquiring one supplementary acre of land by the head adds 0.1 percentage points. Whereas, one more year lived by the head raises the chance to access to extension by 0.3%, and an additional year of experience, proxied by the squared years of schooling, achieved by the head would also increase positively the probability to access extension, even if the magnitude of the effect is very weak. At the same time, there does not seem to be a bias in extension delivery against female headed housheolds; even though the point estimate is negative it is not significant at conventional levels.

Introducing some of the insturments starting with column 2 highlights that supply-side factors have a significant impact on producers' ability ot access technical advice. Being located in a village where the service provider who has received a traininig of trainers course increases the probaiblity of being vistied by between 2.1 and 2.4 points wheras problems of funding or long distances reduce this probability by about 7 or 5 points, respectively. Higher levels of local government spending clearly increase access to extension, with the elasticity between 3.2% and 3.6%. At the same time, and holding all the above factors constant, the lack of significance for the NAADS dummy suggests that this program has thus far failed to improve the outreach of advisory services.[10] In fact, In fact, the negative and significant coefficient on supervision of providers by local government suggests that some of the concerns about decentralization raised by the literature -in particular concerning the lack of technal and supervisory capacity on the- may reduce outreach and effectiveness of the provision of technical advisory services as well (column 3).

Finally, the regressions also support the notion that hosueholds' social status and their participation in local government decision-making is an important determinant of gaining access to extension (column 4). Producers who are members of the LC1 committee are 4.2 points more likely to have access to extension; knowing about the ways in which local revenues are spent -a variable that overlaps almost perfectly with

[9] Coefficients reported denote marginal effects of a given variable at the mean of all other variables and district dummies are included throughout.
[10] This result, which is consistent with the descriptive evidence reported earlier, suggests that higher levels of output in NAADS as compared to non-NAADS districts (Nkonya *et al.* 2004) are more likely to be a reflection of the fact that the program selected districts with higher potential rather than it having had a big impact.

the former- adds another 4.9 points to this probability. Although consistent with fears that high levels of decentralization that lack clear channels of accountability may result in a bias against the poor who are less able to be able to access information or make their voices heard in local decision-making (Platteau and Gaspart 2003), this suggests that NAADS should careful monitor patterns of access to technical advisory services in order to prevent elite capture of farmer groups and other project-related institutions. Complementing this with monitoring of farmers' actual knowledge on specific issues may be useful to ascertain whehter under local govenrments supervision, the links between extension and the research can be maintained, and to take corrective actions if needed.

4.2 Impact of extension on crop diversification and input use

Results of instrumental variable regressions of crop diversification and use of purchased inputs (equation 2) are reported in tables 6 and 7. In addition to supporting the conclusion that access to extension has a significant impact on adoption of high value crops such as coffee, fruits, vegetables, and livestock, as well as purchased inputs, they also suggest that, possibly due to the presence of spillovers, the level of access to extension at the district level, also has an important impact on most of these outcome variables. Point estimates suggest that instrumented access to extension increases the propensity to adopt coffee, fruits and vegtables, cattle, and milk by 3.5, 6.6, 13.8, and 8.9 percentage points, respectively, while it increases the probability of using seeds and chemicals by 23.4 and 15.4 points. In fact, an instrumented regression for the level of diversification that uses the number of crops grown as the right hand side variable points towards access to extension increasing the number of crops grown by any given producer by almost 50 percentage points. In addition, we note that increasing the share of producers in the community who have access to extension by 1% would result in an additional increase in the propensity of producers to produce fruits, milk, or cattle, by 20.4, 45, and 63 percentage points or an additional "indirect" increase in the number of crops produced by 109%. This is ocnsistent with the hypothesis that improved access to technical advice can help to imncrease levels of diversification in Uganda.

Considering other factors adds a number of insights. The coefficient on number of adult family members is positive and highly significant for all products except coffee (where natural suitability may be more of a constraint), implying that higher value crops use labor more intensively, an issue that is of relevance in a setting where the capacity of non-agricultural labor markets remains limited. The level of education by the head is consistently positive (although increasing at a decreasing rate for crops and at an increasing rate for livestock), supporting the notion that the ability to process greater amounts of information is critical to taking up higher value products, consistent with evidence from other countries (Asfaw and Admassie 2004). The negative, though mostly insignificant sign of land owned for all the crops highlights

the land-augmenting nature of crop-based intensification while the positive coefficient in the case of livestock highlights that access to greater amounts of land will be required for the latter. Finally, the positive coefficients on access to various types of infrastructure suggest that the ability to access markets will support tendencies towards diversification.

4.3 The scope for increased productivity

One of the drawbacks of the NSDS is that the large sample needed to generate district level estimates did not allow to collect the detailed information on agricultural inputs and outputs needed to make inferences on productivity that could then be linked to the information on access to extension. To overcome this shortcoming, we used data from the 1999/00 UNHS to establish a direct and an indirect link between access to extension services and productivity that is used here in order to make inferences on possible productivity impacts of increased access to extension.[11] This should be treated more as an illustrative first approximation, to be confirmed by more detailed future investigation, rather than a definitive figure.

Results from estimating a stochastic production frontier are reported in appendix table 1. The test for all the βs equaling 0 is rejected, suggesting that he translog is indeed the appropriate functional form. With, 0.57, the average producer's distance from the frontier is quite large, suggesting considerable scope for improving productivity even within the current technology set, a result that is supported by the presence of significant variation in this distance across communities. Even though non-availability of the supply-side variables which we use as instrumental variables in the 1999/00 survey precludes direct estimation of a relationship between extension and productivity, descriptive statistics suggest that productivity is significantly higher for producers with as compared to those without access, something that is also confirmed by regression analysis which suggests that, other factors (household and community characteristics) being held equal, diversification into one additional crop is associated with a productivity difference of about 7 percentage points.

As policy makers are concerned not only about productivity but also about distributional aspects, we use this value, together with the coefficients from the earlier regression to assess the impact of a very simple experiments that would provide access to all producers who indicated that they are willing to pay for extension services. Results, presented in table 9, illustrate that, in the aggregate, doing so would have quite a significant impact; through an increase in the number of crops produced by the average household of 0.76, it would be predicted to bring about a productivity gain of about 4.5 percentage points. More interestingly, though, disaggregating this impact by quintiles of per capita expenditure suggests that gains

[11] We prefer the indirect measure as it gives an opportunity to account more directly for spillover effects which have been found to be quite important in the empirical literature on the subject(Traxler and Byerlee 2001).

would be distributed equitably but that, largely due to the presence of an external effect, the poorest groups in society would actually benefit most.

Even though these results should be taken as illustrative only, and it would be highly desirable to substantiate these findings more directly with more detailed data, they suggest not only that, in Uganda, a high level of technical inefficiency (0.57 points on average compared to other countries) provides considerable scope for advice to have a positive impact on production outcomes but also that, in this context, strategies to better exploit producers' willingness to contribute could not only contribute to better access to improved technology but also have a very beneficial equity impact. In fact, from the data analyzed here, it appears that capitalizing more on this willingness might provide an opportunity for government programs such as NAADS to increase their impact in a way that could, by enhancing accountability, in the end benefit everybody.

5. Conclusion

We conclude by drawing some implications, both methodologically and for the case of Uganda. At a methodological level, there is little doubt that, in countries where agriculture continues to be an important part of the economy (i.e. definitely in Africa), service delivery and provider surveys that have now become a standard component of household survey programs should include information on agricultural advisory services as well. The discussion in this paper shows that having information on the supply of such services, possibly linked to data on government spending under such programs, makes it much easier to have potential to provide information on the considerable scope for a well-designed interface to regular surveys

There is little doubt that, for Uganda to continue its earlier success in reducing poverty, ways to improve agricultural productivity will be critical. In fact, the recent launch of the NAADS, within the broader context of the PMA, indicates not only the government's awareness of the issue but also its determination to decisively address it by expanding access to technical assistance in the context of broader rural development at the local level. Using the NSDS to explore this issue in more detail allows us to make a number of contributions to the overall policy debate.

We demonstrate that, in view of huge differences in technical efficiency across producers, the potential for measures to increase farmers' knowledge about advanced agricultural practices is indeed considerable. Descriptive statistics illustrate that those with access to extension perform better than those without in almost every measure, a result that is supported by regression analysis. Furthermore, by demonstrating

that it is the poor who tend to be excluded from access to such services, we confirm that expanding access to extension can be justified not only in terms of productivity but also from an equity perspective.

At the same time, we find that implementation of the government's efforts thus far has failed to fully realize the potential from better extension access in a number of respects. The failure to find similarly significant differences in agricultural technology between NAADS and non-NAADS districts suggests that this program has not yet made a significant impact on the ground. Survey results also point towards a considerable amount of unsatisfied demand for extension. While about one third of the farming population would be willing to pay for visits by an extension worker,[12] only 14% actually received such a visit. Our data suggest that thus far the NAADS program appears to have failed to improve the outreach and efficiency with which extension is delivered. In fact, the evidence of significantly lower levels of extension outreach in cases where local government supervises agents and the importance of involvement in local politics in gaining access to extension advice indicate that, unless appropriate institutional arrangements are in place, the delivery of technical advice in a decentralization may be guided more by political expediency than by objective technical needs.

Simulations of the potential impact of providing better access to extension advice suggest that efforts towards this end may well be worth undertaking; even accounting for possible weaknesses in the data and using conservative figures suggests that, merely by providing those who would be willing to pay with access to extension could increase productivity by 4.5 percentage points. Moreover, in view of the importance of externalities that emerges from our regressions, a large part of these productivity benefits will accrue to the poor who can further benefit if some of the proceeds from extension payments will be earmarked to provide advice in a way that is targeted to the poor.

While our results suggest that increased access to extension visits in Uganda could have a significant impact on productivity and equity, such visits are one of a number of channels (in addition to radio, input suppliers, etc.) through which farmers can gain access to the knowledge that is an increasingly important part of the agricultural production process. In fact, the knowledge transmitted through extension is likely to be even more effective if complemented by access to infrastructure, markets, and other support services. Given the importance of access to agricultural technology emerging from our analysis, more detailed evidence on interactions and complementarities between these different factors would be important for government to better understand the factors constraining growth of agricultural productivity and the extent to which these differ across types of farmers. Such analysis could be of great importance to identify avenues for helping to improve rural incomes and thus ensure that the impressive record of

[12] While we lack information on the marginal cost of extension worker visits, the low levels of public spending on agricultural extension suggest that the declared willingness to pay would, in the vast majority of cases, be higher than the cost of providing such services.

equitable poverty reduction that had characterized Uganda in the pre-2000 period can be sustained in the future.

Table 1: Main household characteristics

	Total	Quintile of per capita expenditure				
		1	2	3	4	5
Location and composition						
Rural	75.37%	91.21%	87.39%	82.42%	68.69%	47.15%
Household size	5.2	6.2	5.8	5.3	4.8	3.9
Head's age	41	43	43	42	41	38
No of members 14-60 years old	2.6	3.0	2.8	2.6	2.5	2.3
Members < 14 years	2.4	3.0	2.8	2.5	2.2	1.4
Head female	22.17%	23.81%	20.32%	20.21%	22.75%	23.80%
Head's years of schooling completed	5.7	3.5	4.5	5.1	6.2	9.2
Welfare and asset endowments						
Owning land	60.09%	69.75%	72.27%	68.77%	55.14%	34.51%
Cultivating land	62.69%	72.59%	74.64%	71.65%	57.80%	36.77%
If yes, area cultivated (ac)	2.57	2.01	2.16	2.50	3.29	3.54
Iron sheet roofs	54.16%	34.60%	47.34%	53.83%	61.75%	73.17%
Distance to district headquarters	26.92	31.85	29.56	27.20	25.48	20.54
Number of observations	17521	3505	3504	3504	3504	3504
		Region			Head in agriculture	
	Center	East	North	West	No	Yes
Household composition						
Rural	66.16%	78.96%	76.32%	79.97%	45.07%	88.88%
Household size	4.72	5.46	5.62	5.11	4.31	5.61
Head's age	40	42	41	41	39	42
No of members 14-60 years old	2.41	2.67	2.91	2.65	2.41	2.75
Members < 14 years	2.15	2.57	2.55	2.27	1.76	2.65
Head female	25.29%	18.49%	26.50%	19.36%	26.74%	20.14%
Head's years of schooling completed	6.8	5.8	4.7	5.4	7.5	4.9
Welfare and asset endowments						
Owning land	48.96%	68.32%	51.99%	69.18%	0.34%	86.55%
Cultivating land	53.07%	71.91%	54.30%	69.57%	0.37%	90.29%
If yes, area cultivated (ac)	3.89	2.17	2.17	2.27	1.47	2.58
Iron sheet roofs	75.33%	46.12%	14.27%	73.49%	59.67%	51.71%
Distance to district headquarters	28.65	20.92	29.82	29.00	20.41	29.77

Source: Own computation from 2003 National Service Delivery Survey

Table 2: Access to and demand for extension services

	Total	Quintile per capita expenditure				
		Q1	Q2	Q3	Q4	Q5
1. Actual access pattern						
Heard of PMA	37.6%	26.4%	35.6%	39.4%	44.4%	49.2%
Visited by extension worker last 12 months	13.8%	10.6%	11.7%	13.1%	17.0%	20.5%
of which gov't	66.0%	66.3%	67.9%	63.0%	66.2%	66.7%
of which private	16.8%	18.2%	15.9%	16.2%	15.3%	19.0%
of which others	17.2%	15.5%	16.2%	20.8%	18.5%	14.3%
For those visited:						
Monthly visits	38.6%	36.4%	37.0%	39.6%	39.1%	40.5%
Visited 2-4 times a year	32.7%	32.6%	33.0%	30.8%	33.8%	33.3%
Visited yearly or less	28.7%	30.9%	30.0%	29.6%	27.2%	26.2%
Paid for extension services	45.6%	44.7%	41.3%	44.4%	46.4%	51.4%
Satisfied with services	87.8%	85.6%	87.5%	89.2%	89.2%	86.7%
2. Willingness to pay						
Willing to pay for extension (%)	28.8%	22.5%	26.2%	29.4%	33.1%	38.3%
if yes, payment per visit (US $)	1.92	1.70	1.43	1.93	1.92	2.83

Source: Own computation from 2003 National Service Delivery Survey

Table 3: Patterns of production and input use for agricultural producers

	Total	Access to extension			NAADS district		
		No	Yes	Test	No	Yes	Test
1. Main Agric. Activity							
Crop farming as main activity	93.6%	94.3%	89.0%	***	93.1%	96.5%	***
Animal husbandry as primary activity	3.9%	3.3%	8.0%	***	4.3%	1.8%	***
Animal husbandry as secondary activity	38.6%	36.3%	53.3%	***	38.6%	38.5%	
2. Diversification and cash crop production							
Produces coffee	21.8%	21.1%	26.1%	***	23.7%	12.0%	***
Produces cattle	26.9%	23.3%	48.9%	***	27.8%	22.6%	***
Produces milk	16.2%	13.6%	31.6%	***	16.8%	13.0%	***
Produces vegetables	12.0%	11.2%	17.2%	***	12.0%	12.0%	
Produces fruit	14.1%	13.3%	19.0%	***	13.7%	16.1%	***
Produces maize	69.3%	69.1%	71.0%		70.1%	65.5%	***
Produces matooke	53.5%	53.3%	54.8%		54.5%	48.2%	***
Number of High value items produced	1.5	1.4	2.0	***	1.5	1.4	***
3. Input use							
Distance to next input market	15.50	15.51	15.46		16.23	11.97	
Improved/ hybrid seeds							
Knowledge on input improved since 2000	25.2%	22.2%	43.6%	***	25.0%	26.1%	
Access to input improved since 2000	20.5%	17.6%	38.3%	***	20.3%	21.7%	
Input is used	29.2%	25.7%	50.8%	***	29.3%	28.3%	
Herbicides, fungicides, pesticides							
Knowledge on input improved since 2000	16.9%	14.7%	30.4%	***	16.2%	20.4%	***
Access to input improved since 2000	12.8%	10.8%	25.5%	***	12.4%	15.0%	**
Input is used	15.9%	13.4%	31.2%	***	14.8%	21.1%	***
Animal drugs							
Knowledge on input improved since 2000	17.9%	14.7%	37.8%	***	17.7%	18.8%	
Access to input improved since 2000	14.9%	11.8%	33.7%	***	14.9%	14.6%	
Input is used	22.2%	17.6%	50.7%	***	22.5%	20.8%	
No. of observations	11605	10037	1568		9724	1881	

Source: Own computation from 2003 National Service Delivery Survey

Note: the column “test” reports results from the t-test for equality of means between the two sub-groups with * denoting significance at 10%, **significance at 5%,and *** significance at 1%.

Source: Own computation from 2003 National Service Delivery Survey

Table 4: Comparison between NAADS and non-NAADS districts

	ALL DISTRICTS				
	Total	**Center**	**East**	**North**	**West**
Accountability and total spending					
Controlled by district agricultural office	70.7%	78.9%	70.6%	63.0%	66.8%
Controlled by local government admin.	24.4%	17.9%	26.5%	28.7%	26.9%
Controlled by line ministry	4.9%	3.2%	2.9%	8.3%	6.3%
Local gov't spending p.c.2002 (US $ equiv)	17.79	20.02	15.92	18.00	16.98
on production or marketing	0.55	0.75	0.46	0.64	0.33
Most serious constraints to extension delivery					
Funding	44.7%	53.9%	39.1%	39.8%	43.2%
Inadequate facilities/staff	37.4%	27.2%	50.3%	29.4%	41.8%
Long distances	7.6%	8.8%	5.3%	9.8%	7.1%
Insecurity	3.3%	0.0%	0.3%	17.6%	0.0%
Training received by extension officers (%)					
Training of trainers course	68.2%	70.1%	68.4%	69.2%	65.1%
Communication course	61.3%	63.2%	63.2%	57.8%	59.4%
Technical refresher course	47.7%	52.4%	52.0%	39.8%	43.3%
Households covered for crop production	711.87	630.36	655.10	968.02	669.35
Households covered for animal production	776.06	1155.13	662.29	466.16	616.54
	NAADS DISTRICTS ONLY				
	Total	**Center**	**East**	**North**	**West**
Accountability and total spending					
Controlled by district agricultural office	40.2%	31.4%	35.7%	50.0%	47.5%
Controlled by local government admin.	49.7%	57.2%	54.8%	20.0%	52.5%
Controlled by line ministry	10.2%	11.4%	9.5%	30.0%	0.0%
Local gov't spending p.c.2002 (US $ equiv)	16.63	15.55	16.84	16.23	17.47
on production or marketing	0.63	0.84	0.56	0.78	0.46
Most serious constraints to delivery					
Funding	32.2%	11.1%	36.4%	50.0%	35.6%
Inadequate facilities/staff	44.9%	50.0%	52.7%	31.0%	37.8%
Long distances	8.9%	16.7%	7.3%	4.8%	6.7%
Insecurity	1.9%	0.0%	0.0%	14.3%	0.0%
Training by service providers					
Training of trainers course	62.3%	47.4%	78.2%	42.9%	64.6%
Communication course	61.7%	50.0%	63.6%	61.9%	68.8%
Technical refresher course	50.0%	34.2%	58.2%	38.1%	58.3%
Crop production	856.03	915.43	730.07	341.92	1338.18
Animal production	497.80	557.24	375.27	420.13	638.35

Source: Own Computation from 2003 National Service Delivery Survey

Table 5: Determinants of Access to Extension

	Probit regressions				Sample
	(1)	**(2)**	**(3)**	**(4)**	**mean**
Head's age	0.003***	0.003***	0.003***	0.003**	42
	(2.60)	(2.71)	(2.76)	(2.15)	
Head's age squared	-0.000**	-0.000**	-0.000**	-0.000*	2039.399
	(2.21)	(2.32)	(2.37)	(1.79)	
Head's years of schooling	0.006***	0.006***	0.006***	0.004*	4.872
	(2.77)	(2.92)	(3.06)	(1.90)	
Head's years of schooling squared	0.000	0.000	0.000	0.000	41.083
	(0.70)	(0.59)	(0.48)	(1.32)	
Iron sheet roof	0.038***	0.039***	0.040***	0.038***	0.518
	(5.09)	(5.26)	(5.30)	(5.09)	
Area of land owned	0.001***	0.001***	0.001***	0.001***	4.673
	(4.37)	(4.48)	(4.60)	(4.58)	
Number of available adult labor	0.016***	0.015***	0.015***	0.014***	2.091
	(5.80)	(5.51)	(5.49)	(5.07)	
Female head	-0.010	-0.011	-0.012	-0.008	0.200
	(1.24)	(1.35)	(1.41)	(0.93)	
Per capita local gov't spending		0.034**	0.036***	0.032**	2.803
		(2.47)	(2.65)	(2.30)	
NAADS district		0.016	0.009	0.013	0.163
		(1.58)	(0.91)	(1.34)	
Extension worker received training		0.024***	0.022***	0.021***	0.589
		(3.37)	(3.10)	(3.06)	
Facilities/Funding key problems for prov.		-0.078***	-0.065***	-0.062***	0.768
		(8.42)	(6.72)	(6.45)	
Long distance key problem for provider		-0.050***	-0.047***	-0.047***	0.045
		(3.38)	(3.20)	(3.16)	
Local government supervises			-0.030***	-0.030***	0.152
			(3.59)	(3.56)	
Member of LC1 committee				0.042***	0.209
				(4.67)	
Knows how graduated tax was spent				0.049***	0.079
				(6.05)	
Observations	11509	11505	11505	11494	
Log likelihood	-4409.83	-4370.69	-4364.10	-4320.19	
R-squared					

Robust z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Note: Regional dummies included but not reported

Table 6: Impact of extension access on crop diversification

	Coffee	Fruits	Production of Vegetables	Cattle	Milk
Predicted access to extension	0.035***	0.066***	0.066***	0.138***	0.089***
	(3.32)	(5.44)	(6.40)	(11.04)	(8.94)
Mean access to extension	0.073	0.204***	0.046	0.628***	0.448***
in district	(1.19)	(2.97)	(0.83)	(9.43)	(8.79)
Female head	-0.034***	0.003	-0.007	-0.054***	-0.022***
	(3.79)	(0.28)	(0.74)	(5.24)	(2.72)
No. of adult workers	-0.003	0.014***	0.010***	0.033***	0.024***
	(0.80)	(3.97)	(3.48)	(9.60)	(9.51)
Head's age	0.002*	0.002	-0.002	0.004**	0.003***
	(1.96)	(1.29)	(1.62)	(2.52)	(2.59)
Head's age squared	-0.000	0.000	0.000	-0.000*	-0.000
	(0.99)	(0.02)	(0.69)	(1.70)	(1.52)
Head's years of schooling	0.012***	0.020***	0.013***	-0.004	-0.003
	(5.32)	(7.55)	(5.62)	(1.57)	(1.26)
Head's years of schooling sq.	-0.001***	-0.001***	-0.000***	0.001***	0.001***
	(3.57)	(5.35)	(3.12)	(3.11)	(3.88)
Iron sheet roof	0.092***	-0.015	0.023***	0.030***	0.003
	(11.67)	(1.61)	(2.97)	(3.26)	(0.38)
Area of land owned	-0.000*	0.000	-0.000	0.003***	0.001***
	(1.79)	(1.48)	(0.86)	(5.31)	(4.45)
Access to feeder road	0.033***	0.032***	0.040***	0.027**	0.021**
	(3.05)	(2.60)	(3.88)	(2.19)	(2.16)
Access to community road	0.047***	0.053***	0.020**	0.030***	0.015*
	(4.70)	(4.70)	(2.06)	(2.68)	(1.74)
Observations	11310	11310	11310	11310	11310
Log likelihood	-4860.47	-5898.86	-4593.89	-5537.47	-4150.28

Robust z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Regional dummies included but not reported

Table 7: Impact of extension access on use of modern inputs

	Use of		No. of cash
	Seeds	**Chemicals**	**Crops grown**
Predicted access to extension	0.234***	0.154***	0.481***
	(17.02)	(14.29)	(11.30)
Mean access to extension	0.273***	0.140**	1.094***
in district	(3.53)	(2.44)	(4.97)
Female head	0.000	-0.001	0.005
	(0.11)	(1.04)	(1.15)
No. of adult workers	-0.000	0.000	-0.000
	(0.30)	(0.86)	(0.28)
Head's age	0.000**	-0.000	-0.001
	(2.12)	(1.51)	(1.63)
Head's age squared	0.006**	0.011***	0.042***
	(1.97)	(5.10)	(4.93)
Head's years of schooling	0.081***	0.030***	0.185***
	(8.04)	(4.02)	(6.58)
Head's years of schooling sq.	0.000	0.000	0.003***
	(0.86)	(0.60)	(4.50)
Iron sheet roof	0.008*	0.009***	0.100***
	(1.95)	(2.87)	(8.19)
Area of land owned	-0.023**	-0.031***	-0.154***
	(2.04)	(3.47)	(4.85)
Access to feeder road	0.026**	0.009	0.192***
	(2.03)	(0.95)	(5.22)
Access to community road	-0.009	0.002	0.206***
	(0.76)	(0.23)	(6.03)
Observations	11453	11453	11453
Log likelihood	-6363.56	-4601.92	

Robust z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Note: Regional dummies included but not reported

Table 8: Illustrative: simulations of the impact of better extension access

	Overall	**Quintile of per capita expenditure**				
		Q1	**Q2**	**Q3**	**Q4**	**Q5**
Baseline scenario						
Number of high value items produced	1.60	1.28	1.47	1.63	1.74	1.90
Extension to those willing to pay						
Predicted number of HVI produced	2.36	2.21	2.27	2.35	2.43	2.53
Pred. diversification gain	0.76	0.93	0.80	0.72	0.69	0.63
Pred. increase in productivity	4.5%	5.6%	4.8%	4.3%	4.1%	3.8%
Extension to two lowest quintiles						
Predicted number of HVI produced	2.56	3.40	3.38	1.99	1.99	2.02
Pred. diversification gain	0.96	2.12	1.91	0.36	0.25	0.12
Pred. increase in productivity	5.7%	12.7%	11.5%	2.2%	1.5%	0.7%

Appendix

Table 1: Stochastic Frontier production function estimation for those involved in crop farming

	Translog specification
	Log output value of all crops
Log total number of employees engaged until harvesting	0.459*
	(1.89)
Log costs for soil preparation (oxen, tractor)	-0.055
	(1.39)
Log value of pesticides	0.021
	(0.49)
Log value of fertilizers (manure, organic)	-0.102***
	(2.61)
Log value of seeds	-0.105**
	(2.18)
Log land input 1999 (acres)	1.005***
	(5.97)
Labor squared	0.029
	(0.70)
Capital squared	0.013***
	(3.73)
Pesticides squared	0.012***
	(3.75)
Fertilizers squared	0.011***
	(3.65)
Seeds squared	0.018***
	(7.84)
Land squared	-0.103***
	(3.48)
Labor*Capital	-0.028***
	(3.46)
Labor*Pesticides	-0.004
	(0.29)
Labor*Fertilizers	0.017
	(1.35)
Labor*Seeds	-0.016
	(0.64)
Labor*Land	-0.100
	(1.57)
Capital*Pesticides	-0.001
	(0.75)
Capital*Fertilizers	-0.001
	(0.64)
Capital*Seeds	-0.002
	(0.43)
Capital*Land	-0.006
	(0.79)
Pesticides*Fertilizers	-0.002*
	(1.66)
Pesticides*Seeds	-0.012***
	(3.86)
Pesticides*Land	0.004
	(0.47)
Fertilizers*Seeds	0.000
	(0.05)
Fertilizers*Land	-0.003
	(0.36)
Seeds*Land	0.009
	(0.54)
Constant	11.342***
	(31.90)
Observations	8254
Sigma2	3597.123
Gamma	0.99
Sigma_u2	3596.893
Sigma_v2	0.229
Testing Translog specification vs. Cobb-Douglas	194.60***
(H0: interaction and squared terms are jointly =0)	(0.000)

Absolute value of z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%, Note: Regional dummies included but not reported

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