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Yao Pan
Stephen C. Smith
Munshi Sulaiman

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Yao Pan
Aalto University

Stephen C. Smith
George Washington University and IZA

Munshi Sulaiman
Yale University

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

Agricultural Extension and Technology Adoption for Food Security: Evidence from Uganda*

This paper evaluates causal impacts of a large-scale agricultural extension program for smallholder women farmers on food security in Uganda through a regression discontinuity design that exploits an arbitrary distance-to-branch threshold for village program eligibility. We find eligible farmers experienced significant increases in agricultural production, savings and wage income, which lead to improved food security. Given minimal changes in the adoption of relatively expensive inputs including HYV seeds, these gains are mainly attributed to increased usage of improved cultivation methods that are relatively costless. These results highlight the role of improved basic methods in boosting agricultural productivity among poor farmers.

JEL Classification: O13, Q12, I30

Keywords: agriculture, extension, agricultural technology adoption, food security, regression discontinuity, Uganda, labor markets in developing economies

Corresponding author:

Stephen C. Smith
Department of Economics
Monroe Hall 306 (2115 G St. NW)
George Washington University
Washington, D.C. 20052
USA
E-mail: ssmith@gwu.edu

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1. INTRODUCTION

The recent development economics literature has focused on the need to address fundamental constraints in moving out of poverty in general and improving performance of low-productivity smallholder agriculture in particular. Many proven technologies and improved farming practices hold great promise for boosting agricultural production and reducing poverty in developing countries, but the adoption of such technologies by smallholder farmers, in particular in Sub Saharan Africa, has been slow, at best (Udry, 2010; Duflo, Kremer & Robinson, 2011). The low adoption rates resulted in persistent low agricultural productivity in Sub Saharan Africa (Bank, 2008). Important identified culprits in low adoption include lack of knowledge, lack of access to markets, credit constraints, uninsured risks, and problems of coordination with neighbors (Bank, 2008; Udry, 2010; Barrett, Carter & Timmer, 2010; Jack, 2013). Most research along this line focuses on the adoption of expensive agricultural inputs, such as high yield variety (HYV) seeds and chemical fertilizers. However, there are few analyses of initial adoption and the impacts of improved basic cultivation methods.

This paper contributes to filling this gap by evaluating the impacts of an innovative large-scale agricultural extension program for smallholder women farmers in Uganda on their technology adoption and food security. The program, designed by the NGO BRAC, features two main components to promote improved technology use: training, conducted by Model Farmers; and easier access to, and affordability of, HYV seeds sold through farmers serving as Community Agriculture Promoters (CAPs). According to the program design, eligibility for this program is limited to villages within 6 km to the nearest BRAC branch office, allowing us to analyze the intention-to-treat effects under a regression discontinuity design (RDD) framework. Using agriculture survey data from over 3000 households near the distance threshold, we estimate the effect of program eligibility at village level on individual households' food security, which includes possible within-village spillover effects. In addition, detailed inputs usage and farming practices information are reported, providing us the potential to separate the effect of improvement in farming methods from input changes in promoting production and food security.

Results for food security are dramatic. For farmers residing in eligible villages, per capita household food consumption increased by about 17.1% compared with farmers residing in ineligible villages; and the likelihood of having sufficient food for family needs increased by 28 percentage points over the previous year. Moreover, while the program increased the proportion of households with sufficient food every month in the year prior to the survey, impacts are largest just before the harvest, when food security is generally most precarious. In the month leading up to the survey, households eligible for the program were 10.6 percentage points less likely to worry about insufficient food, 8.2 percentage points less likely to limit consumption varieties, 9.5 percentage points less likely to consume limited portions of food at each meal, and 14 percentage points less likely to skip meals. Among the 54% of households that experienced at least one village shock - drought, flood, pest attack, livestock epidemic, fire, or poor quality seeds - in the 6 months prior to the survey, households eligible for the program were 14 percentage points more likely to cope by using savings; and 6.5 percentage points less likely to respond by begging. Finally, with potential longer-term benefits, treatment households were 11.4 percentage points more likely to reduce consumption and 5.4 percentage points less likely to sell assets during shocks. Together, these results confirm the positive impact of the extension program on improved food security.

In terms of mechanisms, we find the agricultural extension services significantly increase the usage of improved cultivation methods that are relatively costless. Farmers residing in eligible villages are 4.5 percentage points more likely to use manure (organic fertilizer) and 2.8 percentage points more likely to irrigate their land compared with those residing in ineligible villages. Being eligible for the program also increases farmers' adoption rate of intercropping and crop rotation by 6 and 5.4 percentage points, respectively. All these practices have been documented to mitigate soil erosion and increase yields (Liniger et al., 2011). Interestingly, the adoption rate of improved seeds remains unchanged regardless of advocacy in training sessions, improved access, and supply side subsidy. Seed purchase from BRAC does increase by 5.7 percentage points, though, suggesting crowding out of the local supply, although BRAC seeds could be of higher quality than existing market seeds.[1] In addition, the extension program does not change the adoption rate of other costly agricultural inputs, such as chemical fertilizer and pesticides. Given unchanged usage of advanced inputs, the findings of improved food security are likely to be driven by changes in farming methods.[2]

Unlike most papers in the literature that examine the adoption of expensive inputs and new crops (Munshi, 2004; Bandiera & Rasul, 2006; Conley & Udry, 2010; Krishnan & Patnam, 2014), this paper focuses on cultivation methods that require low upfront monetary investment. While some existing studies have documented the effect of agricultural training on the adoption of improved cultivation methods (Kondylis, Mueller & Zhu, 2014) or production outcomes (Godtland et al., 2003; Mutandwa & Mpangwa, 2004; Davis et al., 2012), few focus on both at the same time and provide rigorous causal evaluation of the yield-improving impact of these methods in the field. Our paper fills this critical gap by analyzing the causal effect of agriculture training on adoption of improved farming methods and the resulting impact on production and food security in a quasi-experimental RDD framework.

[1] We do not have data on the relative quality of BRAC seeds and other HYV seeds available on the general market.

[2] The agriculture training may promote other productive farming methods/knowledge than the ones examined here, such as timing and dosage of fertilizer use and diagnostic of pests. However, these additional aspects are not covered by the survey.

Importantly, the data allow us to separate the effect of these inexpensive farming methods from costly inputs. Agricultural training may encourage advanced input usage in addition to promoting improved cultivation methods. As noted by Herdt (2010), separating different factors in integrated agricultural production has been a difficult challenge for understanding the contribution of each factor. In our study, the extension program hardly has any impacts on advanced inputs usages and total input purchase costs. Even though the effect of each cultivation method is hard to identify individually, the overall changes in farming methods alone have a significant positive impact on production and food security. These farming methods require low upfront monetary investment and have fewer adoption constraints compared to more expensive advanced inputs. Hence, this paper provides important insights on the dynamics of agriculture extension provision. The adoption of relatively inexpensive methods in the first place boosts farmers' agricultural production and savings. The farmers' subsequently improved economic status may in turn relax constraints on advanced inputs adoption in the future.

This paper also contributes to the agricultural extension literature by examining the impact on detailed measures of food security and shock-coping methods. Most research to date has focused on advanced input adoption and production; few papers have assessed extension achievements in more comprehensive domains (Anderson & Feder, 2007). Our paper covers essential aspects of food security noted by Barrett (2002): quantitative availability, qualitative aspects concerning types and diversity of food, psychological dimensions relating to feelings of deprivation or anxiety related to food availability, and social consumption patterns such as meal frequency. To the best of our knowledge, this is the first paper to analyze the impacts of agricultural extension on food security in such a comprehensive way. In addition, improved economic status for households exposed to the agricultural program may further lead to changes in shock-coping behaviors, which serve as additional measures of food security status. In particular, we find that, with improved economic status, eligible households are more likely to reduce consumption and less likely to sell asset in the face of covariate shocks. These findings add new empirical evidence on the choice between consumption smoothing and asset smoothing in the face of shocks and confirms the heterogenous response across farmers' wealth levels (Zimmerman & Carter, 2003; Carter & Lybbert, 2012; Janzen & Carter, 2013).

The rest of this paper is structured as follows: Section 2 provides background on agriculture practices in Uganda, introduces the project design, and describes the main data source used in this study. Section 3 presents the empirical strategy. Regression results and discussions are provided in Section 4. Section 5 concludes.

2. CONTEXT AND DATA

Agriculture plays an important role in the Ugandan Economy, accounting for 73% of employment, 50% of household income, and 21% of GDP (UBOS, 2006, 2007, 2010). Despite the importance of agriculture, its growth is slow and subsistence farming is still prevalent in Uganda. Subsistence farmers account for 71% of the total farmers in the country. The adoption rates of advanced agricultural inputs and cultivation methods remain relatively low (UBOS, 2006, 2007).

Launched in August 2008, BRAC's large-scale agriculture program in Uganda seeks to improve food security of smallholders by promoting the usage of HYV seeds, mainly maize[3], and improved farming methods. Adoption of these technology are expected to improve productivity of smallholder women farmers for greater food security, and not necessarily increase revenue from crop productions as agri-businesses. This program provides extension services and supports a network of

[3] Bean and vegetable seeds were also made available for purchase, though only about 10-20% of total value of seeds distributed were non-maize items.

Model Farmers and Community Agriculture Promoters (CAP). The program operates 60 branches[4] in 41 districts in Uganda (Poghosyan, 2011), engages 1200 Model Farmers and reaches 63,936 general farmers by June 2011. Both types of agriculture extension workers are selected from villages within an arbitrary radius of 6 km[5] from BRAC branches according to the program design, which allows us to study the impact of BRAC's agricultural program in a regression discontinuity design framework.

Model Farmers were selected by BRAC from among poor, marginalized women. They are similar to their neighbors in terms of farm size and input use, though slightly more progressive and were chosen from those with some education. They received six days of training in crop production techniques, adoption of new crop varieties and pest control, as well as follow-up refresher courses. Then, they were made responsible for setting up a demonstration plot using learned techniques and providing a three-day training activity for fifty other ("general") farmers in their villages. They received a small compensation, in the form of 10 kg HYV seeds, for each season in service, which were to be used for demonstration purposes on their farms.[6] Each Model Farmer was expected to train fifty general farmers in total. All training sessions recommended the usage of improved farming methods and HYV seeds.

Community Agriculture Promoters (CAPs) were also selected from the same populations; their role is to make available and sell advanced agricultural inputs in the villages, mainly HYV seeds (Barua, 2011). They received the inputs at a modestly subsidized price of 2600 Ugandan Shillings (USh) per kg, which is around 10%

[4]Branch location is primarily determined by BRAC's microfinance program, which was launched before the agricultural program. Thus BRAC branch offices tend to locate in trading centers and are proximate to banks.

[5]As documented in BRAC's office memos, the main reason for choosing 6 km at the cutoff distance was that the field officers can travel this distance on foot or by bicycle.

[6]In another context, BenYishay & Mobarak (2014) show that peer farmers with compensation are more effective in convincing other farmers to adopt technologies as compared to lead farmers and government-employed extension workers.

lower than the market price of 2800-3000 USh, then set their own price to resell to the general public. Compared to direct purchase subsidy, this design aims to improve entrepreneur skills of the CAPs, and help build up the local supply chain so it reaches the village level. The transfer of subsidized price to general farmers is not guaranteed.

The data used in this study come from BRAC's 2011 agriculture survey. There are two cropping seasons each year. The survey covers demographic information and detailed agricultural practices records for the previous two cropping seasons between July 2010 and June 2011. Figure 1 shows the surveyed counties in Uganda. The survey villages are identified within the program receiving counties. 17 villages were randomly selected from a complete village list in each county. Then, 25 households were randomly selected from the chosen villages (Barua, 2011). According to summary statistics for the main estimation sample presented in Table 1, modern techniques adoption rates are low in general and food security is far from being achieved.

3. EMPIRICAL STRATEGY

3.1 Estimation Specifications

As described in Section 2, households' eligibility for the program depends on their villages' distance to the nearest BRAC branch offices. This feature allows us to analyze the impacts of the program using regression discontinuity design.

As the extension activities were not reported beyond six months prior to the survey, we are unable to construct either an indicator of ever received training for each household or a precise measure of the village-level implementation of the program, such as an indicator of program coverage or the fraction of farmers ever received training in the village.[7] Instead, we focus on the intention-to-treat impact of the planned program eligibility at village level on farming technology adoption and food security of households residing in these villages. Although the distance from village centers to the nearest BRAC branch was not directly reported, using GPS coordinates for each household and each branch, we compute the household's distance to the closest BRAC branch and use the median household distance in a village as a proxy to village distance.[8]

We use the nonparametric approach proposed by Hahn, Todd & Van der Klaauw (2001) and Porter (2003) to estimate the treatment effects, which relaxes functional form assumptions in parametric regressions. This method estimates the left and right limits of an outcome variable and a treatment variable using local linear regression and then takes the difference of these two limits. The causal effects of the agricultural program on outcomes τ are given by:

$$\tau_{ag} = \lim_{z \to c_{ag}^-} E[y_i \mid z_i = z] - \lim_{z \to c_{ag}^+} E[y_i \mid z_i = z], \tag{1}$$

where y_i is an outcome variable of household i, z_i is the distance between households i's residing village and the nearest BRAC branch, c_{ag} is the cutoff distance,[9] and τ_{ag} is the impact of the agriculture program on outcome variables. Standard errors are calculated using the delta method. We report our main results using a triangular kernel with a bandwidth of 2.16 km. We follow Imbens & Kalyanaraman (2012) to calculate this optimal bandwidth and also report results for bandwidths ranging from 1.5 km to 3.5 km. Since the treatments are defined as the planned agricultural extension coverage in the village, the estimates can be inter-

[7] The average program intensity is about 41%. This estimate is calculated using administrative data on the overall program outreach and the average village size.

[8] This method may introduce fuzziness around the cutoff if households are not uniformly distributed in the village.

[9] In the context of this study, $c_{ag} = 6km$.

preted as intention-to-treat (ITT) effects. These effects incorporate diffusion and spillover from treated households to other households in the village.[10] As a robustness check, we also report results for main outcomes using parametric regressions, in which standard errors are clustered at the village level.

When interpreting the results, it should be kept in mind that the actual coverage can differ from the plan. Some eligible villages may be excluded while ineligible ones may participate due to imperfect compliance. If this is the case, the change in the program participation rate is less than one at the cutoff distance. Our main results therefore underestimate the impact of program participation estimated by "fuzzy" RD design that uses eligibility as an instrument for participation.

To show evidence of the discontinuity in the participation in the three-year agricultural program at the predetermined cutoff distance, we compile the limited information collected on extension activities in the six months proceeding the survey. We construct a village activities indicator that equals one if any surveyed households in this village ever received training from a Model Farmer or purchase seeds from a CAP in the last six months, and equals zero otherwise. We plot the proportion of households who live in villages with any program activity against their village distances to the nearest BRAC branch office in Figure 2. The curves show lowess fit to the left and right of the threshold. The visual evidence shows a clear decrease in the incidence of program activities in villages at the cutoff value of 6 km.

Note that the training component of the program was implemented more intensively in the beginning of the program period because Model Farmers were only responsible to train up to fifty general farmers in their villages. Therefore, program activities in the six months proceeding the survey provides a somewhat noisy measure of program participation during the whole program period. The actual

[10]The estimation does not take into account possible spillover effect across villages. While BRAC's agriculture workers are restricted to work in certain areas, there may be information spillover effects through communication between farmers in nearby villages. Thus, the results reported in this study may underestimate the overall program effects.

participation gap at the distance threshold is expected to be larger if the approximation error of the participation is of similar magnitude relative to the observed activity on each side of the threshold. With this limitation in mind, for robustness we also estimated the local average treatment effect of program activity by "fuzzy" RD; in general, these estimates find a substantially *larger* program impact than our preferred specifications as reported here.[11]

3.2 Validity of the RD design

One concern of our approach is that ineligible households may move to program villages in order to participate in the program (Lee, 2008). In our sample, the migration rate is very low. Less than 2% households ever moved since the launch of the agricultural extension program (in the last three years). If households excluded from the program purposely moved closer to the branch in order to be eligible for the extension services, we would expect a spike in the households density right below the cutoff distance of 6 km. Figure 3 plots the number of households in each 0.6 km bin against households' distance to the nearest BRAC branch. Visual evidence shows no noticeable jump in the density around the cutoff distance. The density smoothness test proposed by McCrary (2008) also fails to reject the smoothness of households' density at the cutoff.

Valid RD design requires that households are relatively similar over the cutoff, which can be partially tested by the balance of household characteristics. Thus, we check for possible jumps over the threshold for household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as possible discontinuity in the coverage of BRAC's microfinance program, which was operated in the same counties. Figure 4 graphically presents the mean value of each covariate in 0.6 km bins separately with a lowess fit. The visual evidence

[11] These results are reported in the online Appendix Table A7 to A10.

shows no significant discontinuity within and beyond the cutoff distance for these variables. As suggested by Lee & Lemieux (2010), we test the joint significance of all the discontinuities at the threshold in a Seemingly Unrelated Regression (SUR) framework, where each equation regresses one covariate on a threshold dummy, a constant and a fourth order polynomial of distance to the nearest BRAC branch office. The coefficients of polynomials are allowed to be different on each side of the threshold and errors are allowed to be correlated across equations. This test fails to reject the hypothesis that covariates are smooth across the cutoff for the agricultural program.[12] We also add these control variables in the regression to further check the robustness of our results.

4. RESULTS

In this section, we first present the regression results on agricultural technology adoption. We then explore channels through which the agricultural program would affect food security and present results on food consumption and overall food security. At the end of this section, we examine changes in shock-coping methods.

4.1 Adoption of basic techniques vs. advanced inputs

We divide the examined technologies into two categories according to the upfront costs incurred during adoption. The inexpensive cultivation methods include manure usage[13], intercropping, crop rotation, irrigation[14], and weeding. The advanced farming inputs are relatively more expensive, including HYV seeds, chemical fer-

[12]We also run the same local linear regressions for each of these control variables. None has statistically significant discontinuity at the program cutoff distance.

[13]We categorize manure as a farming method instead of an advanced agriculture input because it is readily available and mostly free.

[14]We categorize irrigation as an inexpensive cultivation method as its changes are mainly in the form of lifting water to the farm in studied areas. No new construction of dams, channels or other large-scale irrigation systems were observed in the field during the intervention period.

tilizer and pesticides. All these farming methods and the usage of improved seeds were strongly recommended by the Model Farmer in their trainings to general farmers, except that the program cautiously promoted chemical fertilizer due to environmental concerns. For pesticides, the recommendation is to be aware about diseases and use Model Farmers' service for pesticide use if necessary.

We begin with analysis of the impact of the program on the adoption of improved cultivation methods promoted by BRAC. Regression results reported in Table 2 Column 1 - 4 show that compared with households residing in villages just above the 6 km distance cutoff, residing in villages within the threshold increases the adoption rates of manure by 4.5 percentage points, intercropping by 6 percentage points, crop rotation by 5.4 percentage points, and irrigation by 2.8 percentage points. Observational evidence from the field shows no new construction of dams and other large scale capital intensive irrigation systems. Thus, the increased irrigation is mainly through the often observed labor intensive effort of lifting water to the farm. All these results show that, given small compensations, Model Farmers are effective in promoting their neighbor's adoption of improved basic farming methods that require minimal monetary investments.

Both intercropping and crop rotation have been documented to reduce weed population density in the agronomy literature and are important components of weed management strategies (Liebman & Dyck, 1993; Cléments, Weise & Swanton, 1994). While weeding is also recommended in the agricultural training sessions, the increased practices of intercropping and crop rotation reduce weeding requirements. On net, the extension program significantly decreases the likelihood of weeding by 10.1 percentage points. Since weeding is a labor-intensive task, a reduction of necessary weeding time frees up farmers' labor for other productive activities. This is consistent with previous results, notably the increased irrigation practice by lifting water. In addition, households with decreased demand for agricultural labor may be more likely to send members for wage employment, which we will examine in the next subsection.

The training provided by Model Farmers not only promotes the adoption of improved cultivation methods, but also the usage of HYV seeds. Interestingly, the estimated impact of the program on the adoption rate of improved seed is minimal (Table 2 Column 8), regardless of improved access for general farmers and subsidy to local sellers (CAPs), which may or may not transfer to other farmers. The 2011 agricultural survey did not collect information on prices that the CAPs sell BRAC seeds; but another survey conducted one year later for a different sample collected these price data. The average per kg prices CAPs charged for maize and bean in the first season of 2012 (January-June, 2012) were 2888 USh and 2817 USh, respectively, which lie in the range of market prices, 2800-3000 USh. Thus, the subsidy to CAPs barely transfers to general farmers and has minimal impact on the overall adoption rate of HYV seeds, regardless of possible peer pressure by general farmers to pass along the subsidy. Note that the agricultural extension increases the seed purchase rate *from BRAC* by 5.7 percentage points (Table 2 Column 9), possibly due to advertising BRAC seeds in the training sessions. The increased seed purchase from BRAC and unchanged overall adoption suggest crowding out of the local supply, albeit while saving time and costs of travel to purchase seeds at market centers; so farmers may still benefit in this way.[15] In addition, the effect of the extension program on the adoption rate of chemical fertilizer and pesticides are small and statistically insignificant. Again, these practices were not emphasized part of the program. Results are largely unchanged in robustness checks with different bandwidths[16], with household-level controls (Table 2 Row 2) and using parametric regressions.[17]

[15]BRAC seeds may have higher average quality, but we lack comparative data to address this possibility.

[16]These estimates are reported in Table A2 of the online appendix.

[17]These estimates are reported in Table A6.

Even though no more households eligible for the program started to use these advanced inputs, quantity used may change among existing adopters. To partially rule out this possibility, Table 3 Column 1 shows there is no statistically significant impact of the agricultural program on the total inputs costs. Assuming the prices of these inputs are not changed by the program (i.e. prices are smooth at the cutoff distance) and there is no reallocation of investment across inputs, the unchanged total monetary costs indicate no significant changes in quantity used for each of these advanced inputs. While the non-reallocation assumption cannot be fully tested using our data, the price smoothness assumption is likely to be valid given that the extension program does not subsidize fertilizer and pesticides, and the subsidized price for HYV seeds barely transferred to the general public as documented earlier. Thus, there may be other constraints impeding the farmers' adoption of these beneficial but expensive inputs: households may be credit constrained; this program focuses on women, but female farmers may not have control over households' financial decisions.[18]

4.2 Food security

BRAC's agricultural extension program may affect food security in at least three ways: decreased production costs (due potentially to subsidized seed prices); increased production value (due primarily to improved practices, and possibly marketing of non-subsistence crops); and increased wage income (due to time freed up from labor intensive farming practices, such as weeding). As shown earlier in Table 3 Column 1, there was minimal impact on the overall purchased productions costs. We then focus on the last two channels.

The survey covers information on the production of each crop for the last two sea-

[18] Jack (2013) provides a comprehensive literature review of possible constraints affecting farmer's adoption behavior.

sons. We calculate the overall production value of major crops[19] that are generally (though not always) reported in kilograms, and are then valued using contemporaneous market prices.[20] These crops include common staple varieties, maize, beans, millet, groundnut, along with the leading cash crop, coffee.

The overall production values of these crops increase by 20.9% for households residing in villages eligible for BRAC's agricultural program (Table 3 Column 2). The large impact on production lies within the potential range obtained by agronomic field experiments. In particular, all these cultivation methods promoted by BRAC have been documented in the agronomy literature to significantly increase yield. For instance, intercropping cowpea and millet can increase the yield of millet by up to 103% (Hulet, Gosseye & ILCA, 1986); application of carbonized and dried chicken manure boosts maize yield by up to 43% and soybean yield by approximately 30% (Tagoe, Horiuchi & Matsui, 2008). Moreover, Florentín (2010) finds that maize production increased by more than 30% after rotation with white lupine. In addition, Robins & Domingo (1953) find that 6 to 8 days of water stress during pollination reduced maize yield by 50% in a field study in the U.S., which indicates a 100% yield increase using irrigation during drought (>50% surveyed households in our sample reported that they experienced drought). These findings are further confirmed by Pandey, Maranville & Admou (2000) using an experiment conducted in African context. In particular, they find that deficit irrigation during vegetative and reproductive periods reduces maize yields by up to 52%.[21] Simply adding up the potential yield impact for each of these methods could explain around two thirds of the production increase. Note that these methods work in a complementary way and thus the total yield increase potential of these combined practices could be

[19] Major crops are defined as those grown by more than 5% of the households.

[20] Households report the quantity produced in various units (e.g. kilogram, bunch, sacks, basin).

[21] More references: see Reddy & Willey (1981), Hulet, Gosseye & ILCA (1986) and Li et al. (2001) for intercropping, Bullock (1992) and Berzsenyi, Győrffy & Lap (2000) for crop rotation, Jokela (1992) and Matsi, Lithourgidis & Gagianas (2003) for manure, and Mustek & Dusek (1980) and Doorenbos & Kassam (1979) for irrigation.

significantly higher than revealed by this simple calculation.

Moreover, farmers may learn from the training about local soil quality and switch to crops that (they believe) are more profitable on their farm land. We observe a dramatic change in terms of crop composition grown for households covered by the program.[22] Farmers eligible for the extension program are more likely to grow maize and beans, which were promoted by the program to be intercropped together, and are less likely to grow millet and groundnut. A greater share of these farmers is growing coffee, a popular cash crop that is mainly for sale in the market. Although the survey did not collect information on area cultivated by each crop, it is plausible that shifting towards more profitable crops could partially explain the production increase.

The agricultural training also provides detailed information about other productivity-enhancing activities such as time and dosage of fertilizer and pesticide application, and labor saving harvest methods. In addition to the cultivation methods analyzed in this study, these non-monitored channels likely also contribute to the increase in the value of agricultural production. The very substantial estimated 20.9% increase in production value needs to be understood as the combined impact of these several channels of practices promoted by the program. Based on previous agronomic research, such large effects are very plausible; what is particularly remarkable is that an agricultural extension program could bring about a sufficient package of such change simultaneously so as to realize the huge impact on output value resulting from such low-cost activities.

As for employment, households covered by the agricultural program are 10.5 percentage points more likely to have at least a member working for wages (Table 3, Column 3). This effect may be due to the freeing up of off-farm work times as a result of utilizing the labor saving techniques promoted by BRAC. In treat-

[22] Details are presented in the online appendix Table A1.

ment villages, households' total annual time working for wages increases by an estimated 166.7 hours, a considerable gain of about 7.6% based upon the sample mean of 2187 hours for households with outside employment experience in the last 12 months. Since there is no statistically significant change in hourly wages received, the additional work time in the labor market raises wage income to the family. The dramatic estimated 36.4% increase in household savings (Table 3 Column 6) likely results from a combination of increased production value and greater outside wage income.

Given the unchanged advanced inputs usage, these income and savings benefits are likely driven by the adoption of improved cultivation methods. Note again that these improved techniques are not limited to the ones examined in this paper. Other efficiency-enhancing activities promoted by the training may contribute to the production gains as well. However, these non-monitored methods are also likely to incur little or no investment, a conclusion reinforced by the unchanged total production costs.

The agricultural extension program further increases per capita household's food consumption, as shown in Table 3 Column 5 (reported over the last 7 days) by about 17.1%. When we look at a longer time horizon, the effect is even larger: the likelihood of having sufficient food to meet family needs increases by 28 percentage points over the previous year (Table 3 Column 6). In addition, households also reported which months of the last year they did not have enough food. We run the same local linear regression for each month to see the heterogeneous impact on reducing food insecurity over the agricultural cycle. Figure 5 plots the estimates for each month with 95% confidence intervals. Overall, the agricultural program increased the proportion of households with sufficient food for every month within the one-year horizon. The magnitude of the impacts peak at June-July, 2011. According to the Uganda Food Security Outlook, while abundant rain led to above-average harvest in the second cropping season in 2010, the delayed rain in the first cropping season in 2011 delayed the harvest to July-August and put stress on food security for certain regions in Uganda (FEWSNET, 2010, 2011). The impacts of the agriculture extension program are the largest right before the harvest, during which the food situation is generally worst (as in most developing countries).

As widely noted, food availability is not sufficient for food security (Campbell, 1991; Maxwell, 1996; Barrett, 2002). Fortunately, the survey includes detailed self-reported data, which we use to examine impacts on food security. In the month prior to the survey, households eligible for the agricultural extension programs are 10.6 percentage points less likely to worry about insufficient food, 8.2 percentage points less likely to limit consumption varieties, 9.5 percentage points less likely to consume limited portions of food at each meal, and 14 percentage points less likely to skip meals, compared with control group households (Table 4). Taken together, these results confirm the positive impact of the extension program on improving food security among participating villages.

4.3 Coping with shocks

The methods households use to cope with shocks can serve as another measure of food security. Corresponding to the insufficient rain in the first cropping season of 2011, more than 40% of households reported that they experienced drought conditions. Overall, about 54% of households experienced at least one covariant shock, including drought, flood, pest attack, livestock epidemic, fire, or poor quality seeds in the village in the 6 months prior to the survey.[23] Restricting the analysis to these households, Table 5 shows the impact of program eligibility on the usage of seven most reported shock-coping methods. As shown in Column 1, households in villages covered by the extension program are 14 percentage points more likely to

[23]There is no discontinuity in the incidence of shocks at the cutoff distance of 6 km.

use savings to cope with shocks, which corresponds to greater savings availability given the significantly increased savings documented earlier. Adjustment through savings is a preferred coping strategy as it should have a smaller effect on future production food security. A disadvantageous strategy, begging, is reduced by 6.5 percentage points for households covered by the program.

Both consumption smoothing and asset smoothing are considered unfavorable methods to cope with shocks (Barrett, 2002) as both may limit production capability is often at a cost of impaired future food security. Selling assets implies possible higher transaction costs than adjustment through savings (or credit); farmers may also face unfavorable terms as contemporaneous distress sales of assets by neighbors causes downward pressure on prices (Barrett, 2002). As documented in the literature, reducing consumption is not as unfavorable as asset smoothing, especially for the relatively rich. Zimmerman & Carter (2003), Carter & Lybbert (2012) and Janzen & Carter (2013) have shown that wealthier farmers tend to reduce consumption as opposed to selling assets in the face of shocks. The agricultural program has been shown to enhanced farmers economic status via increased production and savings, and is expected to shift farmers from asset smoothing to consumption smoothing. Moreover, as the program also increases household food consumption (as documented earlier in this section), this leaves more room for consumption reduction while maintaining minimum nutritional levels. Consistently, farmers exposed to the program are 11.4 percentage points more likely to reduce consumption and are 5.4 percentage points less likely to sell assets during shocks.

To sum up, the agriculture extension services significantly improve food security. The results are consistent using different measures of food security. Results are also largely unchanged in robustness checks with different bandwidths, with additional controls,[24] and with parametric specifications.[25]

[24]See Table A3, A4, and A5 in the online appendix.

[25]Table A6 in the online appendix shows the parametric regression results, allowing standard

5. CONCLUSION

This paper examines the impact of a well-known NGO-designed and operated agriculture extension program for smallholder women farmers in Uganda. The BRAC Uganda program features two main components to promote improved technology use: training, and easier access to and affordability of HYV seeds.

In sum, we find the extension activities significantly increase farmers' use of improved cultivation methods that are relatively costless, but there is minimal impact on adoption of relatively expensive inputs including HYV seeds. Moreover, the program leads to improved farmers' food security in terms of quantity and variety of food consumed, meal frequency, and self-reported anxiety related to the availability of food.

Given the unchanged usage of expensive advanced inputs, we attribute the increased agricultural output simply to the adoption of inexpensive farming methods. These methods, most likely, are not limited to ones for which we have data in the survey. In particular, we note that the agricultural training also provides detailed information about specific such efficiency-enhancing activities as time and dosage of fertilizer and pesticides application, and labor saving harvest methods. These non-monitored methods are also likely to incur little or no investment, given the unchanged total production costs, and are topics for future research.

Note that our impact estimates are applicable for households living around the 6 km boundary from BRAC branches, which are located at or near at county centers; thus, although these are rural agricultural households, they have somewhat better

errors to be correlated within villages. The estimated impacts are consistent with results obtained from non-parametric local linear regressions overall. Although a few outcomes, such as the adoption of manure, lose statistical significance in parametric regressions, the sign and magnitudes are in line with local linear regression estimates in general. These discrepancies may arise from the fact that parametric regressions use observations further away from the cutoff. Moreover, local linear regressions put more weight on households near the cutoff distance, while parametric regression assign equal weight to each household. As detailed in Gelman & Imbens (2014), local linear regression is preferred over parametric global polynomial methods.

market access; so we cannot be confident about the external validity of the results for farmers in isolated or hard-to-reach areas. Moreover, the program was not fully nationally representative, because it did not operate in the semi-arid northern districts (a region with mostly one cropping season in a year and sparsely populated farming areas recovering from conflict); however, otherwise the program had a wide geographic coverage. In addition, the program did not include any interventions on the rural value chain; its focus was primarily on food security, so it is not clear that results extend to extension programs with a value chain emphasis.

Regardless of these limitations, the case of BRAC Uganda provides important insights into how agricultural extension services in sub-Saharan Africa can have a substantial positive effect on food security. A large literature indicates that the potential benefits of using advanced inputs are large. However, many constraints impede farmers from adopting these expensive inputs. In contrast, this paper has shown that the improvement of cultivation methods alone, which require minimal upfront monetary investment, can significantly increase production.

It may be that impacts on outcomes such as use of advanced inputs become apparent only after time to consolidate the more foundational improvements such as those identified in this study. In this sense, in countries such as Uganda, food security may need to be achieved in stages, with sequential support from extension services. The important policy question concerning whether extension and development assistance could be more cost-effective if different components are implemented in an sequence is left for future research.

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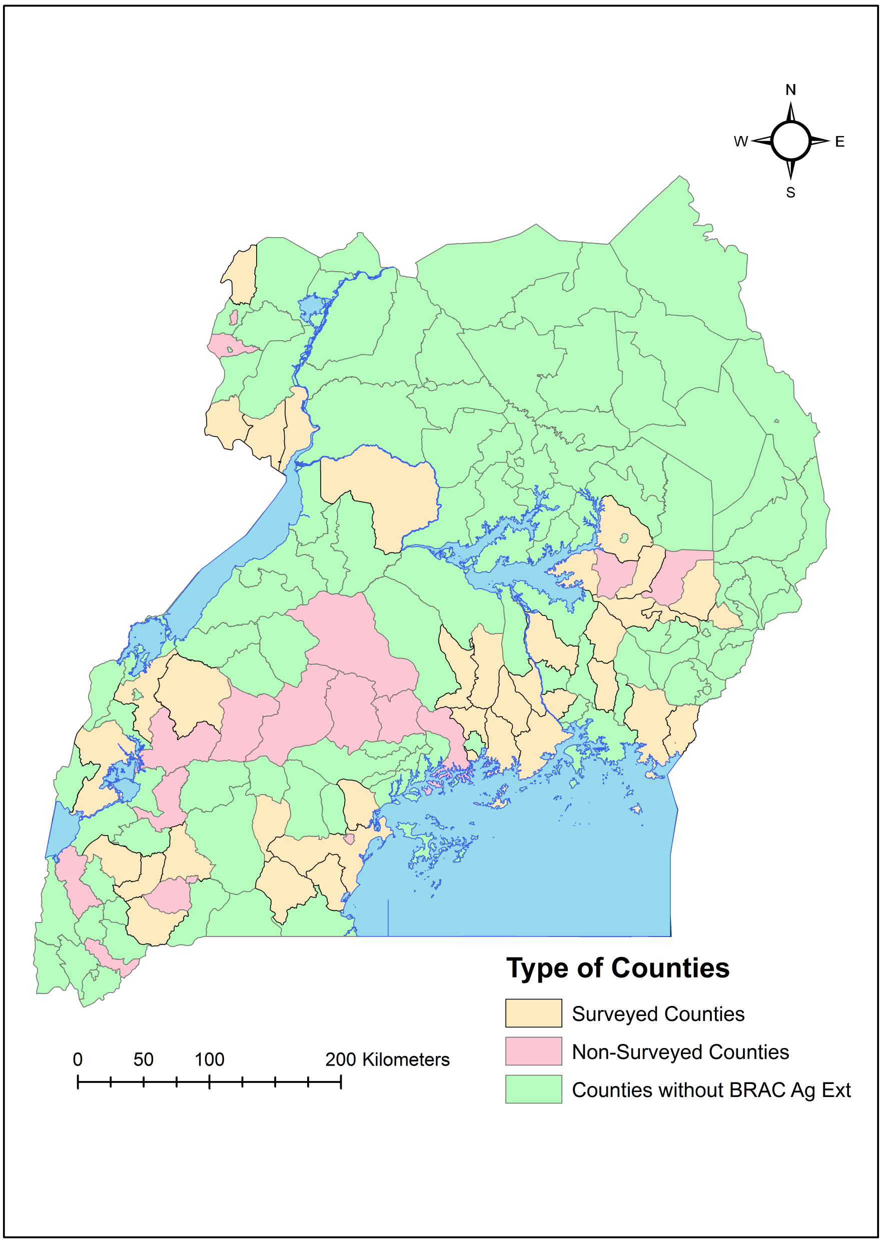
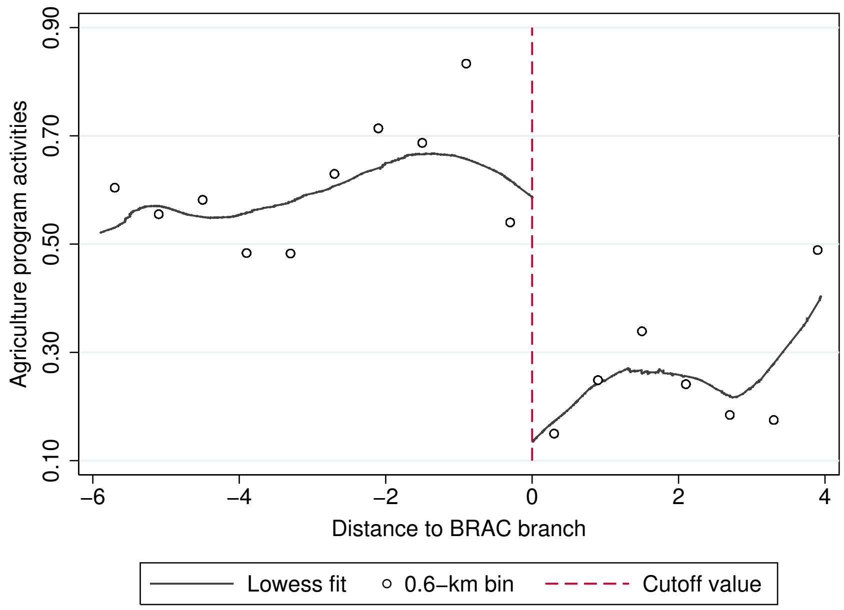
Figure 1: Surveyed Counties



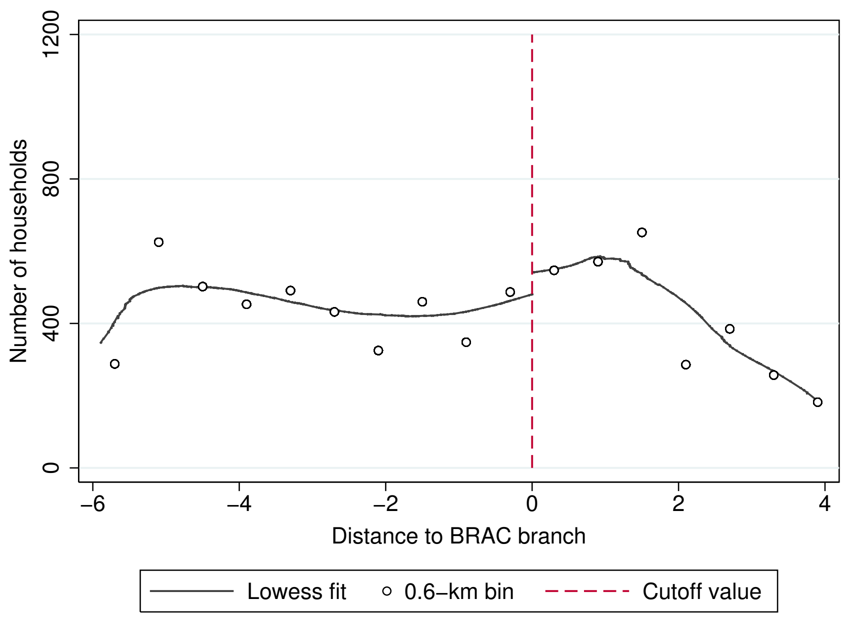
Notes: Figure shows the county coverage of the 2011 agriculture survey. Counties with BRAC's agricultural extension services include both "Surveyed Counties" and "Non-Surveyed Counties".

Figure 2: Program Activities during the Six Months Prior to the Survey



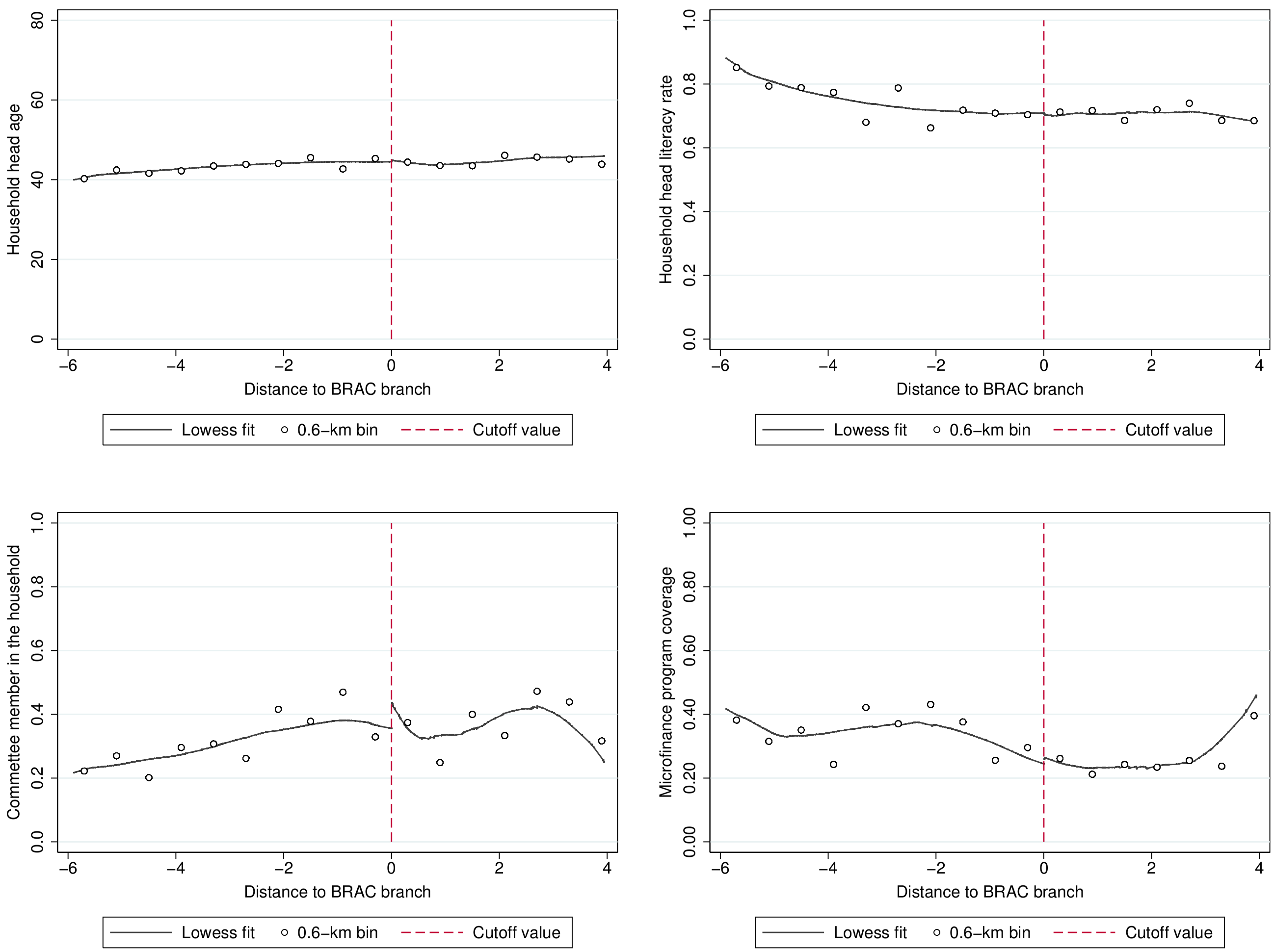
Notes: Figure shows the incidence of BRAC's agriculture extension program activities against distance to the nearest BRAC branch office. Distance is measured in km and is normalized with $6km = 0$.

Figure 3: Household Density against Distances to BRAC Branches



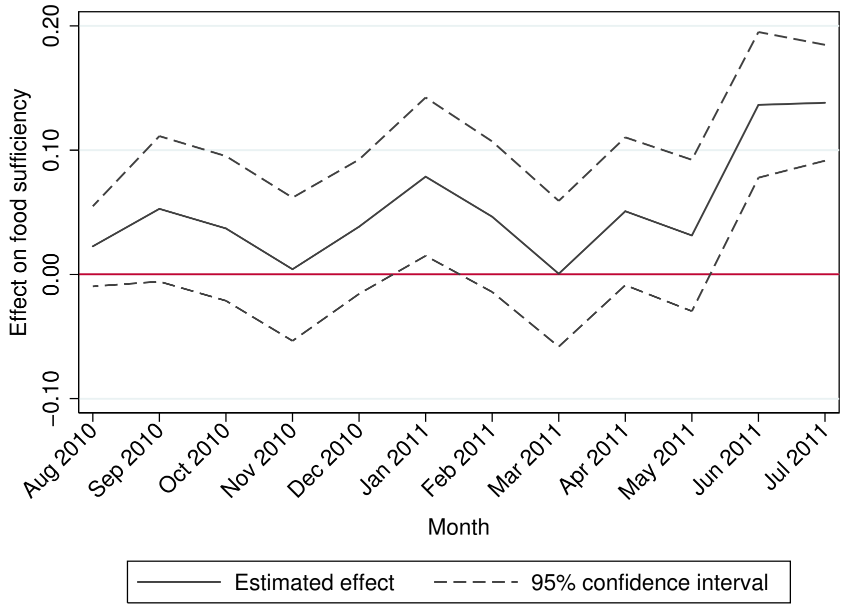
Notes: Figure shows the household density distribution against distance to the nearest BRAC branch office. Distance is measured in km and is normalized with $6km = 0$.

Figure 4: Balance of Covariates



Notes: Figure shows the smoothness of the following covariates at the cutoff distance of 6 km: household heads' age, literacy, whether any household member holds positions in the village or higher level committees, and the coverage of BRAC's microfinance program. Distance is normalized with $6km = 0$.

Figure 5: Program Effect on Food Sufficiency across Months



Notes: Figure shows the estimated impact of BRAC's agriculture extension program on the share of households with sufficient food for each of the 12 months prior to the survey. In general, in the absence of the intervention, the worst months for farmers are pre-harvest months of the main season, i.e. June and July.

Table 1: Summary Statistics

	Mean	S.D.	N
Household characteristics			
HH head age	44.354	14.522	3368
HH literacy	0.704	0.457	3360
HH member in council	0.364	0.481	3403
Modern techniques adoption			
Manure	0.086	0.281	3103
Intercropping	0.813	0.389	3103
Crop rotation	0.823	0.381	3103
Irrigation	0.020	0.141	3103
Weeding	0.711	0.453	3103
Fertilizer	0.072	0.259	3103
Pesticides	0.130	0.337	3103
HYV seeds (HYV)	0.358	0.479	3103
Production, emp. and savings			
Log production costs (in Ushs)	10.681	1.168	2204
Log production value (in Ushs)	12.356	1.357	2978
HH member work for salary	0.232	0.422	3427
Log household savings (in Ushs)	11.282	1.642	2705
Food security			
Log food cons. per capita (last 7 days, in Ushs)	9.109	0.957	3064
Food sufficiency (last year)	0.212	0.409	3290
Worry about food (last month)	0.791	0.407	3408
Limited variety (last month)	0.822	0.382	3414
Limited portion (last month)	0.735	0.441	3411
Skip meals (last month)	0.641	0.480	3416

Note: Summary statistics are reported for the sample used in main estimations, including farmers residing in villages that are within 2.16 km on each side of the 6 km cutoff distance to the closest BRAC branch offices.

Table 2: Technology Adoption

	Manure (1)	Inter-cropping (2)	Crop Rotation (3)	Irrigation (4)	Weeding (5)	Chemical Fertilizer (6)	Pesticides (7)	All HYV Seeds (8)	BRAC HYV Seeds (9)
No controls	0.045*	0.060**	0.054*	0.028***	-0.101***	0.025	0.024	0.020	0.057***
	(0.025)	(0.028)	(0.029)	(0.009)	(0.035)	(0.020)	(0.028)	(0.037)	(0.016)
With controls	0.043*	0.056**	0.046*	0.027***	-0.117***	0.023	0.016	0.013	0.057***
	(0.025)	(0.029)	(0.029)	(0.009)	(0.036)	(0.021)	(0.028)	(0.037)	(0.015)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to BRAC branch office on the adoption of modern cultivation technologies. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table 3: Production, Employment, Savings and Food Security

			Labor Market Employment					
	Production Costs	Production Value	Employed	Employed Hours	Hourly Wage	Savings	Per Capita Food Cons.	Food Suf. Last Year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No controls	-0.070	0.209**	0.105***	166.7**	0.101	0.364***	0.171**	0.280***
	(0.106)	(0.106)	(0.033)	(70.7)	(0.168)	(0.127)	(0.068)	(0.031)
With controls	-0.088	0.190*	0.100***	166.7**	0.124	0.315***	0.163**	0.278***
	(0.103)	(0.103)	(0.033)	(72.4)	(0.167)	(0.119)	(0.069)	(0.031)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to BRAC branch on inputs purchase production costs, total production values, employment, household savings, per capital household consumption in the last seven days and food sufficiency in the last year. Productions costs, production value, hourly wage, household savings and per capita food consumption are all measured in log scale. The calculation of total production values only includes major crops that are mainly reported in kilograms. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table 4: Other Measures of Food Security

	Worry about Insuf. Food (1)	Limited Variety (2)	Limited Portion (3)	Skip Meals (4)
No controls	-0.106^{***}	-0.082^{***}	-0.095^{***}	-0.140^{***}
	(0.031)	0.030	(0.034)	(0.035)
With controls	-0.104^{***}	-0.076^{***}	-0.091^{***}	-0.140^{***}
	(0.031)	(0.030)	(0.034)	(0.036)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to BRAC branch office on detailed measures of food security for the month proceeding the survey. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table 5: Coping with Shocks

	Reduce Consump. (1)	Use Savings (2)	Sell Assets (3)	Additional Emp. (4)	Begging (5)	Borrowing (6)	Friend Transfer (7)
No controls	0.114^{***}	0.140^{***}	-0.054^{***}	0.013	-0.065^{**}	0.016	-0.006
	(0.042)	(0.048)	(0.016)	(0.014)	(0.027)	(0.035)	(0.015)
With controls	0.092^{**}	0.141^{***}	-0.049^{***}	0.018	-0.058^{**}	0.008	-0.006
	(0.042)	(0.049)	(0.016)	(0.013)	(0.028)	(0.035)	(0.016)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to BRAC branch office on major methods used to cope with covariant shocks. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A1: Impact of Agricultural Program on Crops Grown

	Millet (1)	Maize (2)	Rice (3)	Groundnut (4)	Bean (5)	Coffee (6)
No controls	-0.153***	0.231***	-0.011	-0.297***	0.175***	0.240***
	(0.058)	(0.085)	(0.026)	(0.081)	(0.081)	(0.063)
With controls	-0.174**	0.236***	-0.012	-0.305***	0.186***	0.256***
	(0.062)	(0.087)	(0.029)	(0.084)	(0.083)	(0.064)

Note: Table shows the impact of BRAC's agricultural program on farmers' choice of crops grown. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A2: Robustness to Bandwidth Choices: Technique Adoption

	Manure (1)	Inter-cropping (2)	Crop Rotation (3)	Irrigation (4)	Weeding (5)	Fertilizer (6)	Pesticides (7)	Improved Seeds (8)	BRAC Seeds (9)
Bandwidths									
1.5 km	0.033	0.069**	0.052	0.024**	-0.064	0.017	0.010	0.001	0.072***
	(0.031)	(0.032)	(0.034)	(0.011)	(0.042)	(0.023)	(0.033)	(0.044)	(0.023)
2.5 km	0.047**	0.056**	0.063**	0.028***	-0.105***	0.026	0.024	0.020	0.052***
	(0.023)	(0.027)	(0.027)	(0.009)	(0.033)	(0.019)	(0.027)	(0.035)	(0.014)
3.5 km	0.052***	0.055**	0.081***	0.028***	-0.106***	0.021	0.012	0.017	0.044***
	(0.019)	(0.023)	(0.023)	(0.007)	(0.028)	(0.016)	(0.022)	(0.029)	(0.011)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to BRAC branch office on the adoption of modern cultivation techniques, using different bandwidth choices. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A3: Robustness to Bandwidth Choices: Production, Employment, Savings and Food Security

			Labor Market Employment					
	Production Costs	Production Value	Employed	Employed Hours	Hourly Wage	Savings	Per Capita Food Cons.	Food Suf. Last Year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bandwidths								
1.5 km	-0.022	0.300**	0.143***	174.7**	0.092	0.326**	0.075	0.300***
	(0.121)	(0.122)	(0.040)	(84.3)	(0.186)	(0.149)	(0.076)	(0.037)
2.5 km	-0.066	0.176*	0.096***	171.6**	0.119	0.341***	0.183***	0.276***
	(0.102)	(0.101)	(0.031)	(67.4)	(0.161)	(0.121)	(0.065)	(0.029)
3.5 km	-0.032	0.056	0.083***	169.8**	0.088	0.311***	0.209***	0.233***
	(0.087)	(0.085)	(0.025)	(56.7)	(0.144)	(0.104)	(0.056)	(0.025)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to BRAC branch office on production costs, production value, employment, household savings, per capita food consumption in the seven days prior to the survey and food sufficiency in the year prior to the survey, using different bandwidth choices. Production costs, production values, hourly wage, household savings and per capita food consumption are measured in log scale. The calculation of total production values only includes major crops that are mainly reported in kilograms. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A4: Robustness to Bandwidth Choices: Other Food Security Measures

	Worry about Insuf. Food (1)	Limited Variety (2)	Limited Portion (3)	Skip Meals (4)
Bandwidths				
1.5 km	-0.186***	-0.146***	-0.131***	-0.205***
	(0.037)	(0.037)	(0.040)	(0.042)
2.5 km	-0.094***	-0.073***	-0.093***	-0.125***
	(0.030)	(0.028)	(0.032)	(0.034)
3.5 km	-0.060**	-0.043*	-0.058**	-0.062**
	(0.025)	(0.023)	(0.026)	(0.028)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to the BRAC branch office on food security for the month prior to the survey, using different bandwidth choices. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A5: Robustness to Bandwidth Choices: Coping with Shocks

	Reduce Consump. (1)	Use Savings (2)	Sell Assets (3)	Additional Emp. (4)	Begging (5)	Borrowing (6)	Friend Transfer (7)
1.5 km	0.144^{***}	0.088	-0.037^{**}	0.011	-0.079^{**}	0.036	-0.008
	(0.052)	(0.058)	(0.017)	(0.016)	(0.032)	(0.042)	(0.016)
2.5 km	0.107^{***}	0.143^{***}	-0.060^{***}	-0.016	-0.064^{**}	-0.001	-0.003
	(0.040)	(0.046)	(0.016)	(0.013)	(0.025)	(0.033)	(0.014)
3.5 km	0.105^{***}	0.139^{***}	-0.071^{***}	-0.015	-0.050^{**}	-0.033	-0.004
	(0.033)	(0.038)	(0.015)	(0.011)	(0.021)	(0.027)	(0.013)

Note: Table shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to the BRAC branch office on major methods used to cope with covariant shocks, using different bandwidth choices. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A6: Robustness: Parametric Regression for Main Outcomes

(a) Technique Adoption

	Manure (1)	Inter-cropping (2)	Crop Rotation (3)	Irrigation (4)	Weeding (5)	Fertilizer (6)	Pesticides (7)	All HYV Seeds (8)	BRAC HYV Seeds (9)
Est. Discontinuity	0.056	0.089sym*	0.113^{**}	0.037^{***}	-0.136^{**}	0.017	0.004	0.077	0.051^{*}
	(0.040)	(0.048)	(0.052)	(0.014)	(0.066)	(0.034)	(0.051)	(0.076)	(0.029)
N	6413	6413	6413	6413	6413	6413	6413	6413	6357

(b) Production, Employment, Savings and Food Security

	Production Costs (1)	Production Value (2)	Employment (3)	Savings (4)	Per Capita Food Cons. (5)	Food Insuf. Last Year (6)
Est. Discontinuity	-0.031	0.085	0.091^{*}	0.230	0.283^{*}	0.261^{***}
	(0.182)	(0.221)	(0.049)	(0.255)	(0.152)	(0.080)
N	4650	6130	7713	6090	6791	7185

(c) Coping with Shocks

	Reduce Consump. (1)	Use Savings (2)	Sell Assets (3)	Additional Emp. (4)	Begging (5)	Borrowing (6)	Friend Transfer (7)
Est. Discontinuity	0.105	0.208^{**}	-0.080^{***}	0.013	-0.065	-0.061	0.001
	(0.081)	(0.093)	(0.030)	(0.018)	(0.042)	(0.054)	(0.018)
N	4296	4296	4296	4296	4296	4296	4296

Note: Tables shows the reduced form effects of residing in villages that are within the 6 km cutoff distance to BRAC branch office on main outcomes using quadratic regressions, allowing coefficients to be different at each side of the cutoff. Sample is restricted to households residing within 12 km from the nearest BRAC branch office. Panel (c) further restricts sample to those experienced covariant shocks in the 6 months prior to the survey. Errors are clustered at the village level. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A7: Technology Adoption (LATE)

	Manure (1)	Inter-cropping (2)	Crop Rotation (3)	Irrigation (4)	Weeding (5)	Chemical Fertilizer (6)	Pesticides (7)	All HYV Seeds (8)	BRAC HYV Seeds (9)
No controls	0.098*	0.130**	0.116*	0.060***	-0.217***	0.054	0.052	0.043	0.131***
	(0.054)	(0.060)	(0.064)	(0.020)	(0.079)	(0.044)	(0.061)	(0.080)	(0.035)
With controls	0.97*	0.126**	0.103*	0.060***	-0.263***	0.053	0.037	0.030	0.135***
	(0.056)	(0.064)	(0.066)	(0.021)	(0.083)	(0.047)	(0.063)	(0.084)	(0.035)

Note: Table shows the local average treatment effect of incidence of program activities in the 6 month proceeding the survey on technology adoptions. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A8: Production, Employment, Savings and Food Security (LATE)

			Labor Market Employment					
	Production Costs	Production Value	Employed	Employed Hours	Hourly Wage	Savings	Per Capita Food Cons.	Food Suf. Last Year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No controls	-0.142	0.472^{**}	0.241^{***}	390.4^{**}	0.336	0.790^{***}	0.422^{**}	0.643^{***}
	(0.214)	(0.241)	(0.079)	(170.5)	(0.568)	(0.282)	(0.174)	(0.087)
With controls	-0.179	0.449^{*}	0.236^{***}	397.7^{**}	0.336	0.683^{***}	0.301^{*}	0.650^{***}
	(0.207)	(0.247)	(0.080)	(175.8)	(0.457)	(0.261)	(0.182)	(0.088)

Note: Table shows the local average treatment effect of incidence of program activities in the 6 month proceeding the survey on inputs purchase production costs, total production values, employment, household savings, per capital household consumption in the last seven days and food sufficiency in the last year. Productions costs, production value, hourly wage, household savings and per capita food consumption are all measured in log scale. The calculation of total production values only includes major crops that are mainly reported in kilograms. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A9: Other Measures of Food Security (LATE)

	Worry about Insuf. Food (1)	Limited Variety (2)	Limited Portion (3)	Skip Meals (4)
No controls	-0.246^{***}	-0.189^{***}	-0.220^{***}	-0.325^{***}
	(0.076)	(0.071)	(0.080)	(0.087)
With controls	-0.246^{***}	-0.179^{***}	-0.214^{***}	-0.331^{***}
	(0.078)	(0.073)	(0.082)	(0.089)

Note: Table shows the local average treatment effect of incidence of program activities in the 6 month proceeding the survey on detailed measures of food security for the month proceeding the survey. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.

Table A10: Coping with Shocks (LATE)

	Reduce Consump. (1)	Use Savings (2)	Sell Assets (3)	Additional Emp. (4)	Begging (5)	Borrowing (6)	Friend Transfer (7)
No controls	0.289^{**}	0.357^{***}	-0.137^{***}	-0.032	-0.166^{**}	0.040	-0.016
	(0.120)	(0.131)	(0.044)	(0.035)	(0.072)	(0.087)	(0.038)
With controls	0.248^{*}	0.381^{***}	-0.132^{**}	-0.047	-0.156^{**}	0.023	-0.018
	(0.120)	(0.141)	(0.045)	(0.036)	(0.078)	(0.095)	(0.042)

Note: Table shows the local average treatment effect of incidence of program activities in the 6 month proceeding the survey on major methods used to cope with covariant shocks. Controls include household heads' age, literacy, whether any household member holds positions in the village or higher-level committees, as well as the coverage of BRAC's microfinance program. Asterisks *, ** and *** denote significant levels of 10%, 5% and 1% respectively.