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Abstract

We used a randomized control trial to measure how the free distribution of hybrid seeds and chemical fertilizers for maize production affected their adoption by small-scale farmers in the subsequent seasons. Information on their demand for the same inputs was collected through sales meetings which we organized in 2009 and 2011 where the inputs were actually sold. It revealed that the demand for the inputs of the free-input recipients was significantly higher in both 2009 and 2011 than that of non-recipients; that of the neighbors of the recipients fell in-between. The initial treatment assignment has a persistent influence on the farmers' demand over the two years whereas the difference between the free-input recipients and their neighbors has been reduced to some extent. The reduction of their gap in the application level of fertilizers is partly driven by social learning through information networks. However, there was no clear

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evidence of learning effects from peers on the demand for the hybrid seeds. One possible explanation of these mixed results is due to slow dissemination of the new inputs with low profitability. (JEL O13, O33, O55)

1 Introduction

Technology adoption is the key to realizing dramatic improvement in agricultural productivity as proved in Asia's Green Revolution which occurred since the late 1960s and which was nothing but the development of new technologies (or new seed varieties) invented through scientific research and their dissemination (Hayami and Ruttan, 1985). Given the current low application of technologies, there seems to be ample room for small-scale farmers in Sub-Saharan Africa to highly enhance their productivity by the adoption and adaptation of technologies which have been used in the other parts of world. However, many of the productivity enhancing technologies have not been widely adopted in this area.

There has been a growing body of empirical literature on technology adoption in agriculture in Africa. Many studies confirm the high average return of agricultural inputs or methods, for example, fertilizers for maize production in Kenya (Duflo et al., 2008) and hybrid seeds in Kenya (Suri, 2011), fertilizers for cocoa production in Ghana (Zeitlin et al., 2010), and NERICA rice variety in Uganda (Kijima et al., 2008). Nonetheless, such technologies tend to diffuse slowly and incompletely. Recent studies on technology adoption in agriculture among small scale farmers have focused on social learning since it is considered to be a key determinant of the speed of the diffusion of new technologies and hence productivity growth (Foster and Rosenzweig, 1995; Munshi, 2004; Bandiera and Rasul, 2006; Duflo et al., 2011; Conley and Udry, 2010). The evidence on social learning varies substantially depending on the nature of technology and the phase of dissemination. If a technology is new and easy to learn, social learning appears to have a large impact on its adoption and adaptation.[1]

This study is also an attempt to contribute to the literature on social learning. The use of modern inputs in maize production such as hybrid seeds and chemical fertilizers is new to most of the small-scale farmers in Uganda. Because various conditions affect social learning in different manners, I believe that it is worth investigating the mechanism of the dynamic adoption process with social learning in the context of maize production in Uganda, where the dissemination of technologies relating to intensive farming methods is in its nascent stage. Moreover, we use a superior approach to address the issue by combining a randomized control trial of the free distribution of new inputs to small-scale farmers, sales meetings eliciting the input demand information from each of the farmers in subsequent cropping seasons, household-survey panel data tracking household characteristics and maize production over years, and detailed social network information among the target farmers. This approach has two major advantages in measuring the social learning effect. Firstly, the initial randomized control trial can create exogenous variation in the distribution of who are exposed to the new technology among the experiment participants, which is often endogenous.[2]

Secondly, the detailed information of the social networks among the sample farmers enables us to distinguish peers living in geographic proximity and peers with whom information on farming practices is exchanged. As pointed out by Manski (1993), the proper definition of a reference group is crucial to identifying the social learning effect. Nonetheless, only few studies have collected and used the social interaction information to construct a proper reference group in the technology adoption literature.[3] Using this unique and rich information,

[1]For instance, Conley and Udry (2010) showed evidence on the social learning of the fertilizer application among small-scale pineapple producers through information networks in Ghana, while Duflo et al. (2008) found that farmers in Kenya learned not from others but from own experience to find the optimal application level of fertilizer on maize production. These contrasting findings are not a puzzle once we understand that the farming practice is not new to Kenyan farmers, but it is to Ghanian farmers as pointed out by Foster and Rosenzweig (2010).

[2]Recent studies on technology adoption often use field experiments to measure the social-learning effects (Kremer and Miguel, 2007; Duflo et al., 2011; Dupas, 2010).

[3]Notable exceptions are studies by Conley and Udry (2010) and Duflo et al. (2008).

we analyze the dissemination process of the modern inputs for maize production over two years.

Our previous study (Matsumoto et al., 2013) presents the first episode of a series of interventions and examines the outcomes of the first sales meeting held in 2009 just after the cropping season in which the free agricultural inputs were applied by the recipients. It observed the farmers' purchasing behaviors on the same inputs and found that the free input recipients purchased significantly more of the same inputs in the subsequent season and that the input demand of their neighbors (who live in the treatment villages but were not given free inputs) fell in between the free input recipients and the control households (who live in the control villages where no free inputs were given). The neighbors of the free input recipients purchased more inputs if their "information peers" (whom they communicate with) have a higher yield with the use of the inputs compared to the local maize yield.

This paper presents the second episode of the experimental interventions on maize production targeting small-scale farmers in Uganda conducted since 2009 in order to examine the technology adoption of productivity-enhancing inputs and their dissemination process. For this purpose, we implemented a series of interventions. The series started with a randomized control trial in 2009 in which modern agricultural inputs for maize production were distributed for free to the target households living in 46 out of 69 randomly selected target villages for this study. The agricultural inputs given for free were maize hybrid seeds and chemical fertilizers, which had been used by only a few farmers in Uganda before our intervention. The second and third exercises were sales meetings that we organized in each target village to sell the same inputs to the target households.

Those sales meetings, held in 2009 and 2011, gave us an opportunity to observe the change in adoption behaviors and the dissemination process of a new technology. Also it enabled us to examine the farmers' adjustment process of the application level or the input composition of multiple inputs. We obtained the following empirical results. 1) The input demand of the free-input recipients in the treatment villages was significantly higher in 2011 than that of non-recipients living in the control villages and also that of the recipient's neighbors who live in the treatment villages. Thus, the initial treatment status has a persistent influence on the farmers' adoption over the two years. 2) However, the difference in demand across the treatment status has been reduced significantly, in particular, between the free-input recipients and their neighbors for fertilizers. 3) The reduction of the gap in the application level of fertilizers is partly driven by social learning from information peers. 4) In contrast, we found no evidence of learning effects from peers on the demand for the hybrid seeds. One possible explanation of these mixed results of the learning effects is due to low profitability of the modern inputs. The profit gain from the use of the modern inputs was almost zero or negative on average. Although the yield gain from the use of the modern inputs was large and 1.2 tons per ha, the production with the modern inputs required more labor. In addition, the input-output price ratio was less favorable to the producers. Consequently, the speed of the dissemination of technologies with low profitability was slow and thus no clear dissemination pattern of the hybrid seeds through social learning was observed.

The rest of this paper is organized as follows. Section 2 reviews the related literature and provides background information on the current farming system in Uganda. Section 3 describes the experimental design and survey data used in this study. Section 4 discusses the detail of a key variable in this study which is the profitability of maize production with and without the modern inputs. Section 5 reports the purchase quantities of the modern inputs in the sales events by the initial treatment status. Section 6 presents hypotheses on adoption and dissemination of the new inputs and shows the regression analyses. Finally, Section 7 concludes the paper.

2 Background

In the case of Uganda, evidence of the profitability of modern agricultural inputs is sporadic, and some of the available estimates are conflicting. The results of trial plots for experimental purposes indicate the very high physical returns of modern inputs. For instance, based on a report by the National Agricultural Research Organization (NARO) in Uganda, the difference in average crop yields between NARO trial stations that use modern inputs and the plots of local farmers who typically use no modern inputs shows a considerable physical yield response to the inputs, indicating large potential profits (Bayite-Kasule, 2009). Namazzi (2008) reports the results of fertilizer response trials on maize that were carried out in 2003 across different districts by Sasakawa Global 2000, an international nongovernmental organization that promotes agricultural technologies in several African countries, showing that fertilizer application was generally profitable, although the level of profitability varied by region.

Unlike the reports from the trial plots, the results of local farmer surveys tend to be varied. Matsumoto and Yamano (2009) estimate the maize yield function, using plot-level panel data from 2003 and 2005. They compare the marginal physical product of inorganic fertilizer with its relative price to maize grain and conclude that the relative price is too high for the average farmer to make a positive profit from the use of fertilizer. Nkonya et al. (2005) also report that the use of inorganic fertilizer does not appear to be profitable for most farmers, based on the results of their farm household survey.

The inputs' low average economic return on the ground does not necessarily mean that such technologies are not profitable to all farmers who face different weather, soil, and market-access conditions, given the high performance of modern inputs in demonstration plots. Returns could vary among regions and even individuals, depending not only on their environment and conditions but also on their knowledge of how to use the technologies. Several recent studies point out the importance of heterogeneous returns to agricultural technologies, to understand the reasons of the low adoption rate of technologies that have high average expected returns. Suri (2011) argues, in her study of maize production that covers most of the maize-growing areas in Kenya, that the low adoption rate of modern inputs can be accounted for by the heterogeneity of the returns to modern inputs. That is, although the average return is high, the return differs largely across regions, individuals, and time, and hence, some farmers do not use them persistently. Zeitlin et al. (2010) also report that the high average effect of modern inputs on cocoa production among Ghanian farmers were found to be consistent with negative economic profits for a substantial fraction of the farmers who were provided a package of fertilizer and other inputs on credit. A randomized control trial targeting on rice growers in Mali by Beaman et al. (2013) also found that increase in fertilizer use had a large average impact on production but no significant impact on profit.

Owing to the high transportation costs associated with the import of modern inputs, particularly in land locked countries like Uganda, the market price of those inputs is high, and hence their profitability is low (Omamo, 2003). As standard neoclassical models of technology adoption predict, the low profitability of modern inputs has been one of the major reasons for the low adoption rates and application levels among Ugandan farmers. In addition, in the past, the issue of land scarcity was not prominent in Uganda, owing to favorable climate conditions for crop production relative to the population densities of the country. Thus, Ugandan farmers have had little incentive to use modern inputs for intensive farming. Moreover, because of the low potential demand for these inputs, the supply network in Uganda has not been adequately developed to make their use financially feasible. However, conditions for farming have been changing drastically in Uganda. First, because of high population pressure and limitations on the expansion of arable land through land-clearing, land is becoming increasingly scarce; as a result, the average amount of land per household has been decreasing rapidly (National Environment Management Authority, 2007). Second, recent hikes in crop prices are prompting farmers to change their perceptions with regard to crop production. Some farmers have started considering crop production as a business enterprise rather than purely for subsistence. Third, owing to infrastructure improvements such as roads and mobile networks, farmers have had better access to commodity markets and market information than before (e.g. Muto and Yamano, 2009). These factors have created higher potential demand for intensive farming methods among crop farmers in Uganda than in the past. Since these modern inputs are experience goods, a lack of knowledge on their usage and profitability might be a large deterrent to their adoption by farmers who have little experience. Thus, we expected that small interventions involving one-time material support and training on the usage of such modern agricultural inputs would have a large impact on their adoption among Ugandan farmers in the long term.

3 Experimental design and survey data

3.1 The target population

To investigate the impact of a possible policy intervention on technology adoption by small-scale farmers and its dissemination process, we conducted a series of experimental interventions in maize production since 2009. The interventions were sequential and targeted the sites and individuals of the RePEAT panel study in Uganda.[4]

In this study, we targeted the original 639 households who still resided in 69 out of 71 RePEAT villages located in Eastern and Central regions in year 2009 plus 378 households who were neighbors of the original survey sample households living in some of the target villages. These regions are known as maize growing areas, and most farmers plant maize once or twice a year and, hence, we chose maize as the target crop in this study.[5] Indeed

[4]The RePEAT panel study is a research project targeting farmers in three east African countries, Ethiopia, Kenya, Uganda, conducted by a research team of the National Graduate Institute for Policy Studies in collaboration with local research institutes. There are 94 RePEAT villages in Uganda scattered mainly in relatively populated agricultural areas covering the southwest, central, eastern, and a part of the northern regions, which have been often visited for the surveys since 2003. Those RePEAT villages were randomly selected from the six zones stratified based on agro-climatic conditions. There were originally 10 target households randomly selected in each sample village (Yamano, et al., 2004). However, due to migration and dissolution of some of the initial survey households, about 8 percent of the households could not be tracked by year 2009.

[5]Two villages in the Eastern region which are located in Kapchowa district close to the Kenyan border are excluded from this study. Their application rates of chemical fertilizers and their adoption rates of hybrid maize seeds, according to the 2005 RePEAT survey, were exceptionally high. These two villages are very different from others in terms of their experience with modern inputs, and they were thus excluded as unrepresentative outliers.

nearly 85 percent of the target farmers planted maize in the first cropping season in 2008. The dissemination of modern inputs for maize production, however, has been very slow and incomplete. Table 1 shows the timeline of a series of interventions and a survey conducted and the sample sizes in each event.

[Insert Table 1 Here]

3.2 Experimental design

3.2.1 Randomized Control Trial (RCT) of free input distribution, 2009

The first exercise was a RCT at the village level, which took place in February and March 2009, prior to the first cropping season of the year. We distributed free maize inputs to 378 RePEAT households and asked them to allocate a quarter-acre of land (approximately 0.1 ha) as an experimental plot where the inputs would be applied.[6] The free inputs distributed were uniform or non-tailored across villages as well as individual households. They comprised 2.5 kg of hybrid seed, 12.5 kg of base fertilizer, and 10 kg of top-dressing fertilizer.[7] In addition, a 2-hour training session on the use of these modern inputs was delivered to the free-input recipients by an extension service worker whom this project hired.

These households are located within 46 treatment villages (26 and 20 in the Eastern and Central regions, respectively) randomly chosen from the 69 target villages. For convenience, we refer to the target households in the 46 villages as the "treatment households"; this

[6] There were 44 households who were the original RePEAT samples and who invited to the workshop, where free inputs were distributed, but they did not attend and hence did not obtain the inputs. We also call these households "treatment households." Thus, the treatment households can be considered as the "intent to treat" samples. Among those who received the free inputs, the compliance rate (the fraction of those who actually used the free inputs) was reasonably high despite the fact that the final decision on whether the free inputs were actually used or not was made by the recipients themselves. Most of them (88 percent) planted the hybrid seeds given for free in the first cropping season in 2009 as intended; another eight percent of the recipients planted the seeds in the second season, whereas only five percent did not plant the hybrid seeds in 2009 (as given in Appendix Table 1).

[7] The composition of the inputs is the one for growing a quarter-acre of maize which was recommended by an agronomist at the National Agricultural Research Organization, Namulonge, Uganda just for our research purpose to implement a uniform intervention. It may not be optimal under some circumstances because it does not consider the heterogeneity of agro-climatic environments, soil quality as well as the input-output price ratio.

distinguishes them from the remaining target households located in the other 23 control villages (13 and 10 in the Eastern and Central regions, respectively) that are referred to as the "control households." The geographic distribution of those villages is shown in Figure 1. The randomization for the selection of the treatment villages was implemented based on a computer-generated random number after the stratification by region.

[Insert Figure 1 Here]

3.2.2 Sales meeting, 2009

After the free input distribution, we visited the target villages three times to sell the same modern inputs as given in the free input distribution in the following seasons. Our first visit after the free input distribution was for the sales meeting that we organized in each of the target villages in August and September 2009—the intermediate period between the first and second cropping seasons—during which we revisited both 46 treatment and 23 control villages in the Eastern and Central regions to sell the same inputs that had previously been provided for free to the treatment households.[8] In the sales meeting held in each of the target villages, we invited members of all the RePEAT households, as well as randomly selected neighbors of the treatment households (called "neighbor households," hereafter).[9]

Price contingent order form The purpose of the sales experiment was to gather information on the input demand for the participating households and to make comparisons among the three groups—the control, treatment, and neighbor households. To obtain information on their demand in response to changes in price, we used a "price contingent order form" that

[8] We organized the sales meeting and provided the supplies procured from a wholesaler in Kampala by ourselves, rather than working with local input suppliers. This was because the supply network of agricultural inputs had not been well developed, and hence there were places in our target areas where we could not procure the reliable quality inputs from local retailers.

[9] To select the neighbor households, we visited each of the treatment households prior to the sales experiment, asked the household head to list 5 to 10 households living nearby, and then our enumerators randomly selected one household from the list as a "neighbor household." We expected this neighbor-household selection procedure to mitigate the selection bias that would occur if the treatment households were to invite households with special interests or relationships (e.g., friends or relatives), especially, in cases where the treatment households perceived our first intervention to be beneficial.

asked farmers how much of each input they would buy at different discount levels. Three discount rates from the market price were offered, namely, 0, 10, and 20 percent. Which discount rate would be used for the actual sales was not determined until they filled out the order form, although the participants were informed at the beginning of the sales meeting that one of the discount rates would be randomly chosen and that they would need to pay for the amounts indicated on the form at the chosen discounted price. We used a similar order form for credit purchases, on which participants indicated how much of each input they would buy if credit were available. In the proposed credit scheme, the participants were allowed to pay the balance—that is, the total payment with interest, minus the initial payment—at the end of the subsequent season after the harvest, as long as the initial payment exceeded the minimum down-payment agreed upon at the sales meeting. The interest rate and the minimum down-payment rate were randomly assigned by the project at the village level in advance, based on a computer-generating random number after the stratification by region. The interest rates offered were 5, 10, or 15 percent per cropping season. The minimum down payments offered were 20, 30, or 40 percent. After the participants filled out the forms, one of them—typically a village leader—drew a ball from a bingo cage to randomly determine the discount rate; a second ball was then drawn, to determine whether the credit option was actually available to the group. The chance of winning the credit option was one in ten. At the end of the sales experiment, the participants did, in fact, purchase inputs as indicated on the order forms at the discount level, and with or without the credit option as determined by the bingo game. Using the price contingent order form at the sales meeting, we obtained information on the participants' purchase quantity levels at three different discount rates, with and without the credit option—that is, six quantity levels in total, for each input from each participant.

3.2.3 Sales meeting, 2011[10]

We conducted a similar exercise to the sales meeting 2009 in January and February, 2011, in which we sold the modern inputs for maize production again to observe the change in the farmers' adoption behaviors. We used a modified version of the price-contingent order form and also added some minor changes to the arrangement of the sales meeting.

Firstly, we offered a wider variation of discounted prices, or 5 different discount rates, -10, 0, 10, 20, and 40 percent. Secondly, by considering the high inflation rate and market interest rates in the field, we raised by 5 percent the interest rate which was randomly assigned by the project at the village level. Lastly, we paid a random compensation to each participant in the beginning of the sales meeting so that they could use the compensation to buy inputs. The amount of compensation was determined by a bingo game played by each participant. We gave them a 50 percent chance of getting 4,000 Ush, a 30 percent chance of getting 6,000, a 10 percent chance of getting 8,000, and a 10 percent chance of 10,000 Ush. Using the compensation, participants could buy at least 1 kg of hybrid seeds if they wanted. This random compensation helped us to analyze the purchasing behaviors of those who came to the sales meeting without money.[11]

[10]In February and March, 2010, we visited 57 villages randomly selected out of 69 target villages (38 treatment villages and 19 control villages) to sell the same inputs. We did not use the price contingent order form and sold the inputs at a randomly-selected single discount price assigned to each village. Because the period for the project was limited, we could implement only a simpler version of the sales meetings unlike the meetings 2009 and 2011 to a limited number of villages. Because the choice of the sites visited was randomly selected as was the price offered in the sales meeting, our estimations in the current study will not be contaminated as long as they are properly controlled for. In the regressions presented in Section 6, the village dummies are incorporated which are expected to capture the village level effects including the effect of the visit in 2010.

[11]There was another modification in the arrangement of the sales meeting. In addition to the same three maize inputs (a variety of hybrid seed, a base fertilizer, and a top-dressing fertilizer) sold in the sales meeting 2009, we added another option for the seed variety for the participants of the sales meeting 2011. Considering the agro-climatic conditions of the villages, we picked two varieties: one is a type of maize seed for villages at high elevation, while the other is for villages at low elevation. One of these two varieties was added in the list for the sales commodities on the price contingent order form according to the elevation level of the villages. In this study, we combine the demand for these two varieties into one and do not distinguish the difference in this paper although it is interesting to see the switching behaviors of the farmers from the variety used since the beginning of the project to the one newly introduced in the sales meeting 2011. This remains as a future research topic.

3.3 Survey data

In addition to the sales meeting records on the demand for the modern agricultural inputs for maize production, we also use the survey data including the information of both the pre- and post-intervention.

3.3.1 RePEAT Survey 2005 (pre-intervention information)

Since the treatment and control households are the original RePEAT survey households, we have their historical information. Table 2 reports the major characteristics of the treatment and control villages and households from the RePEAT 2005 survey. All the village and household level variables in 2005 are independent from the treatment status, which verifies the success of its randomization.

[Insert Table 2 Here]

3.3.2 RePEAT Survey 2009 (both pre- and post-intervention information)

We use the household survey data from the RePEAT Survey 2009 conducted in October - December in 2009 in the following analyses.[12] Table 3 shows the household characteristics by household type. Although the survey was conducted after the free input distribution and the sales meeting 2009, the variables listed in the table are time-invariant or pre-intervention information. As expected, there are no systematic differences between the treatment and control households except for the experience in the use of chemical fertilizers on maize plots prior to the free input distribution. The test statistics of the mean difference across the household types are given in Column 4-6.[13]

[Insert Table 3 Here]

[12] We missed one of the treatment villages in Central region to be visited for the survey due to heavy rains during the scheduled dates. When we use variables from the RePEAT Survey 2009, we have to drop the samples from the village.

[13] The past use of chemical fertilizers was higher for the control households than for the treatment households. If it had a positive effect on the adoption of modern inputs in subsequent seasons, we would underestimate the treatment effect of our intervention without controlling for this variable and thus our estimates would be considered as conservative.

The control and treatment households have similar characteristics. They are comprised of small-scale farmers; on average, each cultivated 1.2 ha of land, contained slightly fewer than eight family members, and had a head who was 50 years old and had six years of schooling. However, the neighbor households seem different. They are smaller in family size, and in the land size cultivated; their heads were both younger and more educated. These differences between neighbor households and others, despite the sampling scheme (see the explanation of the sales experiment in the previous subsection), may indicate the fact that the treatment and control households are older than the average residents because they are the original RePEAT samples and hence have been sampled since 2003.

In addition to those household characteristic variables, we also collected information on maize production in the post-intervention season in 2009 which provides the input use, yield, and profitability on the experimental plots as well as those on the non-experimental plots. Since they are key variables which explain the adoption decision of the households in the following analyses, we describe them more in details later in the following section.

3.3.3 Data collection during the 2011 sales meeting (post-intervention information including social networks)

While visiting the villages for the sales meeting 2011, we updated the information on maize production in year 2009 and 2010 from the participants since the previous RePEAT 2009 survey. Also, we gathered information on social networks by using a preprinted list of the names of the target households in the same village, together with a questionnaire which asked them about their relationship with each of the target households in the same village.

Social network variables In order to examine the effect of social networks on the adoption behaviors of farmers, we define and use in the following sections two different types of peers: information peers and geographic peers. Information peers of a household are village residents with whom the household exchanges useful information, whereas geographic peers are those living within a close distance from the household. As working definitions, we consider, in each village, the target households with whom a sample household exchanges information on farming business as its "information peers" and those living within 0.5 km radius from a household as its "geographic peers". Table 4 shows the summary statistics of those variables. The number of target households in the treatment and control villages is different by the design of the experiment; namely, there are at most 20 households (10 treatment and 10 neighbor households) in a treatment village while there are at most 10 households in a control village. The ratio of geographic peers to the target households is not different across the household types. On the other hand, the ratio of the information peers is statistically significantly different across the household types; the largest for the treatment households, the smallest for the control households, and in-between for the neighbor households. The difference might be a consequence of our interventions to induce interactions among the target households, in particular, in the treatment villages.

[Insert Table 4 Here]

We may need to pay careful attention to the interpretation of the results in the following analyses especially in the comparison between the control households and the other types of households. The spillover effect that we try to capture in the following analyses may reflect not only the influence by the members of the information network existing before our interventions but also that by new members of the network which evolved over the course of the interventions. Our data do not allow us to distinguish these two effects. We admit the fact that the social network data are not ideal since we collected the information after the free input distribution was held and also because some of the subject households experienced using those inputs. If the network formation is endogenous and evolves over time, our interventions might have a large influence on the formation of social networks. Nonetheless, the network information is useful to observe the differential impact of our intervention across individual households involved in different social networks given their household types.

3.4 Validating the experimental design and the data

3.4.1 Balance check

As shown in Table 2, there is no systematic difference in any variable between the control and treatment villages and households in the RePEAT 2005 survey data. Table 3 also shows that the treatment and control households are similar in most of the pre-intervention characteristics. Thus, we would be able to identify the treatment effect of our free input distribution by comparing the outcome variables between the treatment and control households. The issue might be in the comparison between the neighbor and other types of households since there are systematic differences in some pre-intervention characteristics between them. Such differences may imply that they are also different in their potential demand for intensive farming methods, owing to gaps in land availability, education level, and other factors. In order to mitigate such potential sampling biases, we control for those observable factors in regressions whenever we need to do so.

3.4.2 Sample attrition

There is another issue to be considered. The sample attritions are not negligible, which are indicated by the gap in the number between the target households and the households participating in each sales meeting in Table 1. When we held the meetings, we usually announced our visit and its purpose to village leaders(who were not supposed to be the subject households) two to three weeks prior to the scheduled date via mobile phone and asked them to circulate the information to the target households. Then, we also asked the leaders to mention the compensation for the participation to the target households.[14]

However, some of the target sample households did not show up at the sales experiment because they might have been sick or not interested in the experiment, or not correctly informed about the purpose and venue of the sales experiment. As a consequence, the sample

[14]The amount of compensation was equivalent to a rural daily wage in the sales meeting 2009 and randomized and worth at least a daily wage in the sales meeting 2011.

attrition in the sales experiment was not negligible in some villages and may cause a serious selection bias when we estimate the demand curves in the following analyses. Especially, if those who were not interested in the modern inputs did not participate in the event, the estimates of the demand for the modern inputs based only on the participants' information would be upwardly biased.

Table 5 shows the results of the regressions of the participation in the sales meeting 2011. It shows that the treatment households, those who participated in the past sales meetings and those who purchased inputs in the past sales meetings, are more likely to participate, which implies that those who show more interest are more likely to attend the sales meeting.

[Insert Table 5 Here]

One simple compromise may be to consider those absentees as those who would not purchase any input even if they had participated in and to incorporate them into the samples for the estimation of the demand. In that case, the purchase quantity of the absentees is set at zero and hence the estimates of the demand can be considered as the lower bound. Since the attrition rate is different across the household type, the extent of underestimation also depends on the household type.[15] Because higher attrition causes greater underestimation, the demand estimates for the neighbor households may suffer from the bias more seriously (see the attrition rate by household type in Table 1) than for other types of households. We present the results of the demand estimates in the following analyses based on the samples both with and without the absentees in order to show the effect of the attrition on the estimated results whenever possible.

[15]There is a possibility of overestimation due to attrition if the absentees exhibit a higher demand for the inputs than the participants. This could happen, for instance, if the absentees' opportunity cost is too high to attend the sales meeting in spite of their high demand for the inputs. It seems, however, not to be the case in our study settings since the absentees in the sales meeting 2009 did not exhibit high adoption and application rates of the inputs in the seasons after the sales meeting. (Note that we collected maize production data after the sales meeting from some of the absentees through the RePEAT survey 2009 and could observe their adoption and application level.)

4 Profitability of maize production on the experimental plots

The profitability of the new inputs would be the most important factor which affects farmers' decision making on their adoption. In this section, we elaborate the data on the yield performance and profitability of maize production on the experimental plots where the new inputs given for free by this project were applied in comparison with those on the non-experimental plots where the usual farming practices were applied. Table 6 reports the yield, the value of grain output, cost of inputs, value-added, and profit on the experimental plots as well as those of the non-experimental plots. It has two parts. Part I is based on the information from all the treatment households who reported maize yields and costs while the part II is based on the information from the treatment households who planted maize on both experimental and non-experimental plots and also who reported not only maize yields and costs but also the labor inputs. In other words, the samples used in part II are a subset of those used in part I and have the full information to calculate the profit for both the experimental and non-experimental plots. Although the average yield is slightly higher among the samples in part II than those in part I, the seed and fertilizer cost are similar. They seem to be comparable and, hence, we discuss maize yield, production, and profit based on part II.

[Insert Table 6 Here]

The average grain yield of the experimental plot is 2234 kg per ha, which is larger than that of the non-experimental plot by more than 1,200 kg per ha.[16] The value of grain output was evaluated at the village level sales price, which is the median price of the prices reported by those who sold maize.[17] The seed cost for the non-experimental plot is the cost for the

[16]The yield of this season in general was lower than that of a normal season because many farmers of the study areas suffered from severe draught during the season.

[17]The value of leaves and stalks is not included in this study since there is no information on them. It is true, however, that they are sometimes used as animal fodder, soil amendment, and natural fertilizers. Thus, we may underestimate the value of production, in particular, on the experimental plots. It is also noted that there is no distinction of hybrid and local maize grain in market. Thus, we use the same village

local seeds for one hectare evaluated at the village level sales price of maize grain, while that for the experimental plot is the cost for seeds given for free evaluated at the market price for one hectare. In the non-experimental plots, the average application level of chemical fertilizers is negligible, and thus so is the cost. For the experimental plots, the fertilizer cost is about 30 percent of the grain value.

The labor input is reported for family and hired labor separately. In the survey, we collected the hours spent by family labor and the cost for hired labor by type of activity. The table presents the aggregate figures per ha. The cost for family labor is the evaluated value of the total family labor hours at the community hourly wage rate. Ideally, it should be evaluated at the shadow wage of family workers. Because the shadow wage is typically much lower than the market wage rate since the labor market is often not perfectly functioning, the market wage rate may be considered as the upper bound of the shadow wage for family labor. For the hired labor, the labor input in hours is calculated as the hired labor cost divided by the community hourly wage rate. The total labor hours for the experimental plots are 1614 hours per ha and larger than those for the non-experimental plots by 685 hours. The gap is accounted for mainly by the difference in labor input spent for fertilizer application, weeding, and harvesting (Appendix Table 3). The labor requirement for the production with the new inputs is much higher than that for the traditional production. It is also true, however, that many farmers needed to spend much more time on the experimental plots than that spent on the non-experimental plots because they were not used to using the new inputs. The gap would be shortened to some extent as they get used to using the inputs.[18]

Because of the larger labor cost on the experimental plots than on the non-experimental plots, the experimental plots' average profit becomes slightly lower than that of the non-experimental plots although their value added and income are significantly higher. Looking

level sales price to evaluate the grain outputs for hybrid and local maize.

[18]Suri (2011) reported labor inputs for maize production on plots with hybrid seeds and with local (non-hybrid) seeds separately among Kenyan farmers. Their gap is not so large as that between the experimental and non-experimental plots in our data. Also, the average total labor hours on the experimental plots were much higher than those observed in the study in Kenya although those on the non-experimental plots were comparable with the Kenyan data.

at the standard deviation of the yield and profit, their variation is larger for the experimental plots than for the non-experimental plots, implying that some experimental plots generate much larger yield and profit than the non-experimental plots. In sum, the free input distribution reveals that the hybrid seeds with chemical fertilizer application level recommended by the project enhanced yield but did not bring about a great profit for all the subject farmers. The returns to the modern inputs vary across individuals to a large extent. Also, it might be true that given the high cost for fertilizers as well as the high labor requirement for their application, the optimal application level of fertilizers could be lower than the recommended level by the project for many farmers. We will see the impact of the profitability on the input demand in the following analyses.

5 Effect of the initial treatment status on input demand

This section and the following section addresses four research questions. i) Does the treatment status in the free-input distribution in 2009 still have an influence on the farmers' adoption and application level of the productivity-enhancing inputs in 2011? ii) How did the adoption and application level change over the two years? Is there any difference in the changing pattern depending on the treatment status? iii) Which factors cause the difference in pattern if any? iv) Does own experience matter or neighbor's experience or both?

This section examines the first two, which are related to the average effect of the initial treatment status on input demand and its change over time for fact-finding purposes, and then the next section examines the last two, which are related to the mechanism which explains the differential impact of the initial treatment across the household types.

5.1 Empirical framework

We use an empirical specification identifying the average effect of the household types on the input demand in the sales meeting 2011 and its change over 2 years since 2009 while controlling for some other exogenous variables. We use the following specification of the input demand, denoted by z, of a household i located in a community j given a price level p and the availability of the credit option $Cr \in \{0, 1\}$ in a sales meeting:

$$\begin{aligned} z_{ij}(p, Cr) &= \alpha + \alpha_T T_i + \alpha_N N_i + \gamma p + \gamma_T T_i \cdot p + \gamma_N N_i \cdot p \\ &\quad + \delta Cr + \delta_T T_i \cdot Cr + \delta_N N_i \cdot Cr + \phi X_{ij} + \varepsilon_{ij}(p, Cr), \end{aligned} \tag{1}$$

where T is a dummy variable for the treatment households, N is a dummy variable for the neighbor households, and X is a vector of other exogenous variables associated with the household and the community. The following variables are considered as exogenous control variables X: 1) community level experimental variables chosen by the project based on computer generated random numbers, namely, the down-payment rate that determined the level of minimum down-payment for the credit sales, the interest rate charged for the credit sales, and their interactions with the credit-sales dummy, and a dummy variable indicating we visited the village for the sales meeting 2010; 2) a household level experimental variable that is a random compensation which was given to each participant and whose level was determined by a bingo game played by each participant; 3) household variables from the RePEAT 2009 survey as controls, including the number of family members; the dependency rate (i.e., the ratio of family members aged below 15 or over 65 to those aged between 15 and 65 inclusively); a dummy variable for female-headed households; the household head's age and years of schooling; the size of land owned in ha; assets-holding level in millions of Ush; use of maize hybrid seed before the free input distribution or 2009; and use of chemical fertilizers on maize production before 2009.

We use a modified version of the specification above for regressions of the change in input demand between 2009 and 2011:

$$
\begin{aligned}
dz_{ij}(p,Cr) &= \beta + \beta_T T_i + \beta_N N_i + \gamma' p + \gamma'_T T_i \cdot p + \gamma'_N N_i \cdot p \\
&\quad + \delta' Cr + \delta'_T T_i \cdot Cr + \delta'_N N_i \cdot Cr + \phi' dX_{1ij} + \psi X_{2ij} + u_{ij}(p,Cr), \qquad (2)
\end{aligned}
$$

where the prefix d is an operator to take the first order time difference of a variable following d over the two years, 2009 and 2011.[19] X_1 is a subset of X corresponding to time-variant variables observed in both 2009 and 2011 and X_2 is also a subset of X observed only in 2011, namely, the random compensation and its interaction with the credit-sales dummy. It is also noticed that the time-invariant household characteristics in X are dropped from this regression. In this specification, the coefficients are expected to capture the change in the coefficients in Eq. [1] between 2009 to 2011.

5.2 Empirical results

Sample means of purchase quantities by input type and by household type

Figure 2, 3, and 4 are the graphical representations of the average effect of the initial treatment status on input demand in the sales meeting 2011. The average purchase quantities among the participants (including those who purchased no input) are calculated conditional on household type, price, credit availability and plotted on the price-quantity plane. Each table has four panels, two upper panels from the sales meeting 2009 which are presented for comparison purposes, and two bottom panels from the sales meeting 2011. The first one of the two panels shows the mean quantities in the sales without credit (captioned as "cash sales") while the second one shows those in the sales with credit (captioned as "credit sales"). The colors of the graphs correspond to the household types; the treatment household in orange, the neighbor household in blue, and the control household in green. The two dotted

[19] Since, in the sales meeting 2009, we offered only 3 price-discount levels while we offered 5 levels in 2011, the difference in the input demand over time is obtained at the 3 price discount levels, namely, 0, 10, and 20.

lines along with a solid line indicate the 95 percent confidence interval.

[Insert Figure 2 Here]

[Insert Figure 3 Here]

[Insert Figure 4 Here]

The two panels for the sales meetings in 2009 and 2011 show a very similar pattern. The treatment households purchase the largest amount of the inputs while the control households buy the least amount, and the neighbor households buy an amount in-between. The purchase pattern by household type is similar in the sales with credit option, although the purchase quantities are much larger in the sales with credit option. These observations indicate that the influence of the first intervention, that is, the free input distribution conducted in the beginning of 2009, remains persistently. The difference in the purchased quantity between the household types, however, seems to become smaller in 2011 than 2009 particularly between the treatment and neighbor households. If there exist spillover effects, the demand of the new adopters would converge to that of the early adopters who have used the inputs for longer periods as time goes by. This rationale is consistent with the fact that the difference between the neighbor households and the treatment households became smaller over time.

Results of regressions of the household type on the input purchase

In order to statistically test the difference in the demand for the inputs across the household types, we run the simple regressions specified in Eq.[1] in the previous section for three types of inputs—hybrid seed, base fertilizer, and top-dressing fertilizer—and the aggregate index, which is the total value of the three inputs at the market price divided by 1,000. Two types of regressions, probit and tobit, were applied for each input. The dependent variable of the first type is a binary indicator representing whether a household purchases a particular input or not, while that of the second type is the quantity that a household intended to purchase on the price contingent order form in the sales meeting 2011. Table 7 presents the regression results using the information collected from the participants of the sales meeting 2011.[20]

[Insert Table 7 Here]

Both the likelihood of purchase and the purchase quantity without credit option are the largest for the treatment households (β_T), and the smallest for the control households (reference group); in the middle were the neighbor households (β_N) in most cases except for the likelihood of purchase of the top-dressing fertilizer in which the estimate for the neighbor households is slightly higher than that for the treatment households but not significantly. The difference between the treatment and the control households was significant for the hybrid seed and the aggregate index but not for fertilizers. A similar pattern can be seen in the difference between the neighbor and control households.

The credit option has a large impact on the demand for all types of inputs, which can be observed in the estimates of the coefficient of the credit option dummy. We also confirmed that the credit option had a differential impact, depending on the household type and also the input type: the estimates of the two types of fertilizers were significantly larger for the treatment and neighbor households than for the control households, while the difference between the treatment and neighbor households, which can be seen as the estimate of $(\beta_T + \beta_{TC}) - (\beta_N + \beta_{NC})$ in the bottom part of Table 7, is not significant except for the aggregate index.

The minimum down-payment rate—which is randomly assigned at the community level and determines the amount of cash payment required to be paid during the sales experiment if the credit option becomes available—had a positive impact on the purchase quantity of the top-dressing fertilizer, contrary to our expectation. Firstly, the down payment rate was effective only for credit sales, but the results show that the coefficient of the downpayment rate itself is significant. Secondly, it is supposed to have a negative impact on the credit purchase

[20] We also ran the same regressions but using information not only from the participants of the sales meeting 2011 but also from the non-participants by assuming that those who did not participate in are the households who buy no input and by setting their purchase quantities and their random compensation at zero. The results are presented in Appendix Table 4. They are very similar to those in Table 7 although in some cases the significance levels are different.

if any, but the results show the positive effect on the top-dressing fertilizers. This finding may require further investigation. The interest rate—charged for the cost of credit purchases and randomly assigned at the community level—was also effective for credit purchases only. As we expected, it has a negative impact on the input purchase only for credit purchases. For instance, a 10 percent point reduction of the interest rate increases the purchase of the base fertilizer by 1 kg. The random compensation—which was given to the participants of the sales meeting 2011 in the beginning of the event so that they were able to use it to buy inputs if they wanted—was significantly positive for all inputs in both types of regressions. This suggests that some participants face immediate cash constraints and would not be able to buy the inputs if the compensation had not been given to them.

In the regressions presented in Table 7, other exogenous variables such as household characteristics are not included. We confirmed, however, that the inclusion of household characteristics did not affect the results presented in this table much.[21]

Results of regressions of the household type on the change in input purchase over 2 years

Table 8 presents the results of the regressions of the growth or change in input purchase quantity between the sales meeting 2009 and 2011.[22]

[Insert Table 8 Here]

Table 8 shows that the coefficient of the treatment household dummy (which represents the change in input purchase or fertilizer application level of the treatment households relative to that of the control households) is negative but insignificant while that of the neighbor household dummy is positive but insignificant in most cases. This implies that the direction of the change in the input purchase over the two-year period was opposite between the treatment and neighbor households and, hence, their respective input purchase levels get closer over

[21] Those results will be presented by the author upon request.

[22] The corresponding results with the samples including non-participants by setting their purchase quantities and their random compensation at zero are presented in Appendix Table 5.

time although it is not statistically significant, which can be seen as the difference in their coefficients ($\beta_T - \beta_N$) in the bottom part of Table 8. The difference becomes significant for all the input purchase quantities when the credit option is available, which can be confirmed as the difference in their coefficients $(\beta_T + \beta_{TC}) - (\beta_N + \beta_{NC})$ in Table 8. It is worth noting that the constant term indicates the average change in the input purchase among the control households. Hence, the constant term plus the coefficient of the treatment household dummy represents the average change in the input purchase among the treatment households. For instance, the treatment households increase the hybrid seed purchase by 0.25 kg and the top-dressing fertilizer by 0.3 kg and decrease the base fertilizer by 1.07 kg on average in the sales meeting 2011 compared to the purchase in the sales meeting 2009.

The coefficient of input price can be interpreted as the change in the slope of the demand curve over 2 years. The negative (or positive) sign indicates that the demand became more elastic (or inelastic) than 2 years ago. The coefficient is negative and significant for the hybrid seeds and positive for both types of fertilizers but significant only for the top-dressing fertilizer, implying that when the input prices decline, the participants buy more seeds than fertilizer compared to the purchase pattern in 2009. The interaction term of the price with the dummy for the neighbor households is significant for all types of inputs but significant only for the top-dressing fertilizer. Their demand becomes more elastic in 2011 than in 2009 relative to the control households. The increase in the minimum down payment rate has a negative impact on the seed and base fertilizer purchase significantly with the credit option being available.

In sum, we observed that the effect of the treatment status assigned at the initial intervention remains persistently. Thus, we still see the difference in demand for modern inputs depending on the household types. As time passes, however, the difference between the household types has been reduced, especially, the difference between the treatment and neighbor households. These observations allude to the existence of spillover effects across households. In the following section, we pay careful attention to the mechanism of the dissemination of the new modern inputs.

6 Effect of own experience and information spillovers from neighbors

This section describes a simple model which explores the adoption decision of a new technology and its dissemination by learning in its nascent stage and then derives some testable empirical hypotheses from the model.

6.1 Hypotheses on technology adoption at the early stage of its dissemination

When farmers do not face credit constraints and have good information on a productivity-enhancing input for a particular crop, they decide to buy it if it yields positive profit gain.[23] We consider a simple model in which farmers decide whether to use hybrid or local seeds and the application level of chemical fertilizer. Assuming the optimal application level of seeds for a certain size of land does not vary depending on seed type, we do not consider the application level of seeds. The hybrid seeds are more responsive to chemical fertilizers than local seeds. Thus, hybrid maize yield (kg/ha), y^H, is higher than local maize yield, y^L, given the same level of fertilizer application (kg/ha), q. The i-th farmer's profit gain from the adoption of the hybrid seeds, $\Delta\pi_i$, can be expressed as follows:

$$\Delta\pi_i = p_y(y_i^H - y_i^L) - p_q(q_i^H - q_i^L) - \left(C_s^H - C_s^L\right) - \left(C(l_i^H) - C(l_i^L)\right), \tag{3}$$

where the superscripts, H and L, represent seed types, namely, hybrid and local respectively, p_y and p_q are the unit prices of maize and fertilizer, C_s is the cost for seeds planted for 1

[23] We may have to think of farmers crop choice as well, that is, the possibility of choosing not to plant the particular crop (which is maize in this case) even when it produces positive profit because its profit gain could be smaller than that of other crops. However, since most farmers in the target areas in this study plant maize once or twice a year, it is reasonable to exclude such a case.

ha, and $C(l)$ is the cost of labor inputs used for 1 ha of maize production.[24] We assume that the labor input is a linear function of the fertilizer application level and yield, that is, $l = \tau + \tau_q q + \tau_y y$, where τ_q and τ_y are positive constants.[25] Let ω denote the unit price of labor. The equation can be rewritten as

$$\begin{aligned} \Delta\pi_i &= (p_y - \omega \cdot \tau_y)\Delta y_i - (p_q + \omega \cdot \tau_q)\Delta q_i - \Delta C_s \\ &= \rho_y \Delta y_i - \rho_q \Delta q_i - \Delta C_s, \end{aligned} \tag{5}$$

where $\Delta x \equiv x^H - x^L$ for $x \in \{y, q, C_s\}$, $\rho_y \equiv p_y - \omega \cdot \tau_y$ and $\rho_q \equiv p_q - \omega \cdot \tau_q$.

As Appendix Table 2 shows almost no fertilizer is used for maize production with local seeds, which may be due to the low response rate of chemical fertilizers of local seeds and also to the high relative price of fertilizer to maize. The optimal fertilizer application for local maize is given at the corner solution ($q^{L*} = 0$) for the relevant range of ρ_y/ρ_q. Thus, we assume that the optimal fertilizer application level for the local maize production is zero, $q_i^L = 0$, meaning that the local maize is always planted without fertilizer. We also assume that there is an underlying function g such that $\Delta y = g(q^H) + \varepsilon$, $g' > 0$ and $g'' < 0$ due to the diminishing marginal product of the chemical fertilizer application, where ε is a stochastic disturbance term. Farmers do not know the exact shape of this function but can infer it through their own experience and information from social networks. Learning of a new technology embedded in a productivity-enhancing input is a process of formulation of the

[24]There is an issue to be considered to calculate profit using our data because our maize production data has only a limited number of observations with labor input. We collected maize production information from the RePEAT 2009 survey and also from a supplementary survey focusing on maize production and social networks conducted during the sales meeting in 2011. But the labor input information is collected only from one or two maize plots in the RePEAT 2009 survey. Thus, many observations on maize production do not have labor input information. We use the imputed profit because of the lack of information on labor input.

[25]We estimated the per hectare labor input (hour) equation using the labor input data of the experimental plot (where the free inputs were applied) and the non-experimental plot in 2009 with the household fixed effect regression. The following result is obtained:

$$\hat{l} = 784.4 + 3.61 q_{base} + 2.43 q_{top} + 0.112 y, \tag{4}$$

where q_{base} is the quantity of the base fertilizer applied (kg/ha) and q_{top} is the quantity of the top-dressing fertilizer applied (kg/ha), y is the yield (kg/ha).

unknown function g by farmers.

Formulation of the predicted profit gain

If the expected profit gain from the adoption of hybrid seeds is positive for the coming cropping season, a risk-neutral farmer will plant the hybrid seeds. The likelihood becomes higher as the expected profit gain increases even if farmers are risk-averse. How do they formulate the expectation? Firstly, let us consider a situation where there is no information available on the new inputs. Since they are new, farmers do not know the response of hybrid maize yield to the application of the chemical fertilizer. In other words, farmers do not know the shape of the production function.

A farmer i starts using the inputs for his own experiment, just out of curiosity, or by attending an extension service workshop at the beginning of the period 0. After the harvest, he may keep a pair of records on $(y^H_{i,0}, q^H_{i,0})$ or equivalently $(\Delta y_{i,0}, q^H_{i,0})$, where the second subscript represents the period, in his memory or farmer's diary. He also collects information of others' maize production through his social network, $\left\{(\Delta y_{j,0}, q^H_{j,0})\right\}_{j \in N_i}$ where N_i is a set of i's "information peers" with whom i exchanges information of hybrid maize production. When the time for land preparation (which is the beginning of period 1) comes, farmer i visits an agricultural input shop to decide whether to buy hybrid seeds or not and how much chemical fertilizer to purchase. Given the expected maize price of the next season and the input prices at the shop, he evaluates the profits predicted by pairs of records on yield gains and fertilizer application levels at the period 0 in his reference list, i.e., $\{(\Delta y_{k,0}, q^H_{k,0})\}_{k \in \{i, N_i\}}$. We assume that the farmer's expected maize price at the end of period 1 is equal to the price at period 0, that is, $E[p_{y,1}|I_0] = p_{y,0}$, where I_0 is information set available at period 0. Similarly, the expected labor wage at period 1 is equal to the wage rate at period 0, that is, $E[\omega_1|I_0] = \omega_0$. Then, farmer i can construct a set of the predicted profit gains based on the records of his information peers and himself in the beginning of period 1, given by $\{\Delta\hat{\pi}_{k,1}\}_{k \in \{i, N_i\}}$, where $\Delta\hat{\pi}_{k,1} = \hat{\rho}_{y,1}\Delta y_{k,0} - \hat{\rho}_{q,1} q^H_{k,0} - \Delta C_{s,1}$ (, where $\hat{\rho}_{y,1} = p_{y,0} - \omega_0 \cdot \tau_y$ and

$\hat{\rho}_{q,1} = p_{q,1} + \omega_0 \cdot \tau_q$).

Choice of fertilizer application level and adoption decision on hybrid seed

Because of noise on a series of the predicted profits, farmers may need to use a simple statistical inference to find the better fertilizer application level at period 1. For farmer i, the most reliable information is the record of his own experience, that is, $(\Delta y_{i,0}, q^H_{i,0})$. Since the records from his information peers include errors, each individual record may not be reliable. One possible way for him to utilize the information from his information peers is to average out their predicted profit gains and then to use the average, that is, $\overline{\Delta\hat{\pi}}_{Ni,1} = \hat{\rho}_{y,1}\overline{\Delta y}_{Ni,0} - \hat{\rho}_{q,1}\overline{q^H}_{Ni,0} - \Delta C_{s,1}$ (where $\overline{x}_{Ni,0}$ for $x \in \{\Delta y, q^H\}$ is the average among i's information peers), as a reference of his information peers. If $\overline{\Delta\hat{\pi}}_{Ni,1}$ is greater than his own predicted profit gain, $\Delta\hat{\pi}_{i,1}$, he will update his fertilizer application level toward the average application level of his information peers and will maintain his current application level for period 1 otherwise.

Hypothesis 1 *If a farmer's predicted profit gain from the adoption of hybrid seeds is smaller than the average gain of his information peers ($\Delta\hat{\pi}_{i,1} < \overline{\Delta\hat{\pi}}_{Ni,1}$), he updates the fertilizer application level for the subsequent season toward that of his information peers.*

To what extent will he update his fertilizer application level toward the average level of his information peers? We are not able to predict the extent without assuming any particular updating mechanism. But, in any case, his target application level for the next period can be represented by a convex combination of his own and the average of his information peers, that is, $q^H_{i,1} = (1-\phi)q^H_{i,0} + \phi\overline{q^H}_{Ni,0}$ for $\phi \in (1, 0)$. If he uses the Baysian inference, ϕ becomes larger as the variance of $\overline{q^H}_{Ni,0}$ becomes smaller (or as the information from the peers becomes more reliable). Also, it is natural to think that if a small change in fertilizer quantity generates a big change in profit, the speed of adjustment in the fertilizer quantity can be fast. If it is the case, ϕ may also increase in the gap between the profit gain of his information peers and his own, that is, $\overline{\Delta\hat{\pi}}_{Ni,1} - \Delta\hat{\pi}_{i,1}$.

The updated rule can be rewritten as

$$q^H_{i,1} - q^H_{i,0} = \phi \left(\overline{q^H}_{Ni,0} - q^H_{i,0} \right), \tag{6}$$

which implies that the growth of the fertilizer application level is larger as the gap in the application level between the average of his information peers and his own is larger and also as the information from the peers is more reliable.

Hypothesis 2 *Given the condition that $\Delta\hat{\pi}_{i,1} < \overline{\Delta\hat{\pi}}_{Ni,1}$, the growth of the fertilizer application of a farmer becomes larger i) as the gap in the application level between the peers and his own becomes larger, ii) as the gap in the profit gain between the information peers and his own becomes larger and also iii) as the information from the peers is more reliable.*

Adoption decision on hybrid seeds

When farmer i's predicted profit gain ($\Delta\hat{\pi}_{i,1}$) is positive, i always decides to use hybrid seeds for period 1. Even when it is negative, farmer i may decide to use hybrid seeds for period 1 if his expected profit gain (evaluated at the target fertilizer level, that is, $(1-\phi)q^H_{i,0} + \phi\overline{q^H}_{Ni,0}$) for period 1 conditional on $\Delta\hat{\pi}_{i,1} < \overline{\Delta\hat{\pi}}_{Ni,1}$ being held. A problem is that farmer i is not able to know his expected profit gain for period 1 exactly because the g-function is unknown to him and so is $g((1-\phi)q^H_{i,0} + \phi\overline{q^H}_{Ni,0})$. But he knows that it is larger than the convex combination of i's predicted profit gain and the average of the information peers, that is, $E\Delta\pi_{i,1} > (1-\phi)\Delta\hat{\pi}_{i,1} + \phi\overline{\Delta\hat{\pi}}_{Ni,1}$ because of the concavity of the unknown g-function. The condition that $(1-\phi)\Delta\hat{\pi}_{i,1} + \phi\overline{\Delta\hat{\pi}}_{Ni,1} \geq 0$ or equivalently $\Delta\hat{\pi}_{i,1} + \phi\left(\overline{\Delta\hat{\pi}}_{Ni,1} - \Delta\hat{\pi}_{i,1}\right) \geq 0$ is sufficient for farmer i to adopt hybrid seeds. Then the likelihood of using hybrid seeds for period 1 increases in i's predicted profit gain ($\Delta\hat{\pi}_{i,1}$). Also, it increases in i's information peers' average profit gain, $\overline{\Delta\hat{\pi}}_{Ni,1}$, under the condition that $\Delta\hat{\pi}_{i,1} \leq \overline{\Delta\hat{\pi}}_{Ni,1}$.

Hypothesis 3 *The larger a farmer's profit gain from the adoption of hybrid seeds is, the higher his likelihood of adopting hybrid seeds for subsequent seasons is. Moreover, under the condition that* $\Delta\hat{\pi}_{i,1} \leq \overline{\Delta\hat{\pi}}_{Ni,1}$, *the larger his information peers' average profit gain is, the higher his likelihood of adopting hybrid seeds is.*

Experiences on the production

This simple model can describe farmers' adoption decisions of hybrid seeds and updated rules of chemical fertilizer application only at the early stage of the dissemination of a new technology. As farmers gain more experience on the new production, their reference list for the records on $(\Delta y,\, q^H)$ becomes richer and hence provides them better knowledge on the unknown g-function or the production function under the new technology. Thus, they would not need to rely on new information from their peers in order to find the optimal application level of the inputs as their reference list becomes richer.

Hypothesis 4 *A farmer's past experience weakens the influence of his information peers on the production decision.*

6.2 Empirical specifications

We examine the determinants of the input purchase in the sales meeting 2011 and its change from the meeting 2009 with the consideration of the hypotheses stated above. Since the hypotheses mention about the decision on the input use for the subsequent season rather than the input purchase, we have to translate the input use decision into the input purchase decision in the sales meeting in 2011. Firstly, we consider the following regression model for fertilizer application levels so as to address the hypotheses:

$$Q_{ij,1}(p, Cr) - Q_{ij,0}(p, Cr) \;=\; \beta_j + \beta_q Dq_{i,0} + \beta_\pi D\pi_{i,0} + \beta_{q\pi} Dq_{i,0} \cdot D\pi_{i,0}$$

$$+\beta_I I_{i,0} + \beta_{Iq} I_{i,0} \cdot Dq_{i,0} + \beta_{I\pi} I_{i,0} \cdot D\pi_{i,0} + \beta_{Iq\pi} I_{i,0} \cdot Dq_{i,0} \cdot D\pi_{i,0}$$
$$+\beta_J J_{i,0} + \beta_{Jq} J_{i,0} \cdot Dq_{i,0} + \beta_{J\pi} J_{i,0} \cdot D\pi_{i,0} + \beta_{J\pi q} J_{i,0} \cdot D\pi_{i,0} \cdot Dq_{i,0}$$
$$+\gamma_q \cdot p + \delta_q \cdot Cr + \phi_q' dX_{1ij} + \psi_q X_{2ij} + e_{ij}(p, Cr). \quad (7)$$

The dependent variable is the growth of the intensity level of chemical fertilizer, $Q_{ij,t}(p, Cr)$, ($Q \in${Base fertilizer, Top-dressing fertilizer}, $t \in \{0, 1\}$), which is measured as the ratio of fertilizer quantity to seed quantity intended to be purchased in the price contingent order form at the sales meeting held at year $2009+2t$, given the discounted price level p, the credit availability Cr, and other control variables dX_1 and X_2 used in the analyses in the previous section.[26] As the right hand side variables, the following variables are added: a difference in the fertilizer application level at period 0 between the information peers' average and i's own, denoted by $Dq_{i,0} = \overline{q^H}_{Ni,0} - q^H_{i,0}$; a difference in the profit gain at the end of period 0 between information peers' average and i's own, denoted by $D\pi_{i,0} \equiv \overline{\Delta\pi}_{Ni,0} - \Delta\pi_{i,0}$;[27] two dummy variables, denoted by $I_{i,0}$ and $J_{i,0}$, indicating the relative size of the information peers' average profit gain and i's own profit gain such that $I_{i,0} = 1\left\{D\pi_{i,0} > 0 \, and \, \overline{\Delta\pi}_{Ni,0} > 0\right\}$ and $J_{i,0} = 1\left\{D\pi_{i,0} < 0 \, and \, \Delta\pi_{i,0} > 0\right\}$[28]; the interaction terms of these variables.

Firstly, Hypothesis 1 predicts that $\beta_{Iq} > 0$; that is, when a farmer's information peers get a larger profit, than his own, he adjusts his fertilizer application level toward the level of his information peers' average. Moreover, Hypothesis 2 predicts that $\beta_{I\pi q} > 0$ if the adjustment speed is higher when the difference in the profit gain between the information peers' average

[26]The intensity level of chemical fertilizer application is supposed to be measured as the application amount per hectare. We do not observe the land size allocated for the purchased inputs at the sales meetings. For this reason, we use the ratio of fertilizer quantity to seed quantity as the intensity measurement. However, the ratio can be interpreted as the intensity level of the chemical fertilizer if farmers do not change the plant density (or the seed quantity used for a certain size of land) across plots.

[27]It is noted that the predicted profit gain, $\Delta\hat{\pi}_{i,1}$, and its average among the information peers, $\overline{\Delta\hat{\pi}}_{Ni,1}$, used in the model in the previous subsection are replaced with the realized profit gain at period 0, $\Delta\pi_{i,0} (\equiv \rho_{y,0}\Delta y_{k,0} - \rho_{q,0} q^H_{i,0} - \Delta C_{s,0})$, and its average among the information peers, $\overline{\Delta\pi}_{Ni,0}$, for the empirical specification. Since the difference between the predicted gain and the realized gain is only in prices (of the inputs) that they refer to, the size order of the two terms is not affected by the replacement. Thus, these two terms are comparable across individuals within a village in which they face the same prices.

[28]The reference group corresponding to these two dummy variables is a set of the sample households which satisfy the condition that $\overline{\Delta\pi}_{Ni,0} \leq 0$ and $\Delta\pi_{i,0} \leq 0$.

and his own is larger.

Similarly, we consider the following model for hybrid seed:

$$
\begin{aligned}
S_{ij,1}(p,Cr) - S_{ij,0}(p,Cr) &= \alpha_j + \alpha_\pi \Delta\pi_{i,0} + \alpha_N \overline{\Delta\pi}_{Ni,0} \\
&+\alpha_I I_{i,0} + \alpha_{I\pi} I_{i,0} \cdot \Delta\pi_{i,0} + \alpha_{IN} I_{i,0} \cdot \overline{\Delta\pi}_{Ni,0} \\
&+\alpha_J J_{i,0} + \alpha_{J\pi} J_{i,0} \cdot \Delta\pi_{i,0} + \alpha_{JN} J_{i,0} \cdot \overline{\Delta\pi}_{Ni,0} \\
&+\gamma_s \cdot p + \delta_s \cdot Cr + \phi_s' dX_{ij} + e_{ij}(p,Cr). \qquad (8)
\end{aligned}
$$

If there exists a learning effect from social networks, Hypothesis 3 predicts that $\alpha_{IN} > 0$. Moreover, if there exists a learning effect through own experience, it also predicts that $\alpha_{J\pi} > 0$. Lastly, Hypothesis 4 predicts that there is a differential impact of a farmer's information peers depending on his experience in the use of the modern inputs before the sales meeting 2011. Thus, α_{IN} could be larger for those who have less experience in the use of the modern inputs. The farmers' experience level could be measured by the number of seasons in which the farmers used the modern inputs before the sales meeting 2011. The similar discussion on Hypothesis 4 can be applicable to the model for the chemical fertilizer application levels, too. So, the coefficients which are expected to capture the spillover effects from the information peers, namely, β_{Iq} and $\beta_{I\pi q}$, could be larger for those who have less experience in the use of the modern inputs.

6.3 Empirical results

Adjustment of fertilizer application levels

Table 9 shows the results of the regressions of the change in the ratio of the base fertilizer quantity to the hybrid seed quantity intended to be purchased in the price contingent order form used in the sales meeting 2009 and 2011.[29] The ratio can be interpreted as the intended intensity level of the chemical fertilizer or application level per a certain land size. We use the information peers' data to construct the peer-related variables for the first three specifications (Column 1-3) whereas we use the geographic peers' data for the last three specifications (Column 4-6) for comparison purposes.[30]

[Insert Table 9 here]

The first and fourth specifications are the simplest form, in which the change in the ratio of the base fertilizer quantity to the hybrid seed over the two years is regressed on the following variables: a difference in the fertilizer application level on hybrid maize (kg/ha) between a farmer's information (or geographic) peers and that of his own (denoted by Dq_Peer in the table); a dummy indicating that the average profit gain of his peers is greater than that of his own and, simultaneously, that the peer's average profit gain is positive (denoted by I); a dummy indicating that the average profit gain of his peers is less than that of his own and that his own profit gain is positive (denoted by J); their interactions.[31] Other control variables used in the regressions in the previous subsection are also included (but not reported in the table). Comparing the result of Column 1 with that of Column 4, the coefficient of Dq_Peer is positive and significant for both specifications. Moreover, the coefficient of the

[29]Two out of 69 target villages were dropped from the empirical analyses since only a few observations (less than 5) in a community were reported for the information on maize production.

[30]The information peers of farmer i are defined as the persons among our target sample households whom the farmer i exchanges farming business information with while i's geographic peers are defined as the persons among our target sample households who live within a 0.5 km radius from i' residential point. We calculated the average profit gain and fertilizer application level of information and geographic peers respectively.

[31]As information on maize production for the right hand side variables, we use the information in the first main cropping season after the sales meeting 2009. It was the 1st cropping season in 2010 for many of the target communities and the 2nd cropping season in 2009 for the other target communities. The profit gain from the use of hybrid seeds is the difference in the per hectare profit between the hybrid and local maize. It is calculated as follows. When a farmer planted both local and hybrid maize in 2010 (or 2009 for some target samples), we obtain harvest, plot size, fertilizer quantities for the base and top-dressing fertilizer separately for the local and hybrid maize plot. Then, we calculate the value of the grain output per hectare by evaluating the yield at the average market price of the community and the per hectare fertilizer cost evaluated at the market price. For labor input, we used the formula (Eq. [4] in the foot note in the previous section) to impute the labor input and evaluated it at the community level market wage rate. Then, the profit is calculated as the sales value - (fertilizer cost + labor cost + seed cost) for the hybrid and local maize respectively. If he planted only hybrid maize, the community average of the local maize profit is used as his reference. The profit gain is the difference in the per-hectare profit between the hybrid and local maize calculated as described above.

interaction term of Dq_peer with I is positive and significant for the information peers but insignificant for the geographic peers. These findings suggest that the farmers adjust their fertilizer intensity level toward the average of the information peers when the information peers' average profit is bigger than the farmers' own profit. This is consistent with Hypothesis 1. In contrast, the adjustment of the farmers' fertilizer intensity level toward the average of the geographic peers is not associated with the average profit level of the geographic peers.

The second and fifth specifications introduce a variable representing a difference in the profit gain from use of hybrid seeds between his peers and that of his own (million Ush/ha) (denoted by $D\pi\_Peer$) and its interactions with the variable used in the previous specifications so that they could address a part of Hypothesis 2 which states that the growth of the fertilizer application becomes larger as the gap in the profit gain between the peers and his own becomes larger. Contrary to the prediction, the coefficient of Dq_Peer * $D\pi\_Peer$ * I is negative for the information peers (in Column 2) and not significant for the geographic peers (in Column 5). It seems that the hypothesis is not supported by our data. It might be possible that the large positive profit gap of the peers' average profit gain from his own does not necessarily encourage him to mimic his information peers' techniques on farming because the gap may reflect the environmental difference from their peers or possibly noise in information from the peers. But we are not able to know the truth from the limited information available in this analysis.

The third and last specifications allow the coefficients in the first specification to vary according to farmers' past experience in the use of hybrid seeds by introducing the number of seasons in which they used maize hybrid seeds before the first cropping season in 2011 (denoted by Num_exp) and its interaction terms. Using these specifications, we address Hypothesis 4, which predicts that the spillover effect from the peers could be smaller as farmers have more experience in the modern inputs. The coefficient of Dq_Peer * Num_exp * I corresponds to the hypothesis. Looking at the results, it is negative and significant for the information peers (in Column 3) while it is positive and insignificant for the geographic peers (in Column 6). This suggests that although the farmers adjust their fertilizer application level toward the average level of their information peers, their adjustment become weaker as they have more experience in the use of the inputs, which supports Hypothesis 4.

Table 10 shows the results of the same regressions of the top-dressing fertilizer as shown above for the base fertilizer. We obtained very similar results for the top-dressing fertilizer to those for the base fertilizer.

[Insert Table 10 here]

Firstly, the coefficient of $Dq\_peer * I$ is positive and significant in Column 1, supporting Hypothesis 1. Secondly, the coefficient of $Dq\_Peer * D\pi\_Peer * I$ is positive but insignificant in Column 2, not supporting Hypothesis 2. Thirdly, the coefficient of $Dq\_Peer * Num\_exp * I$ is positive and significant, supporting Hypothesis 4. Unlike the regressions for the information peers, the results for the geographic peers support none of the hypotheses. It is worth noting that the coefficient of Dq_Peer is positive and significant even in the regressions for the geographic peers (Column 4-6). This implies that the farmers adjust their fertilizer application level toward the average of their geographic peers no matter whether the peers' average profit is higher or lower than their own. Such adjustment would not increase their profit level. This happens probably because of limitation of useful information flow from the geographic peers.

These findings clearly show that farmers learn from others' experience through their social networks especially when they have limited knowledge on the farming practices. It is also noted that these results are consistent with the finding in the previous section which shows that the difference in demand for fertilizers across the treatment status, in particular, between the treatment and neighbor households significantly reduced over the two years. In other words, the neighbor households who had less experience in the use of the modern inputs in the initial period adjusted their fertilizer application level toward the treatment households who had more experience by utilizing the information on the modern inputs and their profitability through their social networks.

Demand change in the hybrid seed

Table 11 shows the results of the regressions of the growth of the hybrid seed quantity intended to be purchased in the price contingent order form in the sales meeting 2009 and 2011.

[Insert Table 11 here]

The first and fourth specifications are the simplest form in which the growth of the purchase quantity of the hybrid seed is regressed on two dummies, J and I, indicating the relative size of the farmers own profit gain and the average of their peers and other controls used for the regressions for the chemical fertilizers. Hypothesis 3 predicts that the coefficients of these two dummy variables are both positive. In Column 1 and 4, the results are similar and show that the coefficient of J is positive and significant but that of I is negative and significant. This suggests that when a farmer's profit gain from the use of the hybrid seeds is positive and larger than the average of his peers, he increases the demand for the hybrid seed for the subsequent season while he decreases the purchase when his profit gain is smaller than the average of his peers even if the peers' average is positive. This is not fully consistent with Hypothesis 3.

In the second and fifth specifications, we introduce the farmers' own profit gain, the average of their peers, and their interactions with the two dummy variables. These specifications allow the impact of the profit gain of the farmers own and the average of their peers to differ depending on their level. The result in Column 2 shows that, conditional on $J=1$, the marginal effect of the farmers' own profit gain is obtained as the sum of the coefficients of $\Delta\pi\_own$ and $\Delta\pi\_own * J$, which is equal to 2.13, positive, and significant.[32] Similarly, the marginal effect of the farmers' information peers' profit gain conditional on $I=1$ is obtained by the sum of the coefficients of $\Delta\pi\_Peer$ and $\Delta\pi\_Peer * I$, which is equal to -1.37, negative, and insignificant. This result of the effect of the average profit gain of the information peers does not support the hypothesis on the spillover effect (which predicts the

[32] The p-value of the t-test is 0.002.

positive coefficient). The marginal effect of the average profit gain of the geographic peers conditional on *I=1* is also negative and significant in the result of Column 5.

The third and last specifications allow the coefficients in the second specification to vary according to farmers' past experience in the use of hybrid seeds represented by *Num_ exp*. In Column 3, the result shows that when a farmer's own profit gain from the use of hybrid seeds is positive and larger than the peers' average, that is, *J=1*, the number of seasons of the past use of hybrid seeds has the positive effect on the purchase of the hybrid seeds. The coefficient is also positive and significant in the regression with the geographic peers' variables (in Column 6) but its magnitude is smaller than that obtained in the regression with the information peers' variables. In these specifications, Hypothesis 4 predicts that the coefficient of $\Delta\pi\_Peer * I$ is positive and that the coefficient of $\Delta\pi\_Peer * I * Num\_exp$ is negative. The result in Column 3 is not consistent with the hypothesis. Although the coefficients of interest have the signs predicted by the hypothesis in the result in Column 6, the magnitude of the coefficient of the second term ($\Delta\pi\_Peer * I * Num\_exp$) appears to be somewhat odd. For instance, the past experience in the use of hybrid seeds by one season changes the positive peer effect to negative if we interpret the result as is shown. Further investigation may be needed to fully interpret the peer effect on the purchase of the hybrid seeds.

In sum, we found that the sample farmers increased (decreased) their purchased quantity of hybrid seeds in the sales meeting 2011 in comparison with that in the sales workshop 2009 when their own use of hybrid seeds during the two-year period generated positive (negative) profit. However, we found no evidence of spillover effects from the peers on the purchase quantity of the hybrid seeds. One possible explanation of the finding of no spillover effect is low profitability of the hybrid seeds. As shown in Table 6, the profit gain from the use of the modern inputs was negative or almost zero on average. The yield gain was large and 1.2 tons per ha but the production with the modern inputs required more labor. In addition, the input-output price ratio was less favorable to the producers. The speed of the dissemination of technologies with low profitability is slow. When the dissemination speed is slow, it would not be easy to observe spillover effects.

7 Conclusions

We observed the farmers' adoption behaviors and application levels of the new productivity-enhancing inputs for maize production over two years since the initial experimental intervention in which the new inputs for maize production were distributed for free to the target households living in some of the selected villages. We found that the demand for the inputs of the free-input recipients was significantly higher in both 2009 and 2011 than that of non-recipients; that of the neighbors of the recipients fell in-between. The initial treatment assignment has a persistent influence on the farmers' demand over the two years, whereas the gap across the treatment status, particularly, between the free-input recipients and their neighbors, has been reduced. The reduction of the gap in the application level of chemical fertilizers is partly driven by social learning through information networks. It seems that the farmers adjusted their application level of the fertilizers toward the level of the successful neighbors who had higher profit. However, we found no clear evidence of learning effect from peers on the demand for the hybrid seeds. One possible explanation of these mixed results is due to low profitability of the modern inputs. Because the low profitability makes it difficult famers to observe the impact of the inputs on their peers' plots and hence it affects their ability to learn from others, the speed of their dissemination remains slow and hence we did not observe the learning effects from peers on the demand for the hybrid seeds.

Our results show that the current productivity-enhancing inputs for maize are not necessarily profitable for many farmers and hence their dissemination still remains slow and incomplete. The input-output price ratio seems to be still unfavorable to farmers to make the input use profitable despite the fact that farmers have better access to commodity markets and market information due to the recent improvement of road infrastructure and information networks than in the past. This finding suggests that the improvement of profitability of productivity-enhancing inputs is a key to their dissemination and the realization of dramatic enhancement of maize production in Uganda.

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Table 1. Timeline and sample sizes of interventions and surveys

		Total		Treatment Village				Control Village	
				Treatment Household		Neighbor Household		Control Household	
	Number of target villages by type	69		46				23	
	Number of target households by type	1017		422		378		217	
Mon/Year	***Event***								
Feb-Mar/2009	*Free input distribution*								
	Number of households receiving free inputs	378		378		0		0	
	Attrition rate			0.10		0		0	
Aug-Sep/2009	*Sales meeting 2009*								
	Number of households participating	809		334		288		187	
	Attrition rate			0.21		0.24		0.14	
	Number of households purchasing Hybrid maize seed*	539	(0.67)	239	(0.72)	196	(0.68)	104	(0.56)
	Number of households purchasing fertilizers*	441	(0.55)	195	(0.58)	165	(0.57)	81	(0.43)
Oct-Dec/2009	*RePEAT 3 survey*								
	Number of communities visited	68		45				23	
	Number of households interviewed	947		390		349		208	
	Attrition rate			0.08		0.08		0.04	
Jan-Feb/2011	*Sales meeting 2011*								
	Number of communities visited	69		46				23	
	Number of households participating	779		347		269		163	
	Attrition rate			0.18		0.29		0.25	
	Number of households purchasing Hybrid maize seed*	646	(0.83)	304	(0.88)	227	(0.84)	115	(0.71)
	Number of households purchasing fertilizers*	220	(0.28)	108	(0.31)	75	(0.28)	37	(0.23)

Notes: * The number of households which exhibited positive purchase quantity at the non-discount price in the price contingent order form in the sales meeting.

Ratio of those who purchased inputs to the participants in the sales experiment is given in parentheses.

Attrition rate is defined as the ratio of the number of target households minus participants to the number of target households

Table 2. Summary statistics in RePEAT 2005 survey

	Village Type					
	Control		Treatment			
RePEAT Survey in Aug-Sep 2005	(1)		(2)		(3)	
Num. of Villages	23		46			
Village Characteristics	Mean [a]		Mean [a]		Difference [b]	
1 if Public Electricity is Available	0.17	(0.39)	0.2	(0.40)	-0.02	(0.10)
1 if Mobile Network is Available	0.91	(0.29)	0.89	(0.31)	0.02	(0.08)
1 if any Primary School	0.65	(0.49)	0.67	(0.47)	-0.02	(0.13)
1 if any Secondary School	0.13	(0.34)	0.11	(0.31)	0.02	(0.09)
1 if any Health Facility	0.83	(0.39)	0.67	(0.47)	0.15	(0.11)
Longitude (degree)	33.03	(0.98)	32.97	(1.06)	0.06	(0.26)
Latitude (degree)	0.6	(0.45)	0.59	(0.63)	0.01	(0.14)
Altitude (meter)	1251.07	(181.80)	1204.68	(140.40)	46.39	(43.20)
Household Characteristics						
Household Size	7.94	(3.86)	7.8	(4.16)	0.14	(0.33)
1 if Head is Female	0.16	(0.37)	0.12	(0.32)	0.05	(0.03)
Head's Age	46.86	(14.50)	46.27	(14.00)	0.59	(1.20)
Head's Years of Schooling	6.71	(3.42)	6.62	(3.16)	0.09	(0.30)
1 if having Mobile Phone	0.1	(0.29)	0.14	(0.34)	-0.04	(0.03)
Income (1000sh)	1700.43	(116.50)	1691.6	(92.10)	8.83	(153.10)
Nonfarm Income Share	0.24	(0.29)	0.26	(0.29)	-0.02	(0.02)
Assets (1000sh)	348.73	(1117.0)	320.45	(763.6)	28.29	(83.9)
Cultivated Land (ha) [c]	1.28	(1.03)	1.22	(1.12)	0.06	(0.09)
1 if Planted Maize	0.82	(0.38)	0.85	(0.35)	-0.03	(0.03)
Maize Production among Maize Growers						
Yield (kg/ha)	1664.86	(1460.0)	1436.13	(1796.0)	228.73	(153.9)
Chemical fertilizer Use (kg/ha)	2.77	(12.21)	1.29	(10.28)	1.48	(1.00)
1 if used Hybrid Seed [d]	0.06	(0.24)	0.06	(0.24)	0	(0.02)

Notes: ***, **, * indicate 1%, 5%, 10% significance level, respectively

[a] Standard deviation in parentheses

[b] Standard error in parentheses

[c] Size of land cultivated (ha) in main cropping season.

[d] Because of no direct information in the RePEAT 2005 survey on whether the purchased seed was hybrid or other type, we assumed that the seed whose price was more than 3000 Ush was hybrid.

Table 3. Summary statistics in RePEAT 2009 survey by household type

Household Characteristics	Mean by household type			Mean difference		
	Control	Treatment	Neighbor	Control vs. Treatment	Control vs. Neighbor	Treatment vs. Neighbor
	(1)	(2)	(3)	(4)	(5)	(6)
1{used maize HYV seed before the free input	0.15	0.15	0.12	-0.001	0.03	0.03
distribution in 2009}	(0.36)	(0.36)	(0.34)	(0.03)	(0.03)	(0.03)
1{used chemical fertilizers on maize before the free	0.16	0.10	0.12	-0.07**	0.05	-0.02
input distribution in 2009}	(0.37)	(0.30)	(0.33)	(0.03)	(0.03)	(0.02)
Household size	7.75	7.97	7.12	–0.22	0.63**	0.85***
	(3.45)	(3.82)	(3.31)	(0.31)	(0.30)	(0.26)
1{head is female}	0.18	0.13	0.11	0.05	0.07**	0.02
	(0.38)	(0.34)	(0.32)	(0.03)	(0.03)	(0.02)
Head's Age	50.4	49.7	43.4	0.76	7.01***	6.25***
	(14.20)	(13.10)	(13.70)	(1.20)	(1.24)	(1.00)
Head's years of schooling	5.68	6.05	6.6	–0.37	–0.91**	–0.54*
	(4.03)	(4.19)	(4.30)	(0.35)	(0.36)	(0.31)
Cultivated land (ha) [a]	1.21	1.18	1.03	0.03	0.18**	0.16**
	(0.93)	(0.95)	(0.96)	(0.08)	(0.08)	(0.07)
Assets (millions of Ush)	0.64	1.08	0.5	–0.44	0.15	0.58*
	(2.00)	(5.79)	(0.98)	(0.33)	(0.15)	(0.30)
Assets except vehicle (millions of Ush)	0.45	0.55	0.45	–0.10	0	0.10*
	(0.66)	(0.80)	(0.68)	(0.06)	(0.06)	(0.06)
1{owns mobile phone}	0.51	0.56	0.55	–0.06	–0.04	0.01
	(0.50)	(0.50)	(0.50)	(0.04)	(0.04)	(0.04)

Notes: Standard deviations are given in parentheses in Column (1)-(3). Standard errors are given in parentheses in Column (4)-(6).

[a] Amount of land cultivated (ha) in main cropping season.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 4. Summary statistics of social network variables by household type.

	Mean by village type			Mean difference		
Village Characteristics	Control	Treatment		Control vs. Treatment		
The number of the target households in a village (*Nj*)	9.65	18.26		-8.61***		
	(1.11)	(1.89)		(0.36)		
	Mean by household type			Mean difference		
Household Characteristics	Control	Treatment	Neighbor	Control vs. Treatment	Control vs. Neighbor	Treatment vs. Neighbor
	(1)	(2)	(3)	(4)	(5)	(6)
Ratio of the geographic peers (those living within 0.5 km radius from the household *i*) to *Nj*	0.29	0.29	0.32	0.00	-0.026	-0.025
	(0.24)	(0.24)	(0.25)	(0.02)	(0.02)	(0.02)
Ratio of the information peers (those with whom the household *i* exchanges the information on farming business) to *Nj*	0.30	0.41	0.36	-0.105***	-0.057**	0.049**
	(0.32)	(0.34)	(0.33)	(0.03)	(0.03)	(0.02)
Ratio of the geographic & information peers to *Nj*	0.12	0.15	0.16	-0.032**	-0.033**	0.001
	(0.17)	(0.18)	(0.20)	(0.014)	(0.015)	(0.013)
Ratio of the TREATMENT households who are also the information peers to *Nj*	0	0.21	0.20	-0.209***	-0.202***	0.007
	(0)	(0.19)	(0.19)	(0.01)	(0.01)	(0.01)
Ratio of the target households the household *i* knew who used maize hybrid seed in 2010 to *Nj*	0.10	0.17	0.15	-0.065***	-0.046**	0.02
	(0.19)	(0.27)	(0.25)	(0.02)	(0.02)	(0.02)

Notes: Standard deviations are given in parentheses in Column (1)-(3). Standard errors are given in parentheses in Column (4)-(6).
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
This network information was collected at the sales meeting 2011 from the participants.

Table 5. Determinants of the participation in the Sales Meeting 2011.
Dependent variable: 1 if participating in Sales Meeting 2011 and 0 otherwise

	Probit			Logit[a]	
	(1)	(2)	(3)	(4)	(5)
1 if Treatment HH	0.307**	0.328**	0.539***		
	(0.15)	(0.16)	(0.16)		
1 if Neighbor HH	-0.12	-0.0675	0.225		
	(0.15)	(0.16)	(0.15)		
1 if purchasing inputs in Sales Meeting 2009		0.21	0.218	0.0811	0.21
		(0.13)	(0.14)	(0.22)	(0.26)
1 if purchasing inputs in Sales Meeting 2010		0.283**	0.21	0.827***	0.614*
		(0.14)	(0.14)	(0.29)	(0.32)
1 if participating in Sales Meeting 2009		0.358**	0.295*	0.682***	0.258
		(0.18)	(0.18)	(0.26)	(0.32)
1 if participating in Sales Meeting 2010		0.309**	0.237*	0.928***	0.795***
		(0.13)	(0.14)	(0.21)	(0.26)
Household size			0.0277		0.0820**
			(0.02)		(0.03)
Dependency rate			-0.0948*		-0.262**
			(0.05)		(0.10)
1 if female-headed household			0.122		0.163
			(0.17)		(0.33)
Household head's age			0.00587		0.0123
			(0.004)		(0.008)
Household head's years of schooling			0.00258		-0.0154
			(0.013)		(0.028)
Land size owned (Ha)			0.00419		0.0203
			(0.008)		(0.024)
Value of asset (millions of Ush)			-0.0463***		-0.0691**
			(0.015)		(0.034)
Constant	0.678***	0.0503	-0.349		
	(0.122)	(0.19)	(0.317)		
Community Fixed effects				Yes	Yes
Number of households	1008	1008	794	900	682
Number of communities	69	69	68	62	57

Notes: Standard errors are given in parentheses
* p<0.10, ** p<0.05, *** p<0.01
a) The number of samples in the Logit regresions is less than that of the Probit regressions because the inclusion of the community level fixed effects in the Logit regressions drops the samples of the communities where there is no variation in the dependent variable, or all the target samples participated in the 2011 meeting.

Table 6. Maize production on the experimental and non-experimental plots of the treatment households in the 1st cropping season in 2009.

	Non-experimental plot		Experimental plot		Difference		
	Mean	S.D.	Mean	S.D.	Mean	S.E.	
I. All sample (N=207 for non-experimental plot, N= 347 for experimental plot)							
1) Maize yield (Kg/ha)	917.0	(962.5)	1926.3	(1580.5)	-1009.4	(108.0)	***
2) Value of grain output (1000 Ush/ha)[a]	477.8	(489.5)	1032.1	(826.0)	-554.3	(55.9)	***
3) Seed cost (1000 Ush/ha)	19.2	(31.7)	72.4	(28.0)	-53.2	(2.7)	***
4) Fertilizer cost (1000 Ush/ha)	7.1	(35.9)	291.7	(140.5)	-284.6	(7.9)	***
5) Value-added (1000 Ush/ha) = (2)-(3)-(4)	451.5	(472.0)	668.0	(783.4)	-216.5	(53.3)	***
II. Subsample for which full labor information is available and the same household cultivated both non-experimental and experimental plot (N=156)							
1) Maize yield (Kg/ha)	1038.7	(1014.9)	2234.3	(1673.5)	-1195.6	(156.7)	***
2) Value of grain output (1000 Ush/ha)[a]	535.9	(516.4)	1157.5	(854.7)	-621.6	(80.0)	***
3) Seed cost (1000 Ush/ha)	19.6	(34.1)	72.4	(26.6)	-52.7	(3.5)	***
4) Fertilizer cost (1000 Ush/ha)	7.5	(36.7)	288.9	(139.1)	-281.3	(11.5)	***
5) Value-added (1000 Ush/ha) = (2)-(3)-(4)	508.7	(499.9)	796.2	(799.9)	-287.5	(75.5)	***
6a) Family labor input in hours[b]	702.7	(946.9)	1180.1	(845.6)	-477.3	(101.6)	***
6b) Family labor input in Ush (1000 Ush/ha)[c]	315.4	(434.5)	515.6	(384.0)	-200.2	(46.4)	***
6c) Hired labor input in hours[d]	225.9	(424.2)	433.6	(794.0)	-207.7	(72.1)	***
6d) Hired labor input in Ush (1000 Ush/ha)	100.5	(200.4)	192.1	(353.9)	-91.6	(32.6)	***
6) Total labor in hours (1000 Ush/ha) (=(6a)+(6c))	928.6	(999.1)	1613.7	(1173.1)	-685.1	(123.4)	***
7) Maize income (1000 Ush/ha) (=(5)-(6d))	408.2	(477.8)	604.2	(681.8)	-195.9	(66.7)	***
8) Maize profit (1000 Ush/ha) (=(5)-(6b)-(6d))	92.8	(596.8)	88.5	(658.8)	4.3	(71.2)	

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

a) Value of grain output is evaluated at the community median sales price per kg. The value of leaves and stalks is not included.

b) Family labor input in hours indicates the man-equivalent labor hours spent for maize production of one hectare. Woman and child labor hours are converted into man-equivalent labor hours by conversion factors of 0.73 and 0.5 respectively, which are obtained as the estimates of the coefficients of the woman dummy and child dummy in the community level hourly wage regression using the RePEAT 2009 community survey data (with the fixed effect estimation at the community level): $WAGE_{js} = w_j + b_{woman} * Woman\_dummy_{js} + b_{child} * Child\_dummy_{js} + e_{js}$, where j represents community and s represents type of worker in {Man, Woman, Child}.

c) Family labor input in Ush is evaluated at the community level wage rate.

d) Hired labor input in hours is calculated as hired labor cost divided by the community wage rate since labor hours spent are not asked in the survey for the hired labor.

Table 7. Determinants of demand for 3 inputs and aggregate index: Observations are taken from the price-contingent order forms of the sales meeting 2011 zsparticipants.

	Hybrid seed		Base fertilizer (DAP)		Top-dressing fertilizer (UREA)		Aggregate index	
	1 if purchased any	Purchased quantity (Kg)	1 if purchased any	Purchased quantity (Kg)	1 if purchased any	Purchased quantity (Kg)	1 if purchased any	Total value at market price (1000Ush)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1{Treatment HH}: β_T	0.603***	1.252**	0.29	3.797	0.395	5.953	0.661***	9.090***
	(0.21)	(0.54)	(0.21)	(2.47)	(0.27)	(3.94)	(0.21)	(3.48)
1{Neighbor HH}: β_N	0.423*	0.743	0.167	1.974	0.415	5.768	0.558**	6.057*
	(0.23)	(0.50)	(0.21)	(2.44)	(0.27)	(3.76)	(0.23)	(3.35)
Price (=discounted price/market price - 1)	-0.124	-2.017***	-0.187**	-3.748***	-0.216	-3.843*	-0.127	-10.83***
	(0.13)	(0.35)	(0.07)	(0.87)	(0.16)	(2.15)	(0.13)	(1.77)
Price * 1{Treatment HH}	-0.019	-0.282	-0.001	-0.652	-0.117	-1.936	-0.007	-3.343
	(0.15)	(0.48)	(0.09)	(0.98)	(0.18)	(2.42)	(0.15)	(2.41)
Price * 1{Neighbor HH}	0.017	-0.140	-0.075	-0.869	-0.045	-1.664	-0.030	-2.588
	(0.15)	(0.45)	(0.10)	(1.00)	(0.18)	(2.49)	(0.16)	(2.57)
1{Credit sales}	0.0490*	1.097***	0.264***	3.662***	0.503***	7.657***	0.0514*	6.847***
	(0.03)	(0.21)	(0.08)	(1.08)	(0.16)	(2.54)	(0.03)	(1.49)
1{Credit sales} * 1{Treatment HH} : β_{TC}	-0.012	0.298	0.161*	3.197**	0.102	1.900	0.002	6.752***
	(0.03)	(0.27)	(0.10)	(1.32)	(0.17)	(2.39)	(0.04)	(2.47)
1{Credit sales} * 1{Neighbor HH} : β_{NC}	-0.001	0.312	0.287***	3.592***	0.130	1.861	-0.040	5.178**
	(0.05)	(0.26)	(0.10)	(1.33)	(0.18)	(2.46)	(0.03)	(2.17)
Down-payment rate (demeaned)	0.30	5.62	3.29	41.75	7.807***	107.5***	1.11	58.45*
	(2.36)	(4.71)	(2.46)	(27.90)	(3.00)	(38.32)	(2.45)	(31.15)
Down-payment rate * 1{Credit sales}	0.05	-0.14	-0.76	-9.57	-2.06	-25.02	0.25	23.72
	(0.29)	(2.19)	(1.10)	(13.93)	(1.61)	(20.39)	(0.32)	(23.51)
Interest rate (demeaned)	-2.790**	-4.64	0.224	0.392	-0.906	-15.3	-3.307**	-32.06*
	(1.22)	(3.23)	(1.08)	(11.49)	(1.22)	(15.84)	(1.29)	(16.53)
Interest rate * 1{Credit sales}	-0.305	-3.563**	-0.711	-10.36*	-0.821	-15.23	0.0417	-29.78**
	(0.30)	(1.73)	(0.49)	(6.11)	(0.71)	(10.47)	(0.18)	(13.94)
Random compensation (1000Ush) (demeaned)	0.0531*	0.126**	0.0859***	0.950***	0.0568**	0.724**	0.0698**	1.089***
	(0.03)	(0.05)	(0.02)	(0.25)	(0.02)	(0.29)	(0.03)	(0.31)
Random compensation * 1{Credit sales}	0.0058	-0.0182	-0.0336*	-0.340*	-0.0427**	-0.533**	-0.0070	-0.0508
	(0.01)	(0.05)	(0.02)	(0.20)	(0.02)	(0.26)	(0.00)	(0.28)
Constant	0.564***	0.701	-0.925***	-13.08***	-1.701***	-25.61***	0.573***	0.206
	(0.19)	(0.45)	(0.17)	(2.58)	(0.25)	(5.26)	(0.19)	(2.89)
Number of observations	6993	6993	6993	6993	6993	6993	6993	6993
Number of households	777	777	777	777	777	777	777	777
Number of communities	69	69	69	69	69	69	69	69
β_T - β_N	0.179*	0.509*	0.123	1.823	-0.020	0.185	0.103	3.033*
(p-value)	(0.000)	(0.001)	(0.027)	(0.035)	(0.593)	(0.486)	(0.000)	(0.001)
$\beta_T + \beta_{TC}$	0.590***	1.550**	0.452**	6.994***	0.497**	7.853**	0.663***	15.842***
(p-value)	(0.000)	(0.001)	(0.027)	(0.035)	(0.593)	(0.486)	(0.000)	(0.001)
$\beta_N + \beta_{NC}$	0.423*	1.054*	0.454**	5.566**	0.545**	7.630**	0.518**	11.235**
(p-value)	(0.000)	(0.001)	(0.027)	(0.035)	(0.593)	(0.486)	(0.000)	(0.001)
$(\beta_T+\beta_{TC})$- $(\beta_N+\beta_{NC})$	0.168	0.496	-0.002	1.427	-0.048	0.223	0.145	4.607*
(p-value)	(0.000)	(0.001)	(0.027)	(0.035)	(0.593)	(0.486)	(0.000)	(0.001)

Notes: Robust standard errors (clustered by community) are given in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Probit estimation method is applied for the regressions of Column 1, 3, 5, and 7 and Tobit is applied for the others.

Table 8. Determinants of the growth of purchase quantity between the 2009 and 2011 sales meeting.

	d(Hybrid seed) (Kg)	d(Base fertilizer) (DAP in Kg)	d(Top-dressing fertilizer) (UREA in Kg)	d(Aggregate index) (Total value of inputs at market price in 1000Ush)
	(1)	(2)	(3)	(4)
1{Treatment HH} (β_T)	-0.108	-0.626	-0.339	-2.307
	(0.38)	(0.64)	(0.39)	(2.71)
1{Neighbor HH} (β_N)	0.235	0.193	0.00759	1.243
	(0.34)	(0.47)	(0.23)	(2.07)
Price (=discounted price/market price - 1)	-1.271***	0.666	0.851**	-0.857
	(0.36)	(0.68)	(0.33)	(2.77)
Price * 1{Treatment HH}	0.454	0.727	0.409	3.398
	(0.51)	(0.92)	(0.57)	(3.68)
Price * 1{Neighbor HH}	-0.509	-0.114	-1.470**	-4.841
	(0.65)	(0.84)	(0.68)	(3.83)
1{Credit sales}	0.785*	-5.054***	-1.425*	-10.04**
	(0.47)	(1.38)	(0.80)	(4.57)
1{Credit sales} * 1{Treatment HH} (β_{TC})	0.015	-0.357	-0.712	-1.872
	(0.34)	(0.90)	(0.56)	(3.05)
1{Credit sales} * 1{Neighbor HH} (β_{NC})	0.361	1.090	0.410	4.140
	(0.30)	(0.81)	(0.56)	(2.85)
d(Down-payment rate)	-0.94	3.63	3.42	8.98
	(1.49)	(2.94)	(2.22)	(12.91)
d(Down-payment rate) * 1{Credit sales}	-2.465*	-18.57***	-1.84	-49.81***
	(1.30)	(5.98)	(2.63)	(17.85)
d(Interest rate)	-0.0456	3.847	-0.674	6.634
	(2.20)	(3.67)	(1.29)	(15.33)
d(Interest rate) * 1{Credit sales}	-4.179**	3.219	2.7	-4.304
	(1.76)	(3.84)	(2.78)	(13.08)
Random compensation (1000Ush) (demeaned)	0.107*	0.295***	0.061	1.076***
	(0.06)	(0.07)	(0.04)	(0.30)
Random compensation * 1{Credit sales}	0.012	0.103	-0.033	0.232
	(0.06)	(0.12)	(0.10)	(0.40)
Constant	0.354	-0.449	0.636	0.993
	(0.63)	(0.96)	(0.43)	(4.22)
Number of observations	4282	4281	4278	4278
Number of households	476	476	476	476
Number of communities	69	69	69	69
R-sq	0.019	0.043	0.018	0.029
$\beta_T - \beta_N$	-0.343	-0.819	-0.347	-3.550
(p-value)	(0.217)	(0.134)	(0.369)	(0.106)
$\beta_T + \beta_{TC}$	-0.093	-0.983	-1.051	-4.178
(p-value)	(0.877)	(0.420)	(0.182)	(0.407)
$\beta_N + \beta_{NC}$	0.597	1.283	0.417	5.383
(p-value)	(0.249)	(0.213)	(0.545)	(0.216)
$(\beta_T+\beta_{TC})- (\beta_N+\beta_{NC})$	-0.690*	-2.266**	-1.468**	-9.562***
(p-value)	(0.051)	(0.017)	(0.027)	(0.007)

Notes: Robust standard errors (clustered by community) are given in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
OLS regression results are presented.
Observations are taken from the price-contingent order forms of the participants in both the 2009 and 2011 sales meeting.

Table 9. Effect of own experience and information spillovers: determinants of the change in the ratio of the base fertilizer to the hybrid seed quantity between the 2009 and 2011 sales meeting. Dependent variable: *d*(Base fertilizer in Kg/ Hybrid seed in Kg).

	Peer = Information peer			Peer = Geographic peer		
	(1)	(2)	(3)	(4)	(5)	(6)
Difference in base fertilizer application on Hybrid maize (kg/ha) in 2010 between Peers' average and his own: *Dq_Peer = q_Peer – q_own*	0.00328***	0.00343**	0.00197	0.00513***	0.00346***	0.00487**
	(0.00127)	(0.00149)	(0.00234)	(0.00112)	(0.00134)	(0.00222)
Difference in profit gain from use of Hybrid seed (1 million Ush/ha) in 2010 between Peers' average and his own: *Dπ_Peer = Δπ_Peer -Δπ_own*		0.0235			-0.617**	
		(0.272)			(0.258)	
*Dq_Peer * Dπ_Peer*		0.00697			-0.000835	
		(0.00530)			(0.00378)	
1{Δπ_Peer < Δπ_own & Δπ_own >0} (= *J*)	0.0421	-0.346**	0.776***	0.0378	-0.485***	0.828***
	(0.110)	(0.155)	(0.234)	(0.109)	(0.162)	(0.234)
1{Δπ_Peer > Δπ_own & Δπ_Peer >0} (= *I*)	0.239**	0.805***	0.422**	-0.0232	0.883***	0.448**
	(0.114)	(0.163)	(0.186)	(0.127)	(0.208)	(0.216)
*Dq_Peer * J*	0.00790**	0.0139**	0.0236***	-0.00359	0.0140**	-0.00174
	(0.00335)	(0.00547)	(0.00857)	(0.00309)	(0.00584)	(0.00718)
*Dq_Peer * I*	0.00850***	0.0221***	0.0429***	-0.00517	-0.0137*	-0.0130
	(0.00261)	(0.00452)	(0.00723)	(0.00329)	(0.00762)	(0.00941)
*Dπ_Peer * J*		-0.913**			-0.917**	
		(0.404)			(0.443)	
*Dπ_Peer * I*		-2.594***			-2.181***	
		(0.524)			(0.551)	
*Dq_Peer * Dπ_Peer * J*		0.00447			0.0374***	
		(0.00984)			(0.0108)	
*Dq_Peer * Dπ_Peer * I*		-0.0509***			0.00349	
		(0.0101)			(0.0130)	
Number of seasons of own experience in use of Hybrid seed before the sales meeting 2011: *Num_exp*			-0.0804*			-0.160***
			(0.0476)			(0.0490)
*Dq_Peer * Num_exp*			0.000730			-0.000470
			(0.00131)			(0.00113)
*Num_exp * J*			-0.339***			-0.339***
			(0.0989)			(0.0997)
*Num_exp * I*			-0.200**			-0.312***
			(0.0835)			(0.104)
*Dq_Peer * Num_exp * J*			-0.00745**			-8.42e-05
			(0.00375)			(0.00309)
*Dq_Peer * Num_exp * I*			-0.0155***			0.00369
			(0.00291)			(0.00420)
Community dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	3,331	3,331	3,331	3,041	3,041	3,041
Number of households	561	561	561	511	511	511
Number of communities	67	67	67	67	67	67
R-sq	0.046	0.063	0.071	0.038	0.059	0.060

Notes: Standard errors are given in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Observations are taken from the price-contingent order forms of the participants in both the 2009 and 2011 sales meeting.
There are other controls which are not shown in the table, namely, Price (=discounted price/market price - 1), 1{Credit sales}, d(Down-payment rate) * 1{Credit sales}, Random compensation, Random compensation * 1{Credit sales}.
The reference category corresponding to *I* and *J* is {Δπ_Peer < 0 & Δπ_own < 0}.

Table 10. Effect of own experience and information spillovers: determinants of the change in the ratio of the top-dressing fertilizer to the hybrid seed quantity between the 2009 and 2011 sales meeting. Dependent variable: *d*(Top-dressing fertilizer in Kg/ Hybrid seed in Kg).

	Peer = Information peer			Peer = Geographic peer		
	(1)	(2)	(3)	(4)	(5)	(6)
Difference in top-dressing fertilizer application on Hybrid maize (kg/ha) 2010 between Peers' average and his own: *Dq_Peer = q_Peer – q_own*	0.00513***	0.00411***	0.00735***	0.00487***	0.00344***	0.00884***
	(0.00106)	(0.00119)	(0.00241)	(0.00102)	(0.00117)	(0.00229)
Difference in profit gain from use of Hybrid seed (1 million Ush/ha) in 2010 between Peers' average and his own: *Dπ_Peer = Δπ_Peer -Δπ_own*		-0.400**			-0.378**	
		(0.174)			(0.170)	
*Dq_Peer * Dπ_Peer*		-0.00285			0.00488	
		(0.00503)			(0.00306)	
1{Δπ_Peer < Δπ_own & Δπ_own >0} (= *J*)	0.191**	0.0967	0.301*	0.110	-0.228**	0.516***
	(0.0760)	(0.110)	(0.168)	(0.0753)	(0.115)	(0.167)
1{Δπ_Peer > Δπ_own & Δπ_Peer >0} (= *I*)	0.198**	0.463***	0.256**	-0.0225	0.383***	0.0979
	(0.0791)	(0.113)	(0.126)	(0.0877)	(0.131)	(0.135)
*Dq_Peer * J*	-0.00112	-0.00238	0.00164	-0.00398*	0.00847**	-0.00982*
	(0.00243)	(0.00381)	(0.00694)	(0.00228)	(0.00427)	(0.00586)
*Dq_Peer * I*	0.0115***	0.0108**	0.0228***	-0.00227	-0.00449	-0.000263
	(0.00254)	(0.00524)	(0.00682)	(0.00290)	(0.00574)	(0.00800)
*Dπ_Peer * J*		0.214			-0.529*	
		(0.272)			(0.311)	
*Dπ_Peer * I*		-0.687*			-1.113***	
		(0.351)			(0.381)	
*Dq_Peer * Dπ_Peer * J*		-0.00170			0.0228**	
		(0.00713)			(0.00890)	
*Dq_Peer * Dπ_Peer * I*		0.000101			-0.0105	
		(0.0102)			(0.0104)	
Number of seasons of own experience in use of Hybrid seed before the sales meeting 2011: *Num_exp*			-0.0927***			-0.0954***
			(0.0329)			(0.0338)
*Dq_Peer * Num_exp*			-0.00150			-0.00242**
			(0.00111)			(0.00102)
*Num_exp * J*			-0.0230			-0.166**
			(0.0717)			(0.0720)
*Num_exp * I*			-0.0409			-0.0978
			(0.0572)			(0.0696)
*Dq_Peer * Num_exp * J*			-0.000724			0.00337
			(0.00287)			(0.00246)
*Dq_Peer * Num_exp * I*			-0.00555*			-0.000993
			(0.00295)			(0.00350)
Community dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	3,330	3,330	3,330	3,040	3,040	3,040
Number of households	561	561	561	511	511	511
Number of communities	67	67	67	67	67	67
R-sq	0.042	0.048	0.051	0.023	0.037	0.036

Notes: Standard errors are given in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Observations are taken from the price-contingent order forms of the participants in both the 2009 and 2011 sales meeting.
There are other controls which are not shown in the table, namely, Price (=discounted price/market price - 1), 1{Credit sales}, d(Down-payment rate) * 1{Credit sales}, Random compensation, Random compensation * 1{Credit sales}.
The reference category corresponding to *I* and *J* is {Δπ_Peer < 0 & Δπ_own < 0}.

Table 11. Effect of own experience and information spillovers: determinants of the growth of hybrid seed purchase quantity between the 2009 and 2011 sales meeting. Dependent variable: *d*(Hybrid seed in Kg).

	Peer = Information peer			Peer = Geographic peer		
	(1)	(2)	(3)	(4)	(5)	(6)
Profit gain from the use of hybrid seeds in 2010 by himself (1 million Ush/ha): *Δπ_own*		0.952	0.0985		0.483	-0.461
		(0.600)	(0.626)		(0.581)	(0.598)
Average profit gain from the use of hybrid seeds in 2010 by his Peers: *Δπ_Peer*		0.772	2.197*		0.0442	-1.548
		(0.871)	(1.123)		(0.757)	(0.980)
1{Δπ_Peer < Δπ_own & Δπ_own >0} (= *J*)	0.533**	0.0327	-2.507***	0.510**	-0.00410	-1.838***
	(0.214)	(0.338)	(0.637)	(0.207)	(0.342)	(0.618)
1{Δπ_Peer > Δπ_own & Δπ_Peer >0} (= *I*)	-0.763***	-0.522	-0.246	-0.536**	0.675*	0.744
	(0.225)	(0.365)	(0.504)	(0.244)	(0.398)	(0.566)
*Δπ_own * J*		1.176	1.276		1.222	1.701*
		(0.909)	(0.938)		(0.905)	(0.941)
*Δπ_own * I*		0.0121	-0.232		2.054*	1.551
		(1.127)	(1.167)		(1.202)	(1.244)
*Δπ_Peer * J*		1.619	1.657		-0.332	-0.0990
		(1.310)	(3.484)		(1.221)	(3.304)
*Δπ_Peer * I*		-2.144	-5.576**		-5.805***	2.483
		(1.451)	(2.174)		(1.854)	(3.355)
Number of seasons of own experience in use of Hybrid seed before the sales meeting 2011: *Num_exp*			-0.714***			-0.202
			(0.152)			(0.145)
*Δπ_Peer * Num_exp*			-0.881			1.544***
			(0.574)			(0.527)
*J * Num_exp*			1.464***			0.858***
			(0.264)			(0.250)
*I * Num_exp*			-0.151			-0.423
			(0.241)			(0.315)
*Δπ_Peer * J * Num_exp*			-0.0923			-1.108
			(1.546)			(1.453)
*Δπ_Peer * I * Num_exp*			2.177**			-4.446***
			(1.103)			(1.657)
Community dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	3331	3331	3331	3,041	3,041	3,041
Number of households	561	561	561	511	511	511
Number of communities	67	67	67	67	67	67
R-sq	0.025	0.031	0.056	0.017	0.026	0.055

Notes: Standard errors are given in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Observations are taken from the price-contingent order forms of the participants in both the 2009 and 2011 sales meeting.
There are other controls which are not shown in the table, namely, Price (=discounted price/market price - 1), 1{Credit sales}, d(Down-payment rate) * 1{Credit sales}, Random compensation, Random compensation * 1{Credit sales}.
The reference category corresponding to *I* and *J* is {Δπ_Peer < 0 & Δπ_own < 0}.

Appendix Table 1. Compliance rate on the experimental intervention of the free input distribution

Feb/2009	Free input distribution	
	Number of households receiving free inputs	378
Oct/2009	RePEAT 3 survey	
	Number of the free input recipients whose maize production records were tracked in the survey	351
	Fraction of the free input recipients who planted Hybrid seeds in the first cropping season in 2009	0.88
	Fraction of the free input recipients who planted Hybrid seeds in the second cropping season in 2009	0.08
	Fraction of the free input recipients who did not plant seeds in 2009	0.05

Appendix Table 2. Maize production and use of modern inputs

Year	2008		2009		2010	
Season	1	2	1	2	1	2
Treatment Households						
Number of maize producing households	270	260	374	231	251	191
Maize producing households with LOCAL seed						
Number of households	241	243	189	155	148	163
Average yield (kg/ha)	1218.1	1089.8	869.0	1312.8	1120.1	868.0
	(1104.7)	(993.7)	(971.5)	(1042.5)	(911.5)	(857.4)
Average chemical fertilizer use (kg/ha)	1.6	0.3	2.0	3.1	7.6	1.0
	(15.3)	(4.1)	(16.4)	(12.3)	(34.7)	(4.6)
Maize producing households with Hybrid seed						
Number of households	29	17	352	152	130	39
Average yield (kg/ha)	1448.9	1900.4	1841.9	1836.6	1588.6	1059.1
	(1486.2)	(2269.7)	(1476.7)	(1297.2)	(1547.9)	(1211.1)
Average chemical fertilizer use (kg/ha)	1.0	7.8	150.7	42.5	31.3	16.6
	(5.5)	(31.1)	(77.4)	(54.6)	(50.4)	(26.1)
Control Households						
Number of maize producing households	157	140	164	130	117	91
Maize producing households with LOCAL seed						
Number of households	145	136	146	112	77	76
Average yield (kg/ha)	1338.9	1231.3	1077.1	1572.5	1334.9	1061.0
	(1416.8)	(1039.6)	(1081.8)	(1093.0)	(1204.5)	(863.5)
Average chemical fertilizer use (kg/ha)	0.5	1.2	1.2	3.2	1.6	1.9
	(4.6)	(8.0)	(5.7)	(28.1)	(4.9)	(7.7)
Maize producing households with Hybrid seed						
Number of households	12	4	18	65	50	16
Average yield (kg/ha)	1265.5	1399.9	1317.4	1659.7	1387.4	636.0
	(871.6)	(451.8)	(1006.8)	(1164.3)	(937.5)	(650.1)
Average chemical fertilizer use (kg/ha)	8.2	12.4	19.1	28.6	20.7	7.1
	(19.9)	(14.3)	(31.2)	(36.4)	(28.8)	(17.7)
Neighbor Households						
Number of maize producing households	244	233	289	192	179	149
Maize producing households with LOCAL seed						
Number of households	228	226	255	150	115	126
Average yield (kg/ha)	1017.5	1028.4	771.6	1174.3	1049.8	785.0
	(798.1)	(970.4)	(900.9)	(880.3)	(892.6)	(774.1)
Average chemical fertilizer use (kg/ha)	1.0	0.1	0.8	0.2	0.7	0.7
	(10.1)	(1.3)	(7.8)	(1.9)	(3.3)	(5.5)
Maize producing households with Hybrid seed						
Number of households	16	7	36	108	89	29
Average yield (kg/ha)	1667.4	699.0	1335.8	1598.2	1386.6	1061.7
	(1615.1)	(791.4)	(1352.0)	(1387.2)	(1041.0)	(1277.5)
Average chemical fertilizer use (kg/ha)	7.4	12.2	32.1	30.6	26.0	13.0
	(24.9)	(21.2)	(54.9)	(51.0)	(42.0)	(25.6)

Notes: Standard deviations are in parentheses.
Some households plant both Hybrid and LOCAL seeds in the same season.
Maize production data is obtained from the RePEAT survey 2009 in Oct 2009 and the Sales Meeting 2011 in Feb 2011.

Appendix Table 3: Labor input on maize plot in 2009 by activity

Activity	Variable	Non-experimental plot			Experimental plot			Difference		
		N	Mean	Std. Dev	N	Mean	Std. Dev	Mean	Std. Err.	
Land preparation	Family labor (Hours/ha)	165	284.1	(646.65)	165	295.9	(352.94)	-11.9	(57.35)	
	Hired labor cost (1000Ush/ha)	165	41.2	(82.15)	165	72.0	(101.18)	-30.8	(10.15)	***
	Family labor (Hours/ha) given zero hired labor	94	462.5	(806.58)	91	414.2	(389.22)	48.3	(92.66)	
	Hired labor cost (1000Ush/ha) given zero family labor	48	99.2	(92.51)	37	168.8	(76.59)	-69.6	(18.35)	***
Planting and base fertilizer application	Family labor (Hours/ha)	165	97.7	(127.14)	165	177.3	(172.98)	-79.6	(16.71)	***
	Hired labor cost (1000Ush/ha)	165	11.0	(50.24)	165	23.8	(164.23)	-12.8	(13.37)	
	Family labor (Hours/ha) given zero hired labor	141	107.7	(133.52)	137	191.8	(173.18)	-84.1	(18.58)	***
	Hired labor cost (1000Ush/ha) given zero family labor	10	47.4	(44.02)	8	94.8	(82.55)	-47.4	(32.33)	
Weeding (1st)	Family labor (Hours/ha)	165	177.4	(265.18)	165	233.5	(316.10)	-56.1	(32.12)	*
	Hired labor cost (1000Ush/ha)	165	22.0	(57.82)	165	31.4	(62.58)	-9.3	(6.63)	
	Family labor (Hours/ha) given zero hired labor	115	236.7	(294.15)	119	294.4	(344.04)	-57.7	(41.80)	
	Hired labor cost (1000Ush/ha) given zero family labor	30	99.6	(101.30)	25	135.1	(67.11)	-35.5	(22.85)	
Top-dressing fertilizer application	Family labor (Hours/ha)	165	5.1	(41.53)	165	103.3	(199.24)	-98.2	(15.84)	***
	Hired labor cost (1000Ush/ha)	165	1.5	(12.92)	165	7.0	(28.74)	-5.6	(2.45)	**
	Family labor (Hours/ha) given zero hired labor	5	135.6	(215.33)	128	128.9	(219.18)	6.7	(98.23)	
	Hired labor cost (1000Ush/ha) given zero family labor	1	158.1	.	7	101.2	(87.21)	57.0	.	
Weeding (2nd)	Family labor (Hours/ha)	165	72.9	(124.09)	165	157.2	(202.22)	-84.3	(18.47)	***
	Hired labor cost (1000Ush/ha)	165	6.8	(26.09)	165	20.3	(54.74)	-13.5	(4.72)	***
	Family labor (Hours/ha) given zero hired labor	75	156.5	(144.19)	102	227.2	(201.57)	-70.8	(25.99)	***
	Hired labor cost (1000Ush/ha) given zero family labor	13	74.7	(57.97)	18	127.4	(88.19)	-52.7	(26.28)	*
Harvesting	Family labor (Hours/ha)	165	82.1	(102.87)	165	158.0	(156.81)	-75.8	(14.60)	***
	Hired labor cost (1000Ush/ha)	165	6.9	(27.44)	165	10.2	(33.53)	-3.3	(3.37)	
	Family labor (Hours/ha) given zero hired labor	134	91.8	(104.33)	132	169.7	(155.78)	-77.9	(16.28)	***
	Hired labor cost (1000Ush/ha) given zero family labor	9	50.7	(57.63)	3	128.5	(69.19)	-77.7	(44.33)	
Other activity	Family labor (Hours/ha)	165	60.1	(155.14)	165	142.7	(457.34)	-82.6	(37.60)	**
	Hired labor cost (1000Ush/ha)	165	10.0	(30.79)	165	26.5	(82.41)	-16.5	(6.85)	**
	Family labor (Hours/ha) given zero hired labor	81	101.5	(197.97)	86	224.3	(600.85)	-122.8	(68.42)	*
	Hired labor cost (1000Ush/ha) given zero family labor	16	48.8	(61.61)	15	169.9	(167.83)	-121.0	(45.99)	**
Total	Family labor (Hours/ha)	165	779.4	(1112.54)	165	1267.7	(1439.79)	-488.3	(141.65)	***
	Hired labor cost (1000Ush/ha)	165	99.3	(197.22)	165	191.3	(346.28)	-91.9	(31.02)	***

Notes: Observations are households who planted both hybrid seeds with chemical fertilizers obtained for free from the project and local varieties in the 1st crop season in 2009.

Woman and child labor hours are converted into man-equivalent labor hours by the conversion factors of 0.73 and 0.5 respectively, which are obtained as the estimates of the coefficients of the woman dummy and child dummy in the community level hourly wage regression using the RePEAT 2009 community survey data (with the fixed effect estimation at the community level): $WAGE_{js} = w_j + b_{woman} * Woman\_dummy_{js} + b_{child} * Child\_dummy_{js} + e_{js}$, where *j* represents community and *s* does type of worker in {Man, Woman, Child}.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Appendix Table 4. Determinants of demand for 3 inputs and aggregate index: Observations are taken from the price-contingent order forms of the sales meeting 2011 participants and also include non-participants, whose purchase quantities are set at zero.

	Hybrid seed		Base fertilizer (DAP)		Top-dressing fertilizer (UREA)		Aggregate index	
	1 if purchased any	Purchased quantity (Kg)	1 if purchased any	Purchased quantity (Kg)	1 if purchased any	Purchased quantity (Kg)	1 if purchased any	Total value at market price (1000Ush)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1{Treatment HH}: β_T	0.577***	1.722***	0.336*	4.559*	0.411	6.512	0.603***	11.80***
	(0.16)	(0.55)	(0.18)	(2.36)	(0.25)	(3.97)	(0.16)	(3.62)
1{Neighbor HH}: β_N	0.213	0.589	0.115	1.538	0.352	5.291	0.266*	4.906
	(0.16)	(0.50)	(0.18)	(2.28)	(0.25)	(3.74)	(0.16)	(3.29)
Price (=discounted price/market price - 1)	-0.0785	-1.704***	-0.170**	-3.543***	-0.204	-3.775*	-0.0789	-9.235***
	(0.08)	(0.31)	(0.07)	(0.86)	(0.15)	(2.15)	(0.08)	(1.59)
Price * 1{Treatment HH}	0.001	-0.339	-0.002	-0.649	-0.111	-1.956	0.010	-3.369
	(0.09)	(0.43)	(0.08)	(0.97)	(0.17)	(2.42)	(0.09)	(2.18)
Price * 1{Neighbor HH}	0.031	-0.028	-0.054	-0.681	-0.029	-1.337	0.020	-1.604
	(0.08)	(0.39)	(0.09)	(0.99)	(0.16)	(2.43)	(0.09)	(2.24)
1{Credit sales}	0.027	0.873***	0.224***	3.357***	0.457***	7.355***	0.0308*	5.428***
	(0.02)	(0.18)	(0.07)	(1.06)	(0.15)	(2.50)	(0.02)	(1.26)
1{Credit sales} * 1{Treatment HH} : β_{TC}	-0.011	0.331	0.156*	3.193**	0.108	2.069	-0.006	6.334***
	(0.02)	(0.24)	(0.09)	(1.30)	(0.16)	(2.38)	(0.02)	(2.22)
1{Credit sales} * 1{Neighbor HH} : β_{NC}	-0.008	0.241	0.240***	3.385***	0.108	1.740	-0.0276*	4.033**
	(0.02)	(0.23)	(0.09)	(1.31)	(0.16)	(2.44)	(0.02)	(1.85)
Down-payment rate (demeaned)	-0.20	3.87	2.83	38.93	7.103**	104.0***	0.16	44.34
	(1.77)	(4.77)	(2.27)	(28.01)	(2.87)	(39.56)	(1.79)	(33.34)
Down-payment rate * 1{Credit sales}	0.04	-0.32	-0.93	-11.70	-2.21	-28.44	0.12	16.91
	(0.14)	(1.89)	(0.94)	(13.08)	(1.48)	(20.14)	(0.15)	(19.81)
Interest rate (demeaned)	-1.518*	-4.587	0.147	-0.162	-0.898	-15.73	-1.678*	-31.61*
	(0.90)	(3.37)	(0.98)	(11.43)	(1.18)	(16.36)	(0.94)	(18.64)
Interest rate * 1{Credit sales}	-0.11	-2.965*	-0.659	-10.06*	-0.726	-14.29	0.0538	-24.71**
	(0.13)	(1.52)	(0.42)	(5.78)	(0.66)	(10.30)	(0.08)	(12.15)
Random compensation (1000Ush) (demeaned)	0.158***	0.380***	0.127***	1.466***	0.0879***	1.198***	0.175***	2.667***
	(0.03)	(0.07)	(0.02)	(0.30)	(0.02)	(0.33)	(0.02)	(0.42)
Random compensation * 1{Credit sales}	(0.01)	(0.02)	-(0.02)	-(0.27)	-0.0353**	-0.465*	(0.00)	(0.28)
	(0.01)	(0.05)	(0.02)	(0.20)	(0.02)	(0.28)	(0.00)	(0.27)
Constant	-0.0149	-0.870*	-1.139***	-16.42***	-1.844***	-29.13***	-0.0128	-9.287***
	(0.13)	(0.47)	(0.14)	(2.68)	(0.23)	(5.59)	(0.13)	(3.16)
Number of observations	9072	9072	9072	9072	9072	9072	9072	9072
Number of households	1008	1008	1008	1008	1008	1008	1008	1008
Number of communities	69	69	69	69	69	69	69	69
β_T - β_N	0.364***	1.133***	0.221**	3.020**	0.059	1.222	0.337***	6.893***
(p-value)	(0.000)	(0.001)	(0.027)	(0.035)	(0.593)	(0.486)	(0.000)	(0.001)
$\beta_T + \beta_{TC}$	0.566***	2.053***	0.493***	7.752***	0.519**	8.581**	0.597***	18.133***
(p-value)	(0.000)	(0.004)	(0.003)	(0.001)	(0.013)	(0.019)	(0.000)	(0.001)
$\beta_N + \beta_{Nc}$	0.205	0.829	0.355**	4.923**	0.460**	7.031**	0.238	8.939**
(p-value)	(0.198)	(0.191)	(0.032)	(0.027)	(0.033)	(0.039)	(0.135)	(0.047)
$(\beta_T+\beta_{TC})$- $(\beta_N+\beta_{NC})$	0.361***	1.224***	0.138*	2.829**	0.060	1.550	0.359***	9.194***
(p-value)	(0.000)	(0.003)	(0.093)	(0.018)	(0.388)	(0.188)	(0.000)	(0.004)

Notes: Robust standard errors (clustered by community) are given in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Appendix Table 5. Determinants of the growth of purchase quantity between the 2009 and 2011 sales meeting: Observations are taken from the price-contingent order forms of the sales meetings in 2009 and 2011 participants and also include non-participants, whose purchase quantities are set at zero.

	d(Hybrid seed) (Kg)	d(Base fertilizer) (DAP in Kg)	d(Top-dressing fertilizer) (UREA in Kg)	d(Aggregate index) (Total value of inputs at market price in 1000Ush)
	(1)	(2)	(3)	(4)
1{Treatment HH} (β_T)	0.0378	-0.39	-0.268	-1.197
	(0.27)	(0.43)	(0.28)	(1.82)
1{Neighbor HH} (β_N)	0.0966	0.068	-0.0856	0.329
	(0.24)	(0.30)	(0.17)	(1.37)
Price (=discounted price/market price - 1)	-0.722**	1.517***	0.725**	2.32
	(0.33)	(0.56)	(0.29)	(2.43)
Price * 1{Treatment HH}	0.143	0.413	0.412	1.739
	(0.42)	(0.72)	(0.47)	(3.00)
Price * 1{Neighbor HH}	-0.471	-0.173	-0.659*	-3.459
	(0.43)	(0.54)	(0.36)	(2.56)
1{Credit sales}	0.313	-2.280***	-0.470	-4.495
	(0.29)	(0.80)	(0.47)	(2.91)
1{Credit sales} * 1{Treatment HH} (β_{TC})	0.127	-0.068	-0.721	-0.902
	(0.26)	(0.65)	(0.44)	(2.31)
1{Credit sales} * 1{Neighbor HH} (β_{NC})	0.228	0.571	0.151	2.217
	(0.23)	(0.55)	(0.36)	(2.01)
d(Down-payment rate)	0.80	3.726**	2.406*	14.15**
	(0.85)	(1.66)	(1.33)	(6.96)
d(Down-payment rate) * 1{Credit sales}	-1.22	-6.829***	0.21	-18.03**
	(0.97)	(2.45)	(1.69)	(8.17)
d(Interest rate)	-0.891	0.788	-0.612	-2.973
	(1.05)	(1.69)	(0.96)	(7.43)
d(Interest rate) * 1{Credit sales}	-2.296*	-1.233	-0.106	-10.89
	(1.15)	(2.49)	(1.80)	(9.21)
Random compensation (1000Ush) (demeaned)	0.175***	0.304***	0.0723*	1.333***
	(0.05)	(0.07)	(0.04)	(0.28)
Random compensation * 1{Credit sales}	0.047	0.121	0.012	0.458
	(0.05)	(0.10)	(0.09)	(0.37)
Constant	0.522*	0.244	0.469**	2.973*
	(0.28)	(0.32)	(0.21)	(1.64)
Number of observations	6636	6636	6631	6631
Number of households	722	722	721	721
Number of communities	69	69	69	69
R-sq	0.015	0.027	0.018	0.022
β_T - β_N	-0.059	-0.458	-0.182	-1.526
(p-value)	(0.748)	(0.184)	(0.452)	(0.266)
$\beta_T + \beta_{TC}$	0.164	-0.458	-0.989*	-2.099
(p-value)	(0.718)	(0.586)	(0.092)	(0.558)
$\beta_N + \beta_{NC}$	0.325	0.639	0.065	2.546
(p-value)	(0.422)	(0.328)	(0.885)	(0.387)
$(\beta_T+\beta_{TC})$- $(\beta_N+\beta_{NC})$	-0.161	-1.097*	-1.054**	-4.645*
(p-value)	(0.563)	(0.094)	(0.021)	(0.070)

Notes: Robust standard errors (clustered by community) are given in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

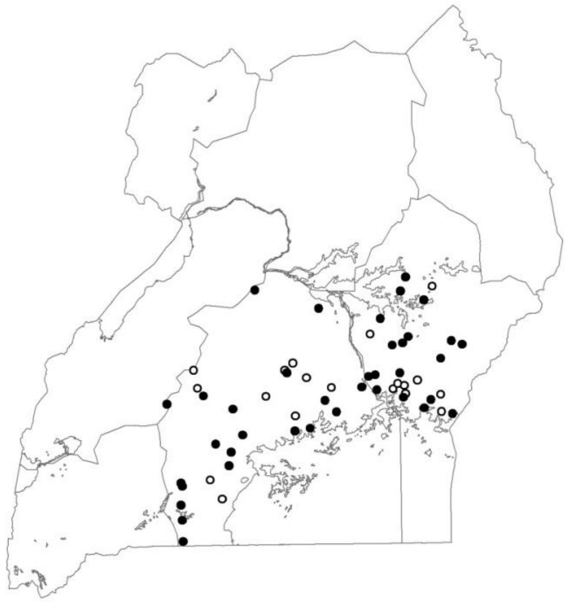


Figure 1. Survey Villages in Uganda
Note: Black dots indicate treatment villages; white dots indicate control villages.

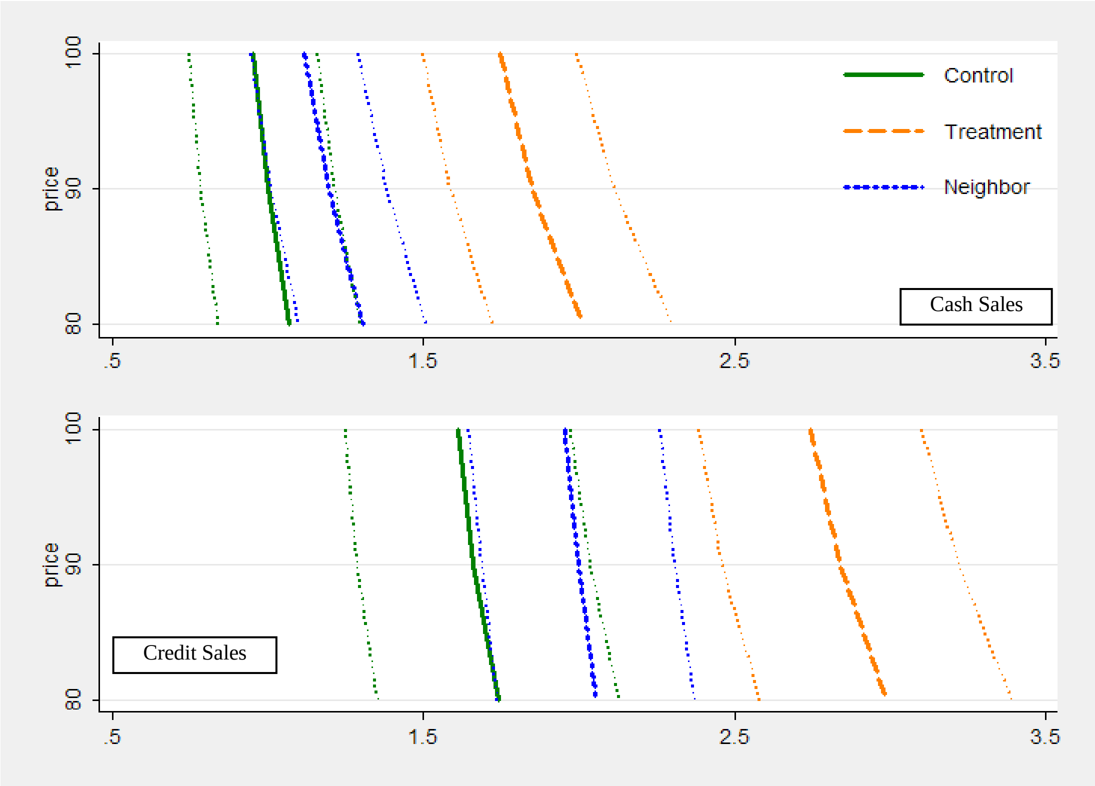
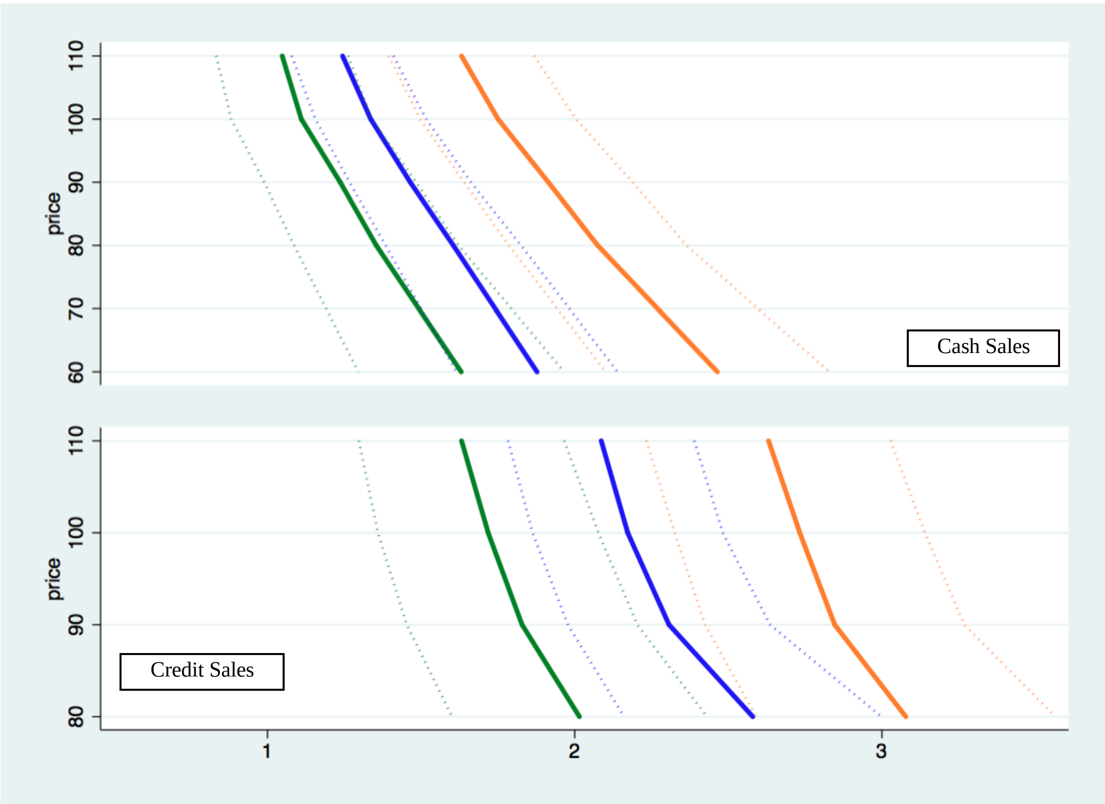


Figure 2. Hybrid seed: Estimated demand curves in Sales Meeting 2009 (above) and 2011 (below)



Note: The dotted lines indicate the 95 % confidence interval. The estimated demand is the sample average of the quantities given different prices and credit option availability that the sales workshop participants filled out in the price-contingent order form used in the sales meeting. The vertical axis represents the price index normalized by the market price set at 100. The horizontal axis represents the purchased quantity in kilograms.

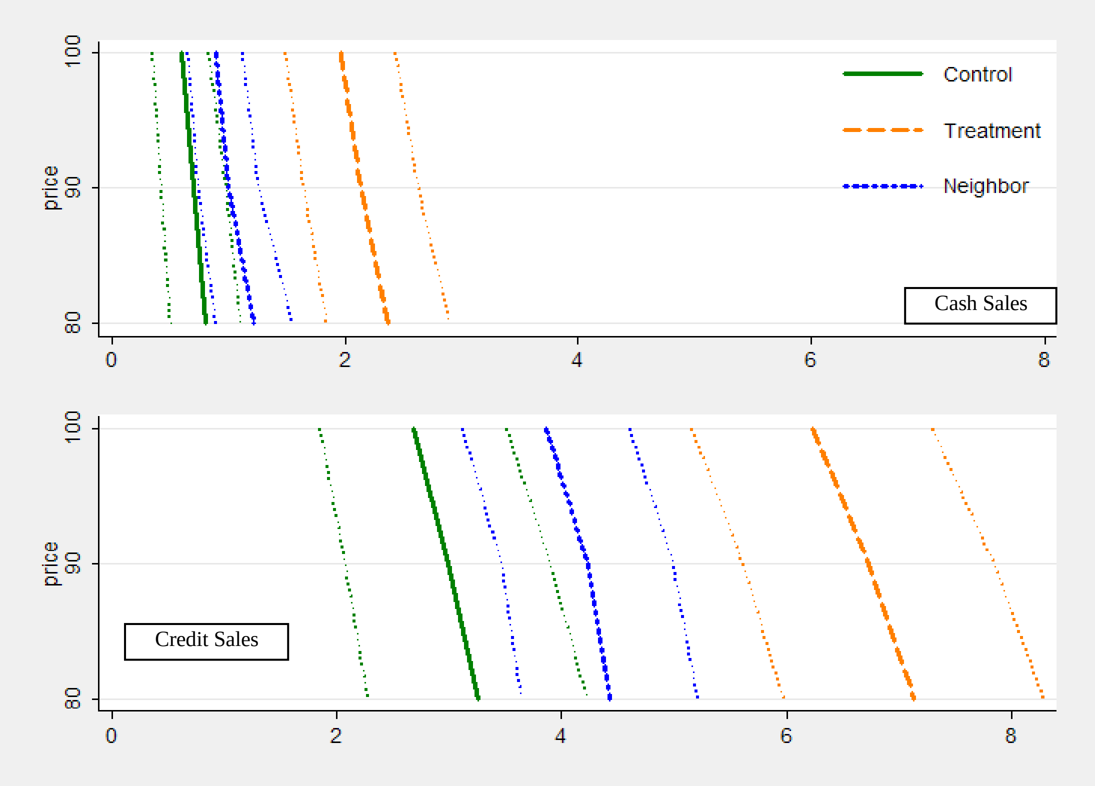
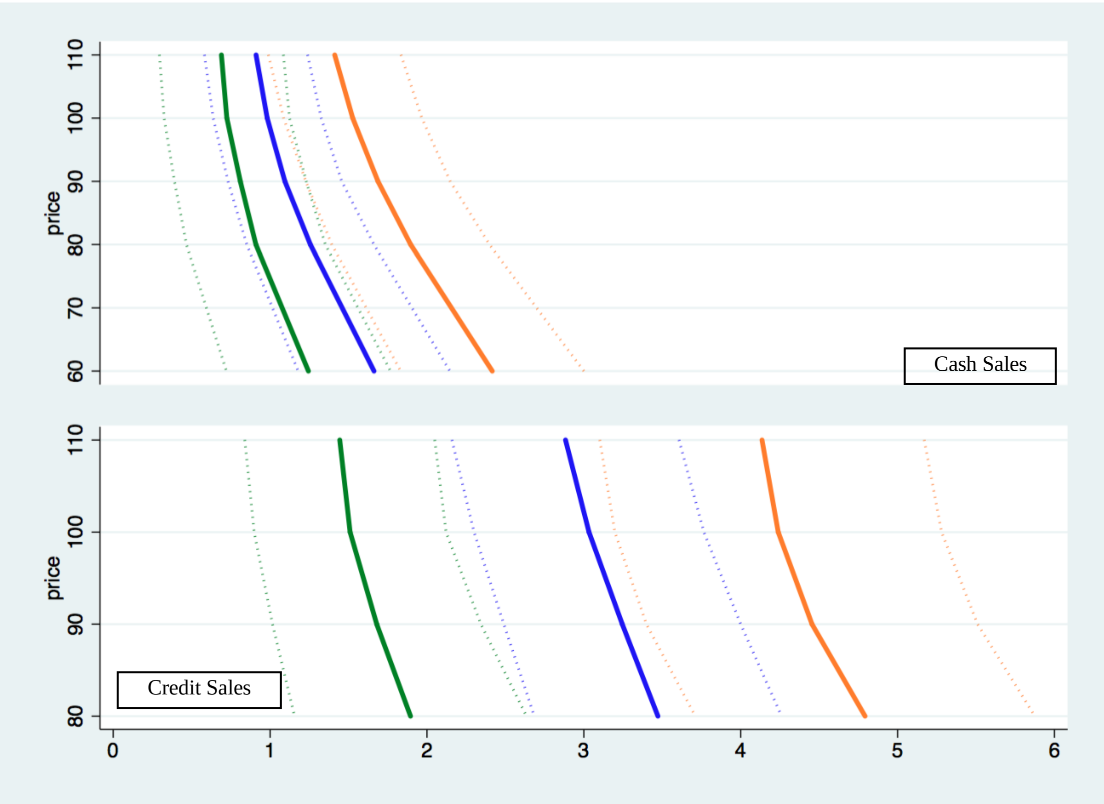


Figure 3. Base fertilizer: Estimated demand curves in Sales Meeting 2009 (above) and 2011 (below)



Note: The dotted lines indicate the 95 % confidence interval. The estimated demand is the sample average of the quantities given different prices and credit option availability that the sales workshop participants filled out in the price-contingent order form used in the sales meeting. The vertical axis represents the price index normalized by the market price set at 100. The horizontal axis represents the purchased quantity in kilograms.

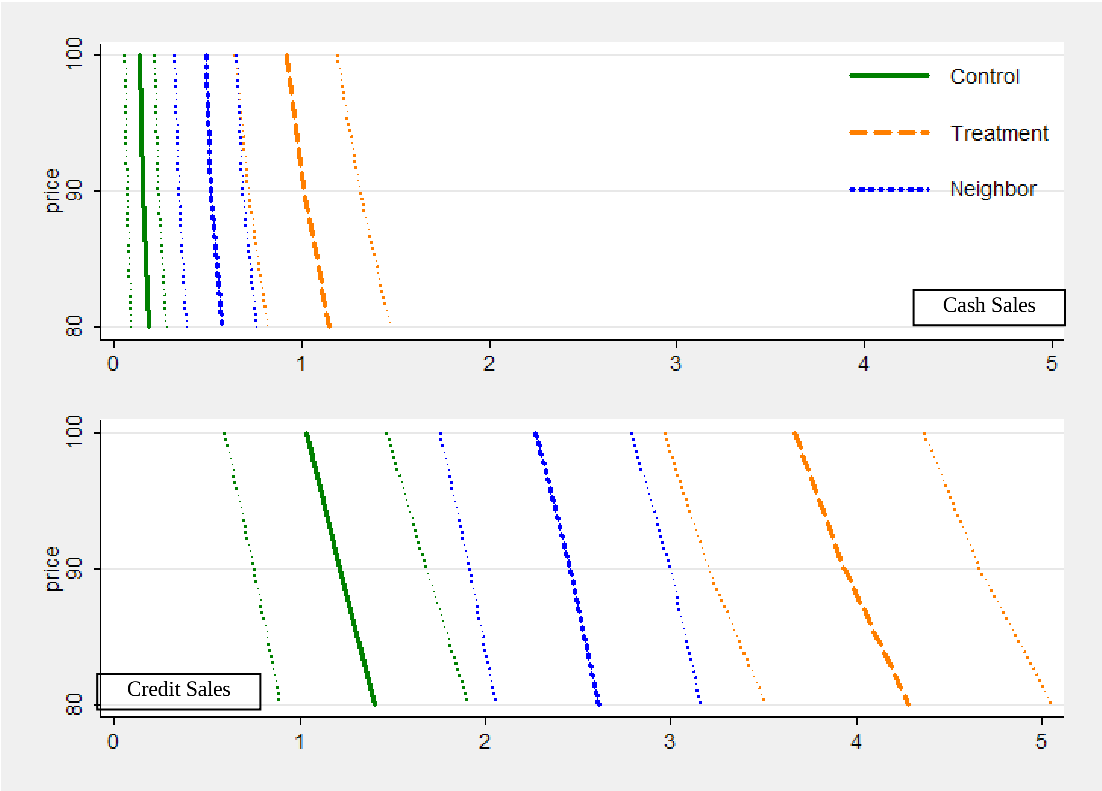
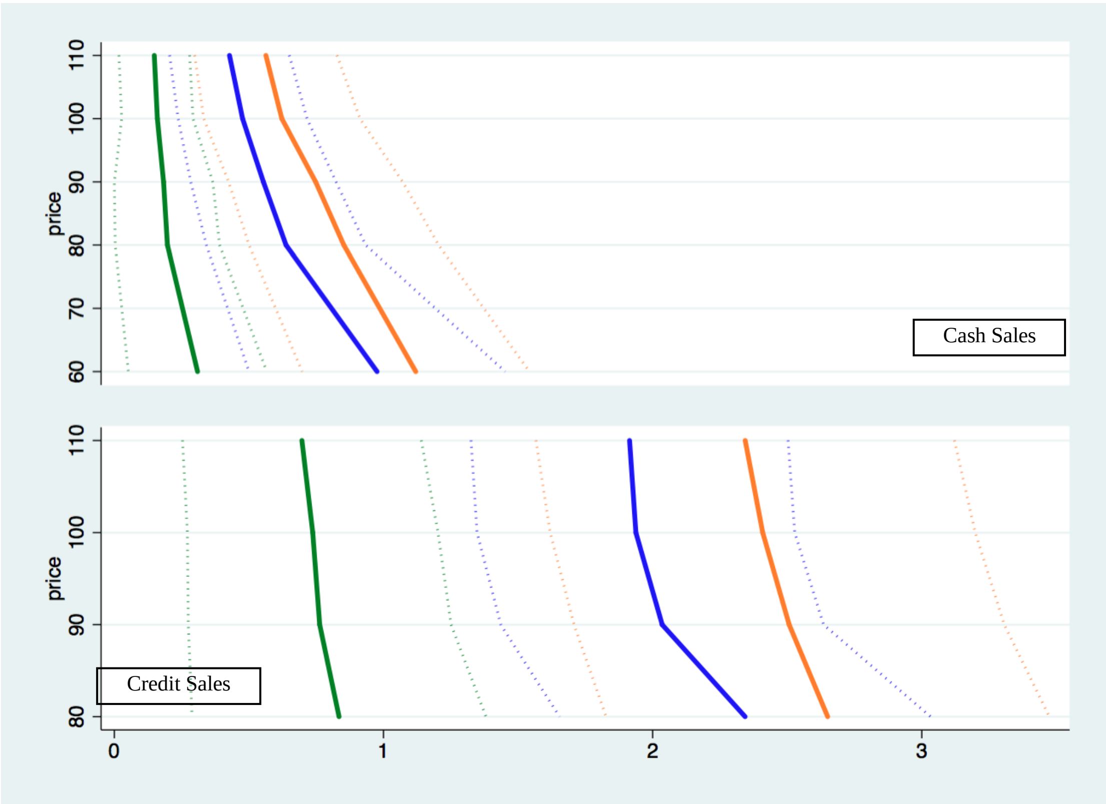


Figure 4. Top-dressing fertilizer: Estimated demand curves in Sales Meeting 2009 (above) and 2011 (below)



Note: The dotted lines indicate the 95 % confidence interval. The estimated demand is the sample average of the quantities given different prices and credit option availability that the sales workshop participants filled out in the price-contingent order form used in the sales meeting. The vertical axis represents the price index normalized by the market price set at 100. The horizontal axis represents the purchased quantity in kilograms.