Are Gender Differences in Performance Innate or Socially Mediated?[1]

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Abstract

Even with comparable innate ability, women's relative performance in market tasks may suffer if they are subject to discrimination. We run a field experiment across 142 Malawian villages in which either men or women were assigned the task of learning about a new agricultural technology (a private task), and then communicating it to others to convince them to adopt (requiring interaction). When the communicator role is reserved for women, they learn and retain the new information just as well as men, and those taught by women experience greater farm yields. However, women are not as successful at teaching or convincing others to adopt the new technology. Micro-data on individual interactions from 4,000 farmers suggest that other farmers perceive female communicators to be less able, and are less receptive to the women's messages. Performance-based incentives mitigate this performance gap, although a perception gap remains.

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1. Introduction

Gender gaps in earnings and in other economic outcomes have been documented extensively by economists (Blau and Kahn 2000). While gaps favoring men exist in virtually every country, disparities in income, health, education, and decision-making power are more pronounced in developing countries (Jayachandran 2015). Understanding the causes of these gaps has received a lot of attention in the literature, with most of the empirical work focused in developed countries.[2] Review articles on the topic published a decade apart show that the early literature documented cases of discrimination against women in the market as a source of disparity in outcomes (Altonji and Blank 1999), while a more recent literature has also considered gender differences in innate preferences and ability as underlying causes (Bertrand 2011).

Many audit studies (Neumark 1996), blinded natural experiments (Goldin and Rouse 2000, Moss-Racusin et al 2012), and field experiments with fictitious resumes or emails (Bertrand and Mullainathan 2004; Riach and Rich 2006; Petit 2007; Milkman et al 2012) have documented gender discrimination. In parallel, researchers have uncovered innate gender differences in risk preferences or attitudes towards competition both in the lab (e.g. Gneezy et al 2003, Niederle and Vesterlund 2007) and in the field (e.g. Flory et al 2015). Yet, if women face a backlash when adopting behaviors or occupations traditionally associated with men, they will opt out of these activities (Akerlof and Kranton 2000). Those reactions stemming from discriminatory beliefs or practices may reflect back as women having worse performance or characteristics in equilibrium (Bertrand and Duflo 2017).

We report on a field experiment in which we randomly assign either male or female farmers the task of learning about a new agricultural technique, communicating about it to other villagers, and convincing them to adopt. In the process, we document the role that gender discrimination plays in shaping the diffusion of a new technology across 142 villages in Malawi. We add a cross-cutting experiment to explore whether providing small incentives to promote social diffusion helps eliminate the gender differences.

We administer knowledge tests to the communicators one and two agricultural seasons after the initial training to measure how well they learned about the technology and retained that

[2] See Bertrand (2011) and Niederle (2015) for reviews of the literature.

information, and whether they themselves adopted. To measure these communicators' performance in the social diffusion task, we collect two years of follow-up data on a random sample of other nearby farmers to track how well these other farmers learned and retained information about the technology from their assigned communicator, and whether they adopted the technology. The former allows us to compare male and female communicators in terms of their raw innate ability to learn, while the latter allows us to track how that ability translates into performance in the field when those communicators have to interact with society at large to complete the assigned task. Comparing across the two stages allows us to infer whether women under-perform on the field task due to a raw ability gap, or because of issues related to social interactions, norms and attitudes.

Most real-world labor market tasks are characterized by situations where a woman must rely on or interact with male (or female) colleagues to be successful in her job. This is true for any job that requires managing or supervising teams of workers, teaching or training others, or interacting with customers. Labor markets in the modern economy rarely offer opportunities for individuals to work and succeed in isolation. In such situations, equally able women may under-perform relative to men because of overt discrimination and lack of cooperation from colleagues (Bagues and Esteve-Volart 2010; Delfgaauw et al 2013), because of social norms and attitudes (Gneezy et al 2009, Bertrand, Kamenica and Pan 2013), or because gender identities require women to behave differently when interacting with male colleagues (Akerlof and Kranton 2000).[3] Perceptions of women's performance may also not accurately reflect their actual performance (Beaman et al 2009).

A lab experimental literature presents some related evidence that women either perform worse, or display some different innate attitudes when they are in mixed-gender environments compared to single-gender environments (Booth and Nolen 2012a, 2012b). We add to this literature by setting up a large-scale field experiment to document the effects of gender discrimination on the diffusion of a technology that has important productivity consequences. Our core idea is that women's relative performance may change when they move from single-gender or isolated environments (where true innate ability is expressed in private tasks), to a field

[3] Hoff and Pandey (2014) provide field experimental evidence on how low-caste children in India perform worse on cognitive tasks in the presence of high-caste children, especially when caste identity is made salient.

environment where they have to interact with other men or women to complete the task successfully.

We find that women do just as well as men in learning about and adopting the technology themselves, but that their relative performance drops when they are reliant on others to diffuse the new technique. We use micro data on individual interactions collected from around 4,000 farmers to explore why. We show that it is not simply the case that learning and teaching are different skills, and that women are better learners than they are teachers. Direct measures of teaching performance indicate that women put more effort into teaching, and farmers they teach experience better yields compared to those in male communicator villages. This does not seem to be about cross-gender frictions in communication either: Nearly half of all maize plots in our sample villages are farmed by women, and the gender gaps remain regardless of whether we examine the responses of other male or female maize farmers.

Instead, we find that both male and female maize farmers perceive male communicators to be more knowledgeable about agriculture, although by our objective measures those men are no more knowledgeable about the new technology introduced through the experiment. Accordingly, other farmers do not pay as much attention to female communicators. Biases in perception and attention appear to be the most likely underlying causes of the patterns we document.

Offering performance-based incentives lead both male and female communicators to increase effort, which leads to greater interaction with other farmers and eliminates gender gaps in performance. While providing small incentives to communicators is cost-effective at both improving farm profitability and negating the effect of gender discrimination on performance, it fails to erase the gender gap in perceptions.

Understanding the role of gender discrimination in the diffusion of a new agricultural technology is important for policy. Agricultural yields have remained low and flat in Sub-Saharan Africa over the last 40 years, and low adoption of productive technologies is thought to be a major cause (World Bank 2008). Lack of persuasive sources of information may make farmers reticent about new technologies, which makes the communication task we assign to men and women in our field experiment extremely important. Yield and other outcome data collected from over 4,000 farmers living in our study villages suggest that success in the assigned tasks has large welfare implications. Use of the new technology increases yields by over 30% in arid areas (BenYishay and Mobarak 2014; Beaman et al 2015).

More broadly, gender disparities in the United States and other developed countries have been studied extensively, and we add to that literature by investigating the sources of disparities in developing countries where gender inequality is more pronounced (Jayachandran 2015). Gender discrimination also has more devastating consequences in developing countries, where 6 million women are reportedly "missing" at birth, and many do not survive into adulthood (World Bank 2011; Duflo 2012).

The rest of the paper is organized as follows: In section 2, we describe the context and our experimental design. Section 3 discusses the data, while results on communicators' unmediated and mediated tasks are presented in section 4. Mechanisms are discussed in section 5. We offer a brief conclusion along with implications for policy in section 6.

2. Context and Experiment

2.1 Extension Network

Malawi is predominantly agricultural, and 85% of the population lives in rural areas (Malawi National Statistics Office 2011). 56.6% of the rural population was classified as poor in 2011 (Malawi National Statistics Office 2011). Maize is the primary staple food in Malawi. With one rainy season, there is typically one maize harvest per year. The Ministry of Agriculture communicates with maize farmers through a national public, decentralized agricultural extension system. All agrarian areas are in principle staffed by an Agricultural Extension Development Officer (AEDO), but in practice, these frontline positions are chronically understaffed. Each AEDO is responsible for providing extension services to 1,465 households on average, and moreover, many AEDO vacancies remain unfilled. At the outset of our study in 2009, only 56% of all AEDO positions were filled across our study districts, according to Ministry records. As a result, only 18% of farmers participated in extension activity according to the last National Agricultural and Livestock Census (Malawi National Statistics Office 2007). Informational deficiencies remain a key challenge that hinders adoption of yield-enhancing technologies.

In addition, the traditional extension network is male-dominated: the average ratio of male to female AEDOs from 2005-2010 was 8:1 (Masango and Mthinda 2012). The Ministry had adopted a 'lead farmer' approach to extend the reach of extension, in which a few farmers are chosen to act as extension partners to communicate with their neighbors. These positions are typically filled by men. These gender imbalances suggest that involving more women to communicate with farmers about new technologies may be a promising way to address informational deficiencies, especially since 48% of maize farms in our study area are cultivated by women. This creates a rich setting to study the roles played by innate ability, social norms and attitudes, and gender identity in determining the relative performance of men versus women in a field-based task, by involving women in the delivery of extension advice.

2.2 Experimental Design

We partner with the Ministry of Agriculture and Food Security (MoAFS) in Malawi to conduct a large-scale field experiment with 142 maize farming communities in 8 districts across the country. In 2009, the MoAFS was preparing to roll out a new extension activity[4] in these eight districts, and we convinced them to incorporate ideas from the social learning literature to improve delivery. Under this approach, a few village residents are chosen as extension partners or *communicators*, and are asked to serve as the interlocutor between the AEDO assigned to the area and the rest of the village farming community. A communicator has two main categories of tasks:

> *Task A:* receive training on a new technology, and acquire, retain and use this knowledge on her own farm.
>
> *Task B:* communicate about the new technology to other (non-communicator) farmers in her village, and convince them to acquire, retain and use this knowledge on their farms.

To explore gender dimensions of communication, we randomly select 48 villages where we reserved the communicator role for women. In the other 47 treatment villages, we did not impose any such gender reservation.[5] Measuring the relative performance of male and female

[4] A decentralized T&V model of extension is set up such that information on new technologies flows from researchers to extension workers and on to producers via farmer communicators, points of contact between extension agents and other farmers (Kondylis et al. 2017).
[5] BenYishay and Mobarak (2018) study social learning and communication in this subset of 47 villages, plus 25 villages not included in this paper where established extension workers were the primary communicator.

communicators (in gender-reserved versus non-reserved villages) in Task A allows us to isolate gender differences in innate ability, while the comparison to Task B allows us to gauge relative changes in performance across these men and women, when success is contingent on communicating with others and persuading them to accept their message.

In a second, cross-cutting treatment arm, we provide performance-based incentives to a random subset of communicators. This makes up four treatment arms (female-reserved without incentives, female-reserved with incentives, and non-reserved with and without incentives), in addition to a fifth pure control arm.

2.3 AEDO Training

Each extension officer (AEDO) is responsible for a group of villages, which is called a "section". Our sampling frame is restricted to the 457 sections (out of 822) actually staffed by an AEDO in our study districts. Within this set, we randomly select 121 sections where we conduct the project. We first randomly assign 26 sections to "pure control" and the 95 other sections to one of the four treatment arms.[6]

Appendix A provides a detailed timeline of project activities. In August 2009, prior to launching any intervention, AEDOs serving our 95 treatment sections received a three-day training on (a) the new technologies we were introducing for this project, and (b) how to transfer knowledge about those technologies to a village-based communicator. The training materials were prepared and delivered by the two agencies most relevant to the two technologies we introduced (Departments of Agricultural Research Services and Land Resources Conservation). The Department of Agricultural Extension Services (DAES) coordinated the trainings. The sessions were attended by all AEDOs and their direct supervisors (Agricultural Extension Development Coordinators, AEDCs). Each AEDO and AEDC was trained only on the one technology relevant to their assigned districts.

The first day of the training was devoted to familiarizing AEDOs and their supervisors with the aims of the project. The concept of *communicator* was discussed, as well as the

[6] We chose additional "spillover" control villages in 19 of the treated sections, to study whether treatment leads to displacement of AEDO attention away from other villages he is responsible for. We do not find any evidence of effort displacement, and all results reported in this paper are robust to controlling for an indicator for such sections.

motivations for a gender reservation mechanism. This part of the training was key in ensuring good compliance to the study protocols, since the AEDO played a central role in the identification of communicators. The second and third days of training were allocated to classroom and hands-on training on the new technology that the AEDO would then disseminate to communicators. Classroom discussions took place at the training centre, while hands-on modules were held in adjacent demonstration plots. The training closed with an explanation of each AEDO's specific village assignment, including any gender reservation requirements for the extension partner or "communicator" they had to help identify.

2.4 Communicator Identification and Gender Assignment

The first village visit was designed to identify the communicators in all treatment villages. The AEDO assigned to that village convoked and led a half-day meeting that was open to anyone in the community, including local leaders, social groups and associations within the village such as youth groups, church, savings and loan associations, etc. Turnout was usually substantial. Communicators were described as representatives of these main local social groups who would be willing to learn and disseminate a new technology to others. The specific (random) gender assignment was shared in this first meeting.[9] Both men and women assigned to the communicator role were well integrated in the social tissue of the community and chosen in conjunction with community members, so as to reduce the chance that any chosen communicator of either gender would be resented thereafter. To reduce gender stereotyping of the communicator role, AEDOs told the meeting attendees that men and women could be equally successful at this task.

After this first discussion, leaders worked with the assembled community members to produce a short list. In a second step, the AEDO selected the communicator from the short list, and verified the assignment and/or the good faith attempt of complying with the assignment.

[9] In all communities, we asked community leaders to designate up to 5 "peer farmers" and 1 "lead farmer". However, the specific communicator type is not the focus of this paper and, in the interest of statistical power, we pool these groups and focus on the gender assignment. In *lead farmer* villages, the gender assignment required that the one selected communicator be a woman. In *peer farmer* villages, our gender treatment required that a majority of communicators be women. We pool these two treatment arms into one general *communicator* treatment, and study the effects of the (cross-cutting, random) gender reservation treatment. We control for the lead versus peer farmer treatment in all analysis reported in this paper. A separate paper (BenYishay and Mobarak 2018) studies the effects of communicator type using only a sub-sample of our villages where there was no gender reservation treatment.

Third, AEDOs and leaders went back to the larger assembly to share their final choice of communicator. This last step ensured that the community endorsed the pick. These meetings were completed during August-September 2009.

Appendix Tables B1 and B2 report compliance with the gender reservation treatment, separately for villages with and without incentives, and for lead versus peer farmer villages. The tables show that there was imperfect compliance with the gender reservation treatment, so we conservatively report *intent-to-treat* (ITT) estimates throughout the paper. The ITT tracks the effect of the village getting *assigned* a female communicator. If different *types* of women or men complied with the treatment assignment, then the local average treatment effect (LATE) of gender reservation becomes difficult to interpret. 61% of villages assigned to the female-reserved treatment choose female lead farmers, whereas every single village not assigned to the gender-reserved treatment chose male lead farmers. 55% of the gender-reserved peer farmer villages (where we required that the majority of communicators be female) complied with the experimental instructions, while 18% of the non-reserved villages had a majority of females as communicators. The experimental assignment therefore did produce a first-stage of increasing the participation of females in communicator roles, but we do not use it as an instrument to estimate the LATE because compliance variation across rounds may be related to communicator performance, and therefore endogenous. We also directly control for the Lead/Peer farmer assignment, given the compliance variation across these two types of villages.

2.5 Shadow Communicators and Training

We follow the same communicator identification process in control villages, to designate "shadow communicators" who *would have* played the communicator role, had that village been treated.[11] These shadow communicators are useful for research purposes, because they represent the correct counterfactual against which to compare the actions of the actual communicators in treatment villages. Identifying and surveying the shadow communicators allows us to report experimental results on what actions and activities the communicators participate in as a result of the project, holding constant the social identity and other unobserved characteristics of the

[11] In control communities, the process ended after the community endorsed the choice of communicator. Unlike communicators in treatment communities, shadow communicators were not trained nor contacted beyond the second step of the identification process.

communicator. These regressions will prove to be useful to understand the mechanisms underlying the effects that we will observe.

This design implies that the only difference between treatment and control communities is that communicators in treatment villages receive subsequent visits and trainings from the AEDOs on a new technology, while shadow communicators do not. AEDOs trained the communicators soon after identification, and ahead of the main planting season. These trainings lasted for half a day. It involved explaining the merits of and demonstrating the application of the new technology. The AEDOs then made follow-up visits to treatment communicators over the course of the next two years.

2.6 Incentives

In a cross-cutting experiment, we randomly assign performance-based incentive payments to communicators in half the villages. We informed only the communicators in villages randomly assigned to the incentive arm about these incentives, through individual meetings in October-November 2009, after the selection and training of communicators was completed, so that the assignment of incentives does not influence the identities of communicators.

The incentive scheme consists of two payouts, one after the first agricultural season, and the associated midline data collection was completed, and the other after the second agricultural season and completion of endline data collection. The first payout was based on gains in knowledge score in their community, because we mostly expected information about the new agricultural technologies to spread during the first year. The threshold for the incentive payment is set at 20 percentage point increase in knowledge scores among interviewed farmers, as measured by an exam administered during the midline that tested farmer knowledge of the details of how to implement the technology (see Appendix C). Communicators are given no prior information about the nature of the exam or the sampling frame for the survey, and therefore have no opportunity to teach others to the test. Furthermore, we rotated the set of households who were sampled in each round, so that there is not a perfect overlap of households across survey rounds. Not surveying the same households across rounds is costly because it creates imperfect panels, but we did it to make it more difficult for the communicators to target a minority of households in order to win the incentive payment.

Endline payouts are indexed on gains in adoption within the community. In order to avoid relying solely on respondent self-reports, we monitor adoption through an on-farm monitoring (OFM) survey administered between planting and harvest. Enumerators trained in the maize farming process visited the farms of 1,400 households to directly observe any evidence of technology use. These farm visits were timed to the agricultural cycle when that evidence would be visible. Gains in adoption of 20 percentage points and higher trigger a payment. The OFM surveys were also conducted on a rolling sample of farmers to ensure that communicators could not easily target effort on a narrow set.

Payouts were given in kind, in the form of demonstration kits and production inputs. The incentives are gender-neutral in nature since maize farms are equally cultivated by men and women in our sample. MoAFS financed the intervention and legislated their value, and project staff ensured that payouts across all villages were roughly equal in value (KW 12,000, or USD 80 per community per year).

2.7 Technology

We promoted one yield-enhancing conservation farming technology in each village. AEDOs in four arid districts were trained on “pit planting” (Rumphi, Neno, Chikwawa, and Balaka districts). “Changu composting” was promoted in villages in the other four districts (Zomba, Mchinji, Dedza, and Mzimba). These conservation agriculture technologies have proven yield benefits and overall positive returns, as documented experimentally for Malawi (BenYishay and Mobarak, 2018; Beaman et al., 2015), and observationally for the sub-region (Thierfelder et al., 2015). These techniques do not confer any added benefit to one gender over another, and there is no gender gap in knowledge of these techniques in our control villages at baseline. While the technologies are yield-enhancing, they require some additional up-front labor effort or learning effort. Farmers may be reluctant to invest this effort on new technologies with uncertain benefits. We will briefly describe the two technologies here, and Appendices D-F provide the training program and detailed training manuals.

Pit planting increases a soil's capacity for storing water while minimizing soil disturbance and, thus, nutrient runoff. In practice, rectangular pits are excavated in a field. Seeds are planted inside the pits, rather than on ridges, which is the status quo practice in Malawi. The pits conserve moisture and allow farmers to use small quantities of inputs more efficiently. Once prepared, pits can be used for at least two consecutive seasons, after which farmers have to reshape the pits. Pit planting was virtually non-existent at baseline in our study area. Only 1 percent reported ever practicing it, and only 12 percent of farmers had ever heard of the technology.

The main benefits of "Changu composting" over other types of compost are (i) reduced heap maturity and (ii) use of easily accessible materials. At baseline, we record that only 7 percent of farmers in control villages had heard of this particular type of compost (overall, 53% had heard of compost in general), and only about 25 percent of those who had heard of Changu composting were able to correctly answer questions on preparation, properties and application methods.

The data analysis will pool all eight districts together and use district fixed-effects to absorb any unobserved technique-specific and geographic heterogeneity.

3. Data and Descriptive Statistics

3.1 Data Sources

We first conduct a full listing of all households in each of the 142 villages. We randomly select households to survey from this sampling frame. We chose all communicators (treated or shadow), plus 25 other randomly selected households for the surveys. We rotate the sample of households participating in each survey round and create imperfect panels to both minimize survey fatigue for each household and prevent communicators from focusing on just a few households, after observing who we survey. This yields samples of 3,685, 3,496 and 3,314 households of 'regular' (non-communicator) farmers and 467, 474, and 329 communicators at baseline, midline and endline, respectively. The baseline was conducted in August-September 2009,[12] a midline in July – September 2010 at the end of the first agricultural season, and an endline in July – September 2011 after the second agricultural season. We augmented our midline and endline instruments with a spouse/additional farmer module, increasing the total number of respondents to 6,006 and 4,693 at midline and endline, respectively.

These surveys capture a rich set of measures of knowledge and adoption of the promoted techniques, along with agricultural production, household demographics, individual characteristics, perception, and social network relationships. To test respondents' knowledge about the technology introduced in their village, we ask seven questions regarding the details of how to apply the technology. The questions are based on the material used by AEDOs to train communicators in treatment villages.[13] We use these questions to construct a [0,1] knowledge index where 0 indicates a respondent could not correctly answer any question, and 1 that a respondent answered all questions correctly. We collect data on adoption of the technology in two different ways: (a) self-reported in the survey, and (b) through direct observations during the on-farm monitoring.

The social network module records farmers' interactions with and perceptions of (shadow or actual) communicators and other farmers in their village. Social network relationships with other non-communicator farmers were recorded as follows. For each respondent, we drew a list of six randomly-picked farmers in the community from our baseline listing. We then asked questions about the nature of the respondent's interactions with each of these farmers, as well as their perceptions about those farmers. Appendix C details the construction of all main outcome variables.

[12] The baseline survey only allowed for one respondent, the head of the household. This implies that baseline individual characteristics on communicators are not available whenever the communicator was not head of the household. We therefore use our midline communicator survey, collected at the time of the on-farm monitoring survey, to establish compliance to the gender assignment.
[13] See Appendices C and D for a detailed record of the knowledge exam, and training manuals, respectively.

3.2 Descriptive Statistics and Balance

Table 1 displays sample characteristics of the communicators chosen for the experiment, and compares them to both shadow communicators and other non-communicators who were randomly selected to respond to our survey. Communicators are similar to regular farmers on most dimensions, with no significant differences by gender (cols 7, 8, 9). Reassuringly, shadow and actual communicators share similar characteristics (col 11). Randomly varying the gender of chosen communicators does not lead to statistical differences in the observable characteristics of the communicators (col 7). This is important to note for the proper interpretation of the statistical differences in post-treatment outcomes across arms that we will report later. Those outcome differences will be attributable to randomly assigning a task to either men or women, who are otherwise similar along observable dimensions.

Table 2 tests for balance in randomization by comparing non-communicator respondents across treatment assignments. We achieve balance on individual observable characteristics across all treatment arms (cols 3, 6, 9), and reject joint significance of these characteristics in determining treatment status. Farmers in our study area are about 41 years old, work mainly in agriculture and cultivate just under 1 hectare of land, own one head of cattle and about 4.6 other assets. These are relatively poor farming households: they live in dwellings made from local material, with only 21 percent owning a tin roof. Their diet consists mainly of maize. Only 5 percent had taken any loan in the year prior to baseline.

4. Regression Results

4.1 Communicators' Performance in the Private Task *(Task A – Learning about the New Technology)*

To explore possible innate gender differences in performance on the assigned tasks, we first compare communicators' relative performance in a task that did not require them to interact with other farmers in society: acquiring, retaining and adopting the new technology themselves. We use the performance of shadow communicators in control villages as the omitted category. This implies that we are holding constant all socioeconomic characteristics, network positions and other unobservables associated with identity, and identifying this relationship on the basis of random assignment of the task (or not). We estimate the following specification:

$$y_{ivdt} = \beta_1 NonIncentMale_{vd} + \beta_2 NonIncentFemale_{vd} + \beta_3 IncentMale_{vd} + \beta_4 IncentFemale_{vd} + \Gamma\, X_{ivdt} + D_t + D_d + \epsilon_{ivdt} \qquad (1)$$

y_{ivdt} is the outcome (such as performance on the technology knowledge test) for communicator *i* in village *v* in district *d* in year *t*. We estimate this specification using OLS regression and include some control variables measured at baseline,[14] district fixed effects, and survey year fixed effects.[15] We cluster standard errors at the village level, which was the unit of randomization. In addition to displaying regression coefficients β_1- β_4 in the table, we also report statistical tests of gender difference in performance within each incentive arm (i.e., β_1= β_2 and β_3= β_4), as well as the effect of incentives for each gender (i.e., β_1= β_3 and β_2= β_4). We also report the overall gender difference pooling across incentive arms. These coefficients and tests are identified off the random assignment of both the gender-reservation and the incentives of communicators through the field experiment.

Given imperfect compliance to our gender assignment, we report intent-to-treat (ITT) estimates of the effect of being assigned to the male or female communicator arm. Treatment-on-Treated or IV specifications would be more complicated to interpret in our setting because: (a) men or women of different types or abilities may choose to comply with the assignment of tasks, and the gender assignment may affect the quality of their replacement; and (b) we report results on many downstream outcomes, such as agricultural yields or crop failure among other farmers who are trained by the either the male or female assigned communicators. We will show that male and female communicators are differentially able to persuade other farmers to adopt, and given the selection of who chooses to adopt, only the ITT estimates are easily interpretable for many specifications we report.

[14] Controls include a constant, communicator-level characteristics (mean landholdings, mean number of plots worked, proportion of HH heads that are male, proportion of HH heads that have completed primary education), and village characteristics (matrilineal dummy, dummies for religion, dummies for language, dummies for village primary economic activity, percentage of HHs in village growing maize, dummies for type of staple food), and district and survey-year indicators. We also add a dummy to indicate whether the village was randomly assigned to the peer or lead farmer village.

[15] We pool both survey rounds for parsimony, with no effect on our central conclusions. For reference, we run the same model on the split survey rounds and find qualitatively similar results (not reported).

Table 3 reports results on four measures of communicator effort in "private" tasks that do not require any interaction with other farmers in his/her society: extensive and intensive margins of participation in trainings on the promoted technology (cols 1, 2), post-training measures of knowledge about the technology to track how well the information was learnt and retained (col 3), and the propensity to adopt the technology on the communicator's own farm (col 4).

Communicators in treated communities are 38-46 percentage points more likely to have been trained by AEDOs than shadow communicators, and we do not detect any significant gender difference in training participation. Communicators in female-reserved villages attend 1.5 additional trainings (3.6 vs 2.1 in non-reserved villages), and the p-value of this difference is 0.12.

Column 3 reports on how well communicators retained the information that they were trained on. Shadow communicators (the omitted category) obtain average knowledge scores of 0.14 across the two survey rounds, which can be interpreted as correctly answering 14 percent of the questions about the technology that they are tested on, or one of the seven questions on average. Trained communicators in treated villages acquire and retain significantly more knowledge about the technology than their shadow counterparts. Their test scores are about double or triple of shadows' scores. Female communicators score slightly higher than men in the knowledge test, but the difference is not statistically significant. Incentives increase scores for both male and female communicators by 8-10 percentage points, although the effect is imprecisely measured for females.

Column 4 shows that only 3% of shadow communicators adopt the new technology, and that there is a sharp increase in adoption among treated communicators. Communicators evidently use own adoption as a strategy to teach and persuade others to adopt. Without incentives, there is a statistically significant female advantage: Communicators in female-reserved villages are 11 percentage points more likely to adopt the technology themselves than in non-reserved villages (p-value = 0.09). These differences vanish in the presence of incentives, as male communicators close the adoption gap.

The promise of incentive payments has much greater impact in non-reserved villages where the communicators are disproportionately more likely to be male. Incentives significantly boost knowledge retention in these villages, while female performance is almost equally strong with or without incentives. This pattern of more pronounced gender differences in the non-incentive arm will be repeated in subsequent tables, as performance-based incentives appear to mitigate the gender gaps we report on in this paper.

4.2 Communicators' Performance in the Socially Mediated Task (Task B – Teaching and Convincing Others about the Technology)

Table 3 focused on tasks that do not require much social interaction with, or dependence on, the rest of the villagers. Table 4, in contrast, focuses on tracking performance in tasks that are *social*: convincing others in the community to acquire and retain information and, ultimately, use the technology. We now use the sample of other, non-communicator farmers in all villages (randomly chosen, excluding the communicators) to evaluate how well information and adoption traveled from the communicators to others.[16] We present the same statistical tests as in Table 3, comparing female-reserved villages to unreserved, and the effects of incentives. Table 4 reports results for three different samples: separately for female and male respondents, and a pooled sample.

There is a change in the *relative* performance of communicators in female-reserved villages (compared to unreserved), when we compare across Tables 3 and 4. While in the absence of incentives, female-assigned communicators were outperforming their male counterparts in adoption of the technology (Table 3, col. 4), they are systematically less successful at convincing others to accept their message (Table 4, col. 1, 2, 3). Without incentives, recipient farmers' knowledge scores in female-reserved villages are 4 points lower than those of recipient farmers in unreserved villages, and this gap is statistically significant (p-value = 0.04). The size of the gap is equivalent to 0.20 standard deviations, or 50 percent of the average knowledge scores in the control group. Un-incentivized female communicators under-perform in transferring knowledge to both male (by -5 points; p-value = 0.07) and female recipients (by -4 points; p-value = 0.04) in the village, suggesting that this gap in performance does not stem from cross-gender frictions in teaching.

[16] In these regressions, controls (coefficients not reported) include a constant, total landholdings, number of plots cultivated, baseline HH characteristics (HH head male dummy, dummy if respondent is HH head, HH head completed primary school education dummy, improved water source dummy, dummy for dwelling with improved roof, dummy for dwelling with improved walls, dummy for whether any HH member took a loan) and village characteristics (matrilineal dummy, dummies for primary religion, dummies for primary language, dummies for primary economic activity, percentage of maize growers in the village, dummies for type of staple food), an indicator for the cross-cutting experiment on peer vs lead farmers, and district and survey-year indicators.

Coefficient estimates in columns 4-6 indicate that communicators in female-reserved villages also under-perform in convincing others to adopt, although the gap is small and imprecisely estimated because adoption among recipient farmers is a relatively rare outcome. Interestingly, there is a larger and more significant drop (of 3 percentage points) when communicators subject to female reservation try to convince other women, casting doubt on frictions in communication across gender as the underlying mechanism.

In the row towards the bottom that reports the gender difference in performance pooling across both incentive arms, estimated coefficients are negative in Table 4 (suggesting a male communicator advantage in transferring knowledge and convincing others to adopt), and significant for the female respondent sample. In contrast, all coefficients in the equivalent row in Table 3 were estimated to be positive (suggesting a slight advantage in favor of female-reserved communicators in acquiring, retaining and using the new technology). This reversal in the gender-reservation advantage is a key result in this paper. Without incentives, communicators in female-reserved villages are as knowledgeable and adopt more, but this relative zeal does not translate into other farmers accepting their message.

These gender differences are again more pronounced in the non-incentive arm, and in Table 4, female communicators catch up to their male counterparts in the incentive arm. For example, recipient farmers' knowledge improves by 5 percentage points with the introduction of incentives in female-assigned villages (p-value = 0.03). Across villages with male and female communicators facing incentives, there is virtually identical knowledge (p-value = 0.89) and adoption (p-value = 0.77). This similarity parallels the similarity in the communicator's own performance on the private learning (p-value = 0.85) and adoption (p-value = 0.70) tasks in the incentive arms reported in Table 3. Thus, performance-based incentives appear to lead to performance in the social task that more closely reflect the underlying skill of men and women.

4.3 Are Women Simply Worse at Teaching than at Learning?

The results we have reported thus far are consistent with women under-performing in relative terms when they move from a private task that requires little social interaction to more public tasks that do. This may be evidence of discrimination against women in societal interactions, but it also may simply be the case that women are better learners than they are teachers. Differences in teaching performance could also arise due to gender disparities in human capital investment earlier in life. To explore these possibilities, in Table 5 we study crop yields and crop failures amongst recipient (non-communicator) farmers. We report results on yields and failure on a random sample of all recipient farmers residing in the village, not conditioning on adoption, to avoid any selection issue regarding who the communicators choose to target across gender-reserved and non-reserved villages.

Columns 1-3 report the effect of our treatments on a measure of maize yield on the farm captured at endline, after the second agricultural season post intervention.[17] The technologies are productive on average, so maize yields are significantly greater across all treatment villages compared to control. As noted above, the overall adoption rate among recipient farmers is very low, so these yield differences are extremely noisy. Nevertheless, in the non-incentive sample, we can reject that yields are lower in female communicator villages (p-value = 0.03). In this arm, yields are 16% greater when women teach rather than men. The female communicator advantage persists for both male and female recipient farmers, so it does not appear to be the case that female communicators are only better at teaching other women.

In line with our results on the "private task" (technology adoption by the communicators), non-reserved villages gain more with incentives, erasing female-reserved communicators' advantage in producing higher yields (p-value = 0.22). While female-reserved villages retain an advantage overall in the full sample, the difference is no longer significant.

Given the difficulty in collecting yield data (that may lead to measurement error), we also study the effects of communication on the incidence of crop failure, which easier to measure. Columns 4-6 show that the likelihood of crop failure is smaller (but statistically indistinguishable) in the female communicator villages. Crop failure is a relatively rare event that year (5% in control villages), and there is no evidence that female communicators cause more disasters or are less able to transfer skills to other farmers.

The fact that yields are the same (or greater) in female-reserved communicator villages suggests that when women manage to teach and convince others to adopt, the recipients do just as

[17] Although we record agricultural production in both survey rounds, we only record it at the plot level in the endline. This allows us to directly assign changes in yields to the individual farmer managing the plot, while at midline we can only provide a household level estimate. Yields are winsorized at the top 2.5% end of the distribution.

well with the technology. It does not appear to be the case that women are worse than men at teaching. Even if women are less confident as teachers, or in terms of the beliefs they express about the new technology, it does not undermine their performance as teachers. The differential gender performance in the private versus public tasks therefore does appear to be related to something else, such as discrimination in the form of social frictions, or perceptions of women, or willingness to accept messages from women.

5. Mechanisms

In this section we explore what types of communication inefficiency can explain why female communicators, despite being as knowledgeable and achieving better command of a new technology, are not as convincing as men in getting others to learn and adopt a new technology. First, women may be worse teachers. The yield data strongly suggest otherwise. Second, there may be some "gender frictions" if farmers learn more from others of the same gender. Then our results could stem from a gender composition effect: there are more male farmers in our sample, who are more receptive to male communicators, and women would be mechanically less effective. As previously reported, this hypothesis is not borne out by the data when we separately estimate effects for male- and female- recipient farmers. This is in line with other findings in the literature, showing that discrimination against women is not solely perpetrated by men (Bagues and Esteve-Volart 2010; Jayachandran 2015).

Third, women may find it more costly to communicate with others. For instance, getting others in the community to pay attention to their message and trainings may be harder for female than male communicators, especially in the presence of gender bias on the demand side. Should this be the issue, we might observe lower attendance at the trainings women organize. Fourth, other farmers may perceive women to not be as good at farming, and may not want to receive advice from them, or give as much credence to the advice they impart. Finally, other farmers may be less inclined to engage in discussions with female communicators due to social norms and attitudes about women's place in society (e.g., "we do not want to talk to women, they should not teach").

We combine our random assignment to performance-based incentives with rich data on all farmers' and communicators' social networks, perceptions and communication patterns to shed light on the relative merits of each of these mechanisms.

5.1 Interactions with Communicators

Our treatment encouraged communicators to hold *formal* training activities on the plots in which they adopted the new technology. We start by examining communicators' self-reported provision of trainings for other farmers (col 1, Table 6). Male and female communicators are equally likely to organize trainings for others. Again, in the non-incentive arm, female communicators put in more effort, but there is no statistical gap in the overall sample.

Even though there is no gap in the communicators' effort in organizing trainings, other farmers are significantly less likely (by 11 percentage points, p-value < 0.01) to participate in trainings organized in the female-reserved communicator villages (cols 2-4). This is equally true for both female farmers (-10 pp, p-value<0.05) and male farmers (-12 pp, p-value<0.01). In summary, although the supply of trainings is comparable across female-reserved and non-reserved villages, the demand for that training is not.[18]

We also collected data on more informal interactions between communicators and other farmers. We asked all farmers in our random sample whether they have ever *discussed the new technology with a communicator,* and columns 5-7 show that these informal discussions are significantly less likely to occur in female-communicator reserved villages. The incentive treatment evidently induces a lot of informal discussion across both types of treatment villages relative to control, but both male and female plot owners are 12 percentage points less likely to have those discussions with female communicators (p-value <= 0.01).

Columns 8-10 examine maize farmers' *general interactions* with communicators, not necessarily about this new technology. Conversations about general topics is quite common

[18] We note that communicators in female-reserved villages are 7 percentage points less likely to provide training in the incentive arm (44% vs 51%), although the difference is not significant. A simple back-of-the-envelope calculation shows that this gap in training provision is unlikely to explain a 50% (7pp) drop in attendance (from 14% to 7%, p-value = 0.06) across those treatment arms. For female-reserved villages in the incentive treatment, a 1% increase in training causes attendance to go up by 0.14%. For non-reserved villages in the incentive treatment, a 1% increase in training provision leads to a 0.25% increase in attendance. Assuming constant attendance rates across trainings (a linear training-attendance relationship), incentivized women would need to provide: (0.13-0.06)/0.14 = 0.50, or 50pp more trainings to eliminate the attendance gap.

everywhere: 77% of randomly sampled men and women report talking to shadow communicators in the control villages. There is no significant difference in general conversations with actual communicators in either female-reserved or non-reserved villages. In other words, it does not appear to be the case that female communicators are less "visible" than male communicators in their respective networks; the gaps arise only when we focus on discussions about the new agricultural technology.

In summary, farmers interact with females in general, but they appear to pay relatively less attention to messages about a new agricultural technology coming from a female communicator, both in informal and formal settings. Table 5 had shown that female communicators transmit the message effectively, despite getting less face time (Table 6). All of this suggests that either women are not perceived to be good at farming, or that there are differentials in male and female "identity" in agricultural occupations (Akerlof and Kranton 2000), and the role of women in agriculture and training.

Providing a performance-based incentive increases interaction between farmers and communicators. This motivates us to investigate whether a lack of exposure to female farmers, and a perception gap about their farming skills explains female-reserved communicators' relative lack of success in convincing others to adopt. We explore these ideas using two further sources of data and outcome variables: (a) rich social network data on who in the community talks to whom about what, and (b) data on villagers' subjective perceptions of the farming ability of men and women.

5.2 Social Network Relationships

We included a social network module in all surveys at midline, which asks the respondent about her interactions with 6 randomly selected other farmers in the village. Table 7 reports the gender dimension of these interactions, by estimating the following model using data in which respondent farmer *i* is asked about his/her interactions with other farmer *j* of a given gender residing in the same village:

$$y_{ijvd} = \delta_{FF} FemaleReserved_{vd} . F_j + \delta_{FM} FemaleReserved_{vd} . M_j + \delta_{MF} NonReserved_{vd} . F_j + \delta_{MM} NonReserved_{vd} . M_j + \lambda F_j + \Gamma X_{ivd} + D_t + D_d + \epsilon_{ivd.j} \quad (2)$$

$FemaleReserved_{vd}$ and $NonReserved_{vd}$ are indicators for the village-level random assignment of female-reserved communicators or not, and M_j and F_j denote whether the other farmer *j* that the respondent *i* is asked about is male and female, respectively. We control for some respondent characteristics in X_{ivd}, including the respondent's own gender. λF_j captures the effect of gender of the farmer whom the respondent is asked about. The sample size is large in these regressions (up to 29,811) because the unit of observation is now an *(i,j)* pair, and there are up to 6 *j*'s (other farmers) for every *i* (respondent). The excluded category is a male farmer's interaction with another male farmer in a control village.

The regressions in Table 7 explore three types of interactions: talking to other farmers in general (cols 1-3); discussing farming (cols 4-6); and, discussing the new technology introduced through the field experiment (cols 7-9). We make three central observations. First, people are no less likely to talk to females in general in the community (cols 1-3), which confirms our earlier observation that females are generally not less visible or more socially isolated in rural Malawi. Females are 3p.p. less likely to talk to others (col. 3), and yet just as likely as male respondents to discuss farming and the new technology (cols 6 and 9). Second, our interventions create more buzz in the village, especially about the new technology. In all treatment villages, regardless of gender reservation, there are significantly more conversations between all farmers about agriculture and about the new technology, relative to control villages. Third, relatively more conversation and buzz occur in male-communicator villages. People appear to engage less when the communicator role is reserved for females (8.5 pp compared to 13 pp), although these differences are not precisely estimated.

5.3 Perceptions of Male and Female Communicators

Farmers engaging less with female communicators may be related to biased perceptions of women's farming and training abilities (Beaman et al 2009). To investigate, we collect data on other farmers' perceptions of the diligence, skills, and knowledge of communicators in their village. Each question elicits a subjective rating on a {1,2,3,4} scale on different dimensions of perception (cf. Appendix C). At midline, perception questions capture how hardworking and skillful a respondent considers the communicator to be, with no reference point. At endline, we ask whether the assigned communicator is (a) knowledgeable and (b) a good farmer, relative to the respondent herself. We construct two separate indices of these measures, and normalize them on a [0, 1] scale.

Table 8 shows that farmers perceive communicators in non-reserved villages to be more hardworking, skillful and knowledgeable than in female-reserved villages. This difference is imprecisely measured at midline, but significant at the 1% level at endline. This perception gap exists regardless of the gender of the respondent, and of the incentive assignment. Both men and women think that non-reserved communicators are better at agriculture. We consider these beliefs and perceptions to be biased against women, because the results in Table 3 and 5 indicate that communicators in female-reserved villages are just as knowledgeable about the new technologies introduced through the experiment, and farmers in these female-reserved villages experience better yields. Again, this is particularly striking in the no-incentive arm, where female communicators are relatively more zealous and induce higher yield increases. While erasing the gender performance gap in the social task, the random provision of incentives fails to combats this perception gap (p-value on the gender gap = 0.05-0.10 in the incentive arm).

To summarize, farmers in villages where the communicator role was reserved for women perceive those communicators to be less knowledgeable, pay less attention to their messages, and are less likely to learn about and adopt the new technology. These differences are more pronounced in the non-incentive arm. The gender differences generally become less noticeable when performance-based incentives were offered to the communicators.

6 Conclusions

This study contributes causal evidence to the large literature investigating the role of gender discrimination in market outcomes. We run a large-scale field experiment to test whether women perform differentially at a 'social task' that requires them to interact with others to succeed, relative to a 'private task' that does not. Women are comparable to men (or even slightly out-perform men) in the private task, but this does not translate into greater success at teaching or persuading others.

We explore underlying mechanisms using a cross-cutting experiment with performance-based incentives for the women and men, detailed micro data on social interactions, perceptions, effort expended, and finally, farm yields to obtain an objective measure of success in the field. We find that women teach better and expend more effort, but others do not perceive them to be as good at farming and teaching, and pay less attention to their message and trainings.

These gender gaps are more pronounced in the no-incentive arm, and assigning a performance-based incentive helps to mitigate these issues. All communicators regardless of the gender assignment exert more effort with incentives, by they make gains on different margins. Interactions between communicators and other farmers in their respective villages intensify with incentives, allowing female communicators more success in passing on their message. Our data do not support a generalized gender communication gap in our study setting (e.g. "nobody talks to women"), nor is it consistent with gender frictions in communication (e.g. "women prefer talking to women, men to men"). Instead, our findings support the notion that farmers in general are less likely to pay attention to and accept a message from a female communicator. There is a significant gender perception gap against communicators in female-reserved villages, and performance-based incentives fail to close this gap.

Our results illustrate the cost that gender discrimination imposes on society. Women transmit information about a productive new technology more successfully, and others taught by women experience greater farming yields in a poor, rural society where increases in productivity hold large welfare consequences. Yet, gender discrimination leads to inefficiencies in their transfer of this information to others. Talent is wasted, as communication and perception barriers prevent relatively more zealous and accomplished female communicators from efficiently spreading their knowledge.

Can a policy of assigning female farmers to teach others help overcome such inefficiencies? We show that a small in-kind incentive can induce female communicators to expend more effort and overcome demand-side biases. Differences in performance in the field stem from gaps in perceptions, so a class of policy actions where women are empowered to take a leading role in acquiring and passing a message to others in their community has the potential to narrow the gender performance gap, and make better use of the available talent. The welfare implications of this transition are large, as we show for the adoption of a new technology which enhances agricultural yields in a poor agrarian society.

References

Akerlof, G.A. and R.E. Kranton. (2000). “Economics and Identity.” The Quarterly Journal of Economics, 115 (3): 715-753.

Altonji, J. and R. Blank (1999). “Race and Gender in the Labor Market,” in O. Ashenfelter and D. Card (eds). *Handbook of Labor Economics* vol 3, Elsevier.

Bagues, M.F., and Esteve-Volart, B. (2010). “Can gender parity break the glass ceiling? Evidence from a repeated randomized experiment.” The Review of Economic Studies, Vol. 77(4).

Beaman, L., BenYishay, A., Magruder, J., Mobarak, A. M., 2015. Can network theory-based targeting increase technology adoption. Mimeo, Yale University.

Beaman, L., Raghabendra Chattopadhyay, Esther Duflo, Rohini Pande and Petia Topalova (2009). “Powerful Women: Does Exposure Reduce Prejudice?” Quarterly Journal of Economics, November.

BenYishay, A. and A. M. Mobarak, 2018. "Social Learning and Incentives for Experimentation and Communication." Review of Economic Studies (forthcoming).

Bertrand, M. (2011) “New Perspectives on Gender,” in O. Ashenfelter and D. Card eds, Handbook of Labor Economics, Volume 4B, 1543-1590.

Bertrand, M, E. Duflo (2017) “Field Experiments on Discrimination,” in E. Duflo and A. Banerjee eds, Handbook of Field Experiments, Volume 1 (forthcoming).

Bertrand, M., E. Kamenica, and J. Pan (2015). “Gender Identity and Relative Income Within Households.” The Quarterly Journal of Economics, 571–614.

Bertrand, M., and S. Mullainathan. 2004. "Are Emily and Greg More Employable Than Lakisha and Jamal? A Field Experiment on Labor Market Discrimination." American Economic Review, 94(4): 991-1013.

Blau, F. & Kahn, L. M. (2000). “Gender Differences in Pay”, *Journal of Economic Perspectives*, 14, 75–99.

Booth, A.L. & P. Nolen (2012a). "Gender differences in risk behaviour: does nurture matter?," Economic Journal, Royal Economic Society, vol. 122(558), pages F56-F78, 02.

Booth, A.L. & P. Nolen (2012b). "Choosing to compete: How different are girls and boys?," Journal of Economic Behavior & Organization, vol. 81(2), pages 542-555.

Delfgaauw, J., R. Dur, J. Sol and W. Verbeke (2013). “Tournament Incentives in the Field: Gender Differences in the Workplace”. Journal of Labor Economics 31: 305-326.

Duflo, Esther. 2012. "Women Empowerment and Economic Development." *Journal of Economic Literature*, 50(4): 1051-79.

Gneezy, U., Niederle, M. and Rustichini, A. (2003). “Performance in Competitive Environments: Gender Differences”, Quarterly Journal of Economics, 118, 1049–1074.

Gneezy, U., Leonard, K. L. and List, J.A. (2009). “Gender Differences in Competition: Evidence from a Matrilineal and a Patriarchal Society”, Econometrica, 7, 909–931.

Goldin, C., and C. Rouse (2000). "Orchestrating Impartiality: The Impact of "Blind" Auditions on Female Musicians." American Economic Review, 90(4): 715-741.

Jayachandran, S. (2015). “The Roots of Gender Inequality in Developing Countries”. Annual Review of Economics, Vol. 7.

Kondylis, F., V. Mueller, and S. Zhu (2017). Seeing is Believing? Evidence from an Extension Network Experiment. Journal of Development Economics, 125, 1-20.

Malawi National Statistics Office (2007). National Census of Agriculture and Livestock. http://www.nsomalawi.mw/images/stories/data_on_line/agriculture/NACAL/Nacal%20Report.pdf

Malawi National Statistics Office (2011). Third Integrated Household Survey. http://www.nsomalawi.mw/publications/integrated-household-survey/third-integrated-household-survey-ihs3.html

Masangano, C. and C. Mthinda (2012). “Pluralistic Extension System in Malawi.” IFPRI Discussion Paper 01171.

Milkman, K. L., Akinola, M., Chugh, D. (2012). “Temporal Distance and Discrimination: An Audit Study in Academia”. Psychological Science.

Moss-Racusin, C.A., J.F. Dovidio, V.L.Brescoll, M.J. Graham, and J. Handelsman (2012). “Science faculty’s subtle gender biases favor male students.” Proceedings of the National Academy of Sciences, 109(41), pp. 16474-16479.

Neumark, D.(1996). “Sex Discrimination in Restaurant Hiring: An Audit Study.” Quarterly Journal of Economics, Vol. 111, No. 3, August, pp. 915-41.

Niederle, M. and Vesterlund, L. (2007). “Do Women Shy Away From Competition? Do Men Compete Too Much?” *Quarterly Journal of Economics*, 122, 1067–1101.

Niederle, Muriel, “Gender” *Handbook of Experimental Economics*, second edition, Eds. John Kagel and Alvin E. Roth, forthcoming (expected publication 2015).

Petit, P. (2007). ‘The Effects of Age and Family Constraints on Gender Hiring Discrimination: A Field Experiment in the French Financial Sector’, *Labour Economics*, 14, 371–391.

Riach, P. A., and J. Rich (2006). “An Experimental Investigation of Sexual Discrimination in Hiring in the English Labor Market.” BE *Press Advances in Economic Analysis & Policy* 6 (2) Article 1.

Thierfelder, C., Matemba-Mutasa, R., Rusinamhodzi, L., 2015. Yield response of maize (zea mays l.) to conservation agriculture cropping system in southern Africa. Soil & Tillage Research 146, 230-242.

World Bank (2008). *World Development Report 2008: Agriculture for Development*. Washington, D.C.: World Bank.

World Bank. 2011. *World Development Report 2012: Gender Equality and Development*. Washington, D.C.: World Bank.

Table 1: Profile of communicator-type farmers

	Mean						Mean Difference				
	Communicators			Shadow Communicators	Non-Communicators		(1) - (2)	(5) - (6)	(1) - (5)	(2) - (6)	(3) - (4)
	Male	Female	Pooled		Male	Female					
	1	2	3	4	5	6	7	8	9	10	11
Respondent is household head	0.96	0.90	0.93	0.91	0.94	0.94	0.06	0.00	0.02	-0.05	0.02
Respondent is primary agricultural decision maker	0.95	0.99	0.97	0.96	0.91	0.96	-0.04	-0.05	0.03	0.03	0.01
Household head is male	0.82	0.76	0.79	0.79	0.69	0.74	0.06	-0.05	0.14	0.02	0.00
Household head age	40.01	42.02	40.98	39.71	41.42	40.54	-2.01	0.87	-1.41	1.48	1.27
HH head has completed primary education	0.62	0.61	0.61	0.56	0.41	0.49	0.01	-0.09	0.21	0.12	0.05
Total cultivated land area in 2008/09 (hectare)	1.16	1.08	1.12	1.08	0.98	0.91	0.07	0.08	0.17	0.18	0.04
Maize yield (kgs/hectare)	812	605	714	1093	714	788	207	-74	98	-182	-378
HH cultivated cash crops	0.99	0.98	0.99	1.00	0.99	0.99	0.01	0.01	0.00	-0.01	-0.01
Majority of agricultural labor done by women	0.25	0.26	0.25	0.29	0.35	0.23	0.00	0.12	-0.10	0.02	-0.04
Dwelling has improved roof	0.26	0.41	0.33	0.33	0.18	0.24	-0.15	-0.06	0.08	0.17	0.00
Dwelling has improved walls	0.39	0.51	0.45	0.52	0.35	0.44	-0.12	-0.09	0.04	0.07	-0.07
HH uses improved water source in dry season	0.80	0.82	0.81	0.92	0.86	0.81	-0.02	0.05	-0.06	0.01	-0.11
HH uses improved water source in rainy season	0.83	0.82	0.82	0.92	0.86	0.80	0.01	0.06	-0.04	0.02	-0.10
Primary staple food is maize	0.94	0.97	0.95	0.98	0.94	0.97	-0.03	-0.03	0.00	0.00	-0.03
Primary staple food is sorghum	0.03	0.00	0.02	0.00	0.05	0.01	0.03	0.03	-0.01	-0.01	0.01
Primary staple food is cassava	0.00	0.02	0.01	0.00	0.00	0.01	-0.02	-0.01	0.00	0.01	0.01
Number of animals owned by the household	1.58	1.65	1.61	1.66	1.22	1.33	-0.07	-0.11	0.36	0.32	-0.04
Number of assets owned by the household	5.57	5.37	5.48	5.50	4.43	4.79	0.20	-0.36	1.15	0.58	-0.03
Primary source of income is the household farm	0.90	0.85	0.87	0.85	0.79	0.84	0.05	-0.05	0.11	0.01	0.02
Primary source of income is casual labor (ganyu)	0.45	0.31	0.39	0.39	0.48	0.48	0.14	0.00	-0.03	-0.17	0.00
Primary source of income is a business	0.30	0.53	0.41	0.41	0.38	0.44	-0.23	-0.06	-0.07	0.10	0.01
At least one HH member took a loan in past year	0.08	0.14	0.11	0.08	0.04	0.05	-0.06	-0.01	0.04	0.09	0.03
Number of farmers	115	105	220	248	1,206	1,260	220	2,466	1,321	1,365	268

Data source: Baseline household survey. Notes: T test inferences are based on standard errors clustered at the village level. Critical values adjusted using Bonferroni correction for number of tests performed. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 2: Balance Test (non-communicator farmers)

	By Communication Method			By Gender Reservation			By Incentive		
	Communicator Vlg	Control Vlg	(1) - (2)	No reservation	Female reservation	(4) - (5)	Incentive offered	No incentive	(7) - (8)
	1	2	3	4	5	6	7	8	9
Respondent is household head	0.94	0.93	0.01	0.94	0.94	0.00	0.93	0.95	-0.02
Respondent is primary agricultural decision maker	0.94	0.94	-0.01	0.91	0.96	-0.05	0.95	0.92	0.02
Household head is male	0.71	0.70	0.01	0.69	0.74	-0.05	0.71	0.72	-0.01
Household head age	40.97	40.81	0.16	41.42	40.54	0.87	40.73	41.22	-0.49
HH head has completed primary education	0.45	0.46	-0.01	0.41	0.49	-0.09	0.46	0.44	0.02
Total cultivated land area in 2008/09 (hectare)	0.94	0.87	0.08	0.98	0.91	0.08	0.90	0.98	-0.08
Maize yield (kgs/hectare)	752	898	-145	714	788	-74	571	939	-368
HH cultivated cash crops	0.99	1.00	-0.01	0.99	0.99	0.01	0.99	0.99	0.00
Majority of agricultural labor done by women	0.29	0.34	-0.05	0.35	0.23	0.12	0.28	0.30	-0.02
Dwelling has improved roof	0.21	0.24	-0.03	0.18	0.24	-0.06	0.23	0.19	0
Dwelling has improved walls	0.40	0.41	-0.01	0.35	0.44	-0.09	0.43	0.36	0
HH uses improved water source in dry season	0.84	0.93	-0.09	0.86	0.81	0.05	0.86	0.81	0.04
HH uses improved water source in rainy season	0.83	0.93	-0.09	0.86	0.80	0.06	0.86	0.80	0.06
Primary staple food is maize	0.95	0.96	-0.01	0.94	0.97	-0.03	0.97	0.94	0.03
Primary staple food is sorghum	0.03	0.01	0.02	0.05	0.01	0.03	0.02	0.04	-0.03
Primary staple food is cassava	0.01	0.00	0.00	0.00	0.01	-0.01	0.00	0.01	0
Number of animals owned by the household	1.27	1.25	0.02	1.22	1.33	-0.11	1.31	1.24	0.06
Number of assets owned by the household	4.61	4.63	-0.02	4.43	4.79	-0.37	4.56	4.67	-0.1
Primary source of income is the household farm	0.81	0.81	0.00	0.79	0.84	-0.05	0.85	0.78	0.07
Primary source of income is casual labor (*ganyu*)	0.48	0.47	0.01	0.48	0.48	0.00	0.51	0.45	0.06
Primary source of income is a business	0.41	0.39	0.02	0.38	0.44	-0.06	0.43	0.38	0.05
At least one HH member took a loan in past year	0.05	0.04	0.01	0.04	0.05	-0.01	0.04	0.05	-0.01
F - stat, test of joint significance			1.83			2.33			2.53
Number of farmers	2,467	1,219	3,686	1,207	1,260	2,467	1,261	1,206	2,467

Notes: See Table 1

Table 3: Communicators' effort & performance

	Attended training	# Trainings attended	Knowledge	Adoption
Village assigned to:	1	2	3	4
No Gender Reservation, no incentives	0.38***	2.37*	0.19***	0.13**
	(0.08)	(1.27)	(0.06)	(0.06)
Communicator Role Reserved for Females, no incentives	0.40***	2.35**	0.22***	0.24***
	(0.09)	(0.97)	(0.06)	(0.07)
No Gender Reservation, with incentives	0.44***	2.13***	0.29***	0.32***
	(0.08)	(0.81)	(0.06)	(0.07)
Communicator Role Reserved for Females, with incentives	0.46***	3.64***	0.30***	0.29***
	(0.09)	(1.05)	(0.06)	(0.07)
PF Village Assignment Dummy	-0.04	-0.72	-0.05	-0.01
	(0.07)	(0.89)	(0.05)	(0.06)
Endline Dummy	-0.10**	0.84**	-0.03	-0.07***
	(0.04)	(0.34)	(0.02)	(0.02)
Constant	0.22**	-0.06	0.27***	0.27***
	(0.11)	(0.57)	(0.09)	(0.1)
N	795	795	795	795
Adjusted R2	0.14	0.07	0.38	0.36
Control Group Mean	0.24	0.02	0.14	0.03
	(0.43)	(0.23)	(0.27)	(0.18)
Gender Difference (pooled incentives) Coefficient for [female reservation. – no reservation]	0.03	1.49	0.04	0.07
	(0.13)	(1.33)	(0.08)	(0.11)
Incentive Ttest: Non-incentivized=Incentivized				
p-values, no reservation vlg	0.56	0.77	0.04	0.01
p-values, female reservation vlg	0.52	0.18	0.23	0.55
Gender Ttest: No reservation=Female reservation				
p-values, non-incentivized communicators	0.89	0.98	0.53	0.09
p-values, incentivized communicators	0.81	0.12	0.85	0.70

Data sources: midline and endline communicator survey. Notes: Regressions include the following control variables: a constant, communicator-level characteristics (land area cultivated, gender of the HH head, education level of the HH head) and village characteristics (matrilineal dummy, dummies for religion, dummies for language), dummy for peer farmer village, and district and survey-year indicators. Crop fail effect not included as a dependent because crop failure experienced by only 10 of the communicators. Columns (1)-(4) are estimated on midline and endline samples, while columns (5-6) are restricted to the endline sample for which yield was captured at the individual level. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 4: Other farmers' knowledge and adoption

	Knowledge Score			Adoption		
	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6
No Gender Reservation, no incentives	0.07***	0.09***	0.08***	0.01	0.02	0.02
	(0.03)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
Communicator Role Reserved for Females, no incentives	0.03	0.04	0.04	0.00	0.02	0.01
	(0.02)	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
No Gender Reservation, with incentives	0.09***	0.08***	0.09***	0.05***	0.04**	0.04***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Communicator Role Reserved for Females, with incentives	0.07***	0.11***	0.09***	0.02*	0.05***	0.04***
	(0.02)	(0.03)	(0.02)	(0.01)	(0.01)	(0.01)
PF Village Assignment Dummy	0.04**	0.02	0.03	0.02*	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Endline Dummy	-0.04***	-0.05***	-0.05***	-0.02**	-0.03***	-0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	0.15***	0.24***	0.22***	0.06***	0.06**	0.06***
	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)	0.02
N	3924	4235	8159	3924	4235	8159
Adjusted R2	0.17	0.22	0.21	0.06	0.06	0.06
Mean of Control Group	0.06	0.09	0.08	0.01	0.02	0.01
	(0.17)	(0.22)	(0.20)	(0.10)	(0.13)	(0.12)
Gender Difference (pooled incentives) Coefficient for [female reservation. – no reservation]	-0.07*	-0.02	-0.04	-0.04*	0.01	-0.01
	(0.04)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)
Incentive Ttest: Non-incentivized=Incentivized						
p-values, no reservation vlg	0.52	0.89	0.82	0.05	0.36	0.12
p-values, female reservation vlg	0.06	0.03	0.03	0.14	0.07	0.06
Gender Ttest: No reservation=Female reservation						
p-values, non-incentivized communicators	0.04	0.07	0.03	0.22	0.83	0.49
p-values, incentivized communicators	0.45	0.45	0.89	0.17	0.5	0.77

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the following control variables: a constant, communicator-level characteristics (land area cultivated, gender of the HH head, education level of the HH head) and village characteristics (matrilineal dummy, dummies for religion, dummies for language), dummy for peer farmer village, and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 5: Other farmers' maize production

	Log Maize Yield			Likelihood of crop failure		
	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6
No Gender Reservation, no incentives	-0.17*	0.1	-0.03	-0.01	0.00	0.00
	(0.10)	(0.09)	(0.08)	(0.02)	(0.03)	(0.02)
Communicator Role Reserved for Females, no incentives	0.00	0.23**	0.13	-0.01	-0.02	-0.02
	(0.12)	(0.09)	(0.09)	(0.02)	(0.02)	(0.02)
No Gender Reservation, with incentives	0.08	0.23**	0.16*	0.00	-0.02	-0.01
	(0.12)	(0.10)	(0.09)	(0.01)	(0.02)	(0.01)
Communicator Role Reserved for Females, with incentives	-0.08	0.19**	0.06	-0.02	-0.02	-0.02
	(0.1)	(0.08)	(0.08)	(0.02)	(0.02)	(0.01)
PF Village Assignment Dummy	0.1	0.06	0.08	-0.01	0.02	0.00
	(0.07)	(0.06)	(0.06)	(0.01)	(0.02)	(0.01)
Constant	5.62***	5.84***	5.75***			
	(0.14)	(0.16)	(0.12)			
N	1392	1441	2833	1763	1623	3820
Adjusted R2	0.28	0.34	0.31	.	.	.
Mean of Control Group	6.49	6.66	6.57	0.05	0.06	0.05
	(0.99)	(0.99)	(0.99)	(0.21)	(0.23)	(0.21)
Gender Difference (pooled incentives) Coefficient for [female reservation. – no reservation]	0.01	0.09	0.05	-0.02	-0.04	-0.03
	(0.14)	(0.13)	(0.11)	(0.03)	(0.03)	(0.02)
Incentive Ttest: Non-incentivized=Incentivized						
p-values, no reservation vlg	0.01	0.14	0.02	0.44	0.47	0.86
p-values, female reservation vlg	0.48	0.61	0.37	0.69	0.93	0.90
Gender Ttest: No reservation=Female reservation						
p-values, non-incentivized communicators	0.07	0.08	0.03	0.99	0.26	0.44
p-values, incentivized communicators	0.14	0.67	0.22	0.20	0.62	0.27

Data sources: Endline HH Survey. Notes: Likelihood of crop failure (1-3) is probit; sample size varies when included controls perfectly predit failure. Maize yield (4-6) is OLS. Regressions include the same controls as in Table 4. Maize yield calculated for all farmers that reported growing maize on at least one plot, and 2.5% top-end winsorized. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 6: Other farmers' interactions with communicators

	Communicator led trainings	Farmers interactions with communicators								
		Farmers participated in trainings			Discussed Technology			Talked to Communicator		
		Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6	7	8	9	10
No Gender Reservation, no incentives	0.30**	0.03	0.01	0.02	0.07*	0.08*	0.07*	-0.07**	-0.11**	-0.10**
	(0.11)	(0.04)	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)	(0.03)	(0.05)	(0.04)
Communicator Role Reserved for Females, no incentives	0.40***	-0.01	-0.04	-0.02	0.01	0.02	0.02	-0.09***	-0.12***	-0.11***
	(0.11)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
No Gender Reservation, with incentives	0.51***	0.14***	0.12***	0.13***	0.21***	0.22***	0.21***	-0.04*	0.01	-0.01
	(0.12)	(0.03)	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.02)	(0.04)	(0.03)
Communicator Role Reserved for Females, with incentives	0.44***	0.07**	0.04	0.06**	0.16***	0.14***	0.15***	-0.05**	0.01	-0.01
	(0.11)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)	(0.03)
PF Village Assignment Dummy	-0.21**	0	0.02	0.01	0.04	0.05	0.04	0.10***	0.13***	0.12***
	(0.09)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Endline Dummy					-0.10***	-0.07***	-0.08***	0.27***	0.34***	0.30***
					(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Constant	-0.07	0.11***	0.18***	0.18***	0.10***	-0.02	0.04	0.69***	0.48***	0.59***
	(0.10)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)
N	325	2663	2000	4663	3550	4970	8520	3730	6571	10301
Adjusted R2	0.14	0.02	0.04	0.03	0.07	0.07	0.08	0.17	0.18	0.19
Mean of Control Group	0.13	0.12	0.20	0.15	0.09	0.13	0.11	0.87	0.72	0.77
	(0.34)	(0.33)	(0.40)	(0.36)	(0.29)	(0.33)	(0.32)	(0.34)	(0.45)	(0.42)
Gender Difference (pooled incentives) Coefficient for [female reservation – no reservation]	0.03	-0.10***	-0.12**	-0.11***	-0.11***	-0.13**	-0.12***	-0.02	0.00	-0.01
	(0.14)	(0.05)	(0.07)	(0.05)	(0.05)	(0.07)	(0.06)	(0.04)	(0.07)	(0.06)
Incentive Ttest: Non-incentivized=Incentivized										
p-values, no reservation vlg	0.06	0.01	0.03	0.01	0.00	0.01	0.00	0.34	0.02	0.03
p-values, female reservation vlg	0.65	0.02	0.07	0.01	0.00	0.01	0.00	0.19	0.00	0.01
Gender Ttest: No reservation=Female reservation										
p-values, non-incentivized communicators	0.84	0.30	0.33	0.25	0.08	0.17	0.12	0.66	0.95	0.84
p-values, incentivized communicators	0.28	0.08	0.11	0.06	0.22	0.15	0.15	0.74	0.95	0.96

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the same controls as in Table 4. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 7: Farmers' Interaction with Each Other, by Gender

Midline Only	Talks			Discusses farming			Discusses technology		
	female	male	pooled	female	male	pooled	female	male	pooled
Respondent refers to a:	1	2	3	4	5	6	7	8	9
Female farmer	0.01	-0.01	0.00	0.00	-0.02	-0.02	0.02*	0.01	0.01
	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Male farmer in No Gender Reservation, no incentives vlg	0.03	-0.02	-0.01	0.13***	0.07*	0.09**	0.18***	0.11***	0.13***
	(0.03)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
Male farmer in Communicator Role Reserved for Females, no incentives vlg	-0.02	-0.02	-0.02	0.04	0.05	0.05	0.11***	0.09***	0.09***
	(0.03)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Female farmer in No Gender Reservation, with incentives vlg	0.05	0.00	0.01	0.16***	0.12***	0.13***	0.16***	0.12***	0.13***
	(0.03)	(0.03)	(0.02)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Female farmer in Communicator Role Reserved for Females, with incentives vlg	0.06*	-0.03	-0.01	0.08	0.06*	0.07*	0.10*	0.07**	0.08**
	(0.03)	(0.03)	(0.02)	(0.06)	(0.03)	(0.04)	(0.06)	(0.03)	(0.04)
Respondent is female			-0.03**			-0.02			-0.01
			(0.01)			(0.02)			(0.01)
PF Village Assignment Dummy	-0.01	0.04**	0.03**	-0.05	0.01	-0.01	-0.07**	0.01	0.00
	(0.03)	(0.02)	(0.01)	(0.04)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
Constant	0.72***	0.85***	0.82***	-0.02	0.04	-0.01	-0.04	-0.04	-0.04
	(0.06)	(0.03)	(0.03)	(0.05)	(0.05)	(0.04)	(0.03)	(0.04)	(0.03)
N	4162	13982	18144	4120	13874	17994	4130	13925	18055
Adjusted R2	0.06	0.03	0.04	0.10	0.07	0.08	0.10	0.09	0.09
Mean of Control Group	0.80	0.84	0.84	0.11	0.13	0.13	0.03	0.05	0.04
	(0.40)	(0.37)	(0.37)	(0.31)	(0.34)	(0.33)	(0.16)	(0.22)	(0.20)
By treatment village: interaction w/ other farmer									
female reservation vlg: female farmer = male farmer	0.00	0.19	0.62	0.36	0.59	0.97	0.65	0.64	0.93
no reservation vlg: female farmer = male farmer	0.03	0.68	0.24	0.44	0.14	0.11	0.97	0.12	0.19
By farmer referred to: interaction w/ other farmer									
female farmer: female reservation. vlg = no reservation vlg	0.66	0.19	0.24	0.22	0.07	0.08	0.35	0.09	0.14
male farmer: female reservation vlg = no reservation vlg	0.13	0.71	0.33	0.00	0.48	0.21	0.01	0.34	0.14

Data sources: midline household questionnaire. Sample: All "regular" farmers (excludes actual and shadow communicators) in treatment and control villages. Farmers were asked about their interactions with 6 randomly selected "regular" farmers from their village. Each respondent-random farmer pair form one observation in this dataset; dependent variables refer to interactions of the respondent farmer with the randomly selected farmer.
Notes: Regressions include the same controls as in Table 4. Sample size varies across columns due because "do not know" and "no opinion" responses are coded as “missing”. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 8: Other farmers' perceptions of communicators

	Midline			Endline		
	Index: hardwork + skillful			Index: knowledgeable + good farmer		
	Female	Male	Pooled	Female	Male	Pooled
Village assigned to:	1	2	3	4	5	6
No Gender Reservation, no incentives	0.07***	0.08***	0.08***	0.06***	0.08***	0.07***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Communicator Role Reserved for Females, no incentives	0.02	0.07***	0.06***	0.05***	0.03	0.04***
	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
No Gender Reservation, with incentives	0.10***	0.12***	0.11***	0.07***	0.08***	0.08***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Communicator Role Reserved for Females, with incentives	0.10***	0.11***	0.11***	0.05***	0.05***	0.05***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
PF Village Assignment Dummy	-0.07***	-0.08***	-0.08***	-0.07***	-0.07***	-0.07***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	0.77***	0.72***	0.74***	0.80***	0.78***	0.76***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	909	3052	3961	2396	1832	4228
Adjusted R2	0.09	0.11	(0.10)	0.07	0.08	(0.09)
Mean of Control Group	0.80	0.79	0.79	0.78	0.73	0.76
	(0.18)	(0.18)	(0.18)	(0.14)	(0.16)	(0.15)
Gender Difference (pooled incentives) Coefficient for [female reservation. – no reservation]	-0.05	-0.02	-0.02	-0.02	-0.08***	-0.05***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Incentive Ttest: Non-incentivized=Incentivized						
p-values, no reservation vlg	0.20	0.03	0.03	0.27	0.74	0.57
p-values, female reservation vlg	0.01	0.01	0.00	0.91	0.14	0.39
Gender Ttest: No reservation=Female reservation						
p-values, non-incentivized communicators	0.05	0.51	0.26	0.73	0.00	0.07
p-values, incentivized communicators	0.90	0.73	0.75	0.10	0.08	0.05

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the same controls as in Table 4. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Appendix A: Project Timeline

Field Activities

Activity	Timing	Responsibility
District-level briefings on impact evaluation with regional and district officials	July 2009	Extension, Land Resources, Research, Planning
AEDOs trained on the new technologies	August 2009	Extension, Land Resources, Research, Planning
AEDOs identify and train village Communicators	August – September 2009	AEDOs
Communicators train other farmers and demonstrate the new technologies	Starting September 2009	Communicators, assisted by AEDOs
Incentivized Communicators are briefed on performance-based rewards program	October-November 2009	Research team collaborating with Planning Department
Recipients of first year performance-based reward identified	November-December 2010	Research team
Incentives delivered	Starting January 2011	Planning Department

Data Collection

Baseline: August - October 2009
- Household questionnaire

Agricultural season: November/December 2009 – May/July 2010

Midline: July - October 2010
- Household questionnaire
- Spouse questionnaire
- Communicator questionnaire
- Village focus group questionnaire

Agricultural season: November/December 2010 – May/July 2011

Endline: July - October 2011
- Household questionnaire
- Spouse questionnaire
- Communicator questionnaire
- Village focus group questionnaire

Appendix B: Compliance to gender assignment of communicators (Source: midline communicator survey)

Table B1: Gender compliance by communicator type

Communicator type	Gender Assignment	Proportion of communicators that are female	Proportion of villages with >=50% female communicators	Number of communicators
Lead Farmer	Non-reserved	0.00	0.00	22
	Female	0.61	0.61	23
Peer Farmer	Non-reserved	0.31	0.18	101
	Female	0.48	0.55	88
Shadow communicators in control villages		0.23	0.17	236
				470

Table B2: Gender compliance across communicator and incentive arms

Communicator type	Gender Assignment	Proportion of communicators that are female	Proportion of villages with >=50% female communicators	Number of communicators
Lead Farmer	Non-reserved, with incentives	0.00	0.00	11
	Female, with incentives	0.55	0.55	11
	Non-reserved, no incentives	0.00	0.00	11
	Female, no incentives	0.67	0.67	12
Peer Farmer	Non-reserved, with incentives	0.30	0.18	53
	Female, with incentives	0.49	0.45	46
	Non-reserved, no incentives	0.33	0.18	48
	Female, no incentives	0.46	0.64	42
Shadow communicators in control villages		0.23	0.17	236
				470

Appendix C: Construction of the main variables

Communicators' Effort (Communicator questionnaire, midline and endline)

- *Attended training*: A binary variable that indicates whether a Communicator reports working with an AEDO over the last farming season.
- *# Trainings attended*: A discrete variable that indicates the number of times a Communicator reports working with an AEDO over the last farming season.
- *Communicator led training:* A binary variable that indicates whether a Communicator led any training involving other farmers in his village during the 12 months prior to the interview.

Knowledge and Adoption (Communicators and Other Farmers)

- *Knowledge*: A [0;1] continuous variable that measures a respondent's understanding of the technology. The score is the fraction of correct answers a respondent provides to seven technology-specific questions for pit planting, and six for Changu composting. The percentage of correct answers is the knowledge score.
- *Adoption*: A binary variable that indicates whether a respondent adopted the promoted technology (pit planting or Changu composting) in the last farming season.

Other farmer Interactions with Communicator (Other farmers ML and EL; both main and additional respondent)

- *Discussed Technology*: A binary variable indicating whether farmers report having discussed the technology (pit planting or Changu composing) with the communicator during the 12 months prior to the interview.
- *Participated in trainings*: A binary variable indicating whether the farmer participated in a group training held by the communicator during the past 12 (asked at endline only).
- *Talked to communicator*: A binary variable indicating whether a farmer talked to their assigned communicator about anything over the past 12 months.

Other Farmers' Perception of Communicators (household & spouse/additional respondent questionnaire, Social Network module)

- *Midline perception index (hardworking + skillful):* An index constructed from two categorical variables indicating the respondent's perception of the communicator.

- Perception of how hardworking the communicator is, scaled from 0 to 1 into 4 levels, where 0 is "not hardworking" and 1 is "very hardworking"
- Perception of how skillful the communicator is, scaled from 0 to 1 into 4 levels, where 0 is "not skillful" and 1 is "very skillful".

- *Endline perception index (knowledgeable + good farmer):* An index constructed from two categorical variables indicating the respondent's perception of the communicator.
  - Perception of how knowledgeable the communicator is, compared to the respondent. It is scaled from 0 to 1 into 5 levels; 0 is "communicator is much less knowledgeable than me" and 1 is "communicator is much more knowledgeable than me"
  - Perception of how good the communicator is at farming, compared to the respondent. It is scaled from 0 to 1 into 5 levels; 0 is "communicator is a much worse farmer than me" and 1 is "communicator is a much better farmer than me."

<u>Other farmers' Interaction with Each Other (Midline Social Network Module)</u>

- *Discussed farming*: A binary variable that indicates whether the respondent reports discussing farming with another randomly drawn farmer from the community during the 12 months prior to the interview.
- *Discussed Technology*: A binary variable indicating whether farmers report having discussed the technology (pit planting or Changu composing) with another randomly drawn farmer from the community during the 12 months prior to the interview.

Knowledge Exam

Knowledge Question	Correct answer	Accepted answers
Pit Planting		
How far apart should the planting pits be?	70 cms	52.5 – 87.5
How deep should planting pits be?	20 cms	15 – 25
How wide should planting pits be?	30 cms	22.5 – 37.5
How long should planting pits be?	30 cms	22.5 – 37.5
How many maize seeds should be planted in each pit?	4	4
Should manure be applied?	YES	YES
How much manure should be applied?	2 double handfuls	2 double handfuls
After harvest what should be done with the stovers?	Maize plants cut off at base, leave roots to decompose in pit, stems and leaves used to cover the soil.	Correct multiple choice option selected.
Changu Composting		
What materials should be used for Changu composting?	Leguminous crop residues (most commonly soybeans and groundnuts), fresh leaves of leguminous trees, maize stoves, chicken or livestock manure	At least 1 correct material listed
How much time should Changu compost be let mature?	60 days	6 weeks – 2 months
How should Changu compost be kept while it is maturing?	In a covered heap	In a covered heap
Should it be kept in the sun or the shade?	Shade	Shade
Should it be kept moist or dry?	Moist	Moist
When should Changu compost be applied to the field?	At least 2 weeks before planting	At least 2 weeks before planting

Appendix D: AEDO Training Program – Conservation Farming

***Training Schedule* -- Monday, 10th August to Friday, 14th August 2009**

Day	Time	Topic	Facilitators
Monday		Arrival of participants	
Tuesday	Morning	Introductory Activities: welcome remarks, norms, introductions	DAPS
		Overview of ADP, ADP-SP, and ADP-SP Impact evaluation	DAPS
	Afternoon	Guidelines for Conservation Farming	DLRC
Wednesday	Morning	Field visit to Conservation Farming site	DLRC
	Afternoon	Discussion of observations from Conservation Farming site	DLRC
Thursday	Morning	Concept of Lead Farmer	DAES
		Concept of Peer Farmer	DAES
		Distinction between Lead Farmer and Peer Farmer	DAES
		Selection of Peer and Lead Farmers	DAES
		Random assignment of gender to Peer and Lead Farmers	DAES
		Monitoring strategy: outcomes of interest and Monitoring instruments	DAPS
	Afternoon	Review of the topics covered and feed back	DAPS
Friday		Departure	

Appendix E: Technical Guidelines for Pit Planting

Pit planting is a conservation farming technology that increases a soil's capacity for storing water while at the same time allowing for minimum soil disturbance. This is because when planting pits are excavated in a field, they may be used for at least two seasons before farmers have to reshape the pits. Planting pits enable farmers to use small quantities of water and manure very efficiently, and are cost and time efficient (although labor to construct the pits can be a constraint). Pits are ideal in areas where rainfall is limited.

The following are the guidelines for pit planting that the project will employ. These guidelines were developed by the MoAFS Department of Land Resources Conservation Conservation.

Step 1: Site Selection

Identify a plot with relatively moderate slopes. If possible the site should be secure from livestock to protect the crop residues.

Step 2: Land Preparation

Mark out the pit position using a rope, and excavate the pits following the recommended dimensions (as shown in the table below). These should be dug along the contour. The soil should be placed on the down slope side. Stones may be placed on the upslope side of the pit to help control run off, but this is optional. If available, crop residues from the previous harvest should be retained in the field so there is maximum ground cover.

Pit dimension and spacing:

Spacing between pits	70cm
Spacing between rows	90cm
Depth	20cm
Length	30cm
Width	30cm

At this spacing, there will be 15,850 pits per hectare (158 pits per 0.1ha). Where rainfall is limited, pits can be made deeper and wider to make maximum use of rainwater.

Step 3: Planting, Manure and Fertilizer Application

The pit can be planted to maize crop at the spacing below:

Crop	Seeds/pit	Plants/ha
Maize	4	63,492

It is recommended that farmers apply 2 handfuls of manure in each pit. Two weeks before rainfall, apply manure and cover the pit with earth. If basal fertilizer is available, it can also be applied at the same time. When manure has been applied, the pits should be covered with soil. A shallow depression should still remain on top. If top dressing is available, it should be applied when the maize is knee high. In some areas, it may be after 21 days.

Step 4: Weed Control and Pest Management

The pits must be kept free of weeds at all times. Weed as soon as the weeds appear and just before harvesting. This will reduce the amount of weeds in the following season. Use of herbicides to control weeds is optional.

Step 5: Harvesting

Remove the crop. Cut plants at base, leaving stems and leaves on the soil. The roots should not be uprooted; they should be left to decompose within the pit.

Increasing the Efficiency of the Pits

It is important to realize that the use of these pits alone will not produce the highest yields. For best results:

- Always incorporate crop residues, leaving a minimum of 30% of crop residue on the field.
- Apply manure generously.
- Protect crops from weeds, pests, and diseases.
- Always plant with the first productive rains.
- Grow crops in rotation; at least 30% of the cropped land should be planted to legumes.
- Using a cover crop / ground cover in conjunction with pits will give best results

Monitoring and Evaluation Indicators

The following indicators will be used to monitor adoption of pit planting:

1. Number of seeds planted per pit
2. Proper spacing of the pits (measured by the number of pits / size of the plot)
3. Quantity of fertilizer applied
4. Use of crop residues
5. Use of a ground cover / cover crop

Training Plan for Pit Planting

1.0 Objectives

By the end of the session, participants should be able to:

- Understand the concept of conservation agriculture
- Distinguish between conservation agriculture and conservation farming
- Understand the options available in conservation agriculture
- Understand the technical recommendations for pit planting

- Demonstrate pit planting

2.0 Steps and Sequence

- Prepare a climate setter
- Outline the objectives on a flip chart
- Outline the concept of conservation agriculture on a flip chart
- Explain the differences between conservation agriculture and conservation farming on a flip chart
- Outline the options in conservation agriculture on a flip chart
- List advantages of conservation farming on a flip chart
- Prepare demonstration set up on pit planting

3.0 Procedure

- Start by setting the climate
- Outline the objectives
- Present the content
  - Brainstorm on the concept of conservation agriculture
  - Explain the concept of conservation agriculture
  - Brainstorm on differences between conservation agriculture and conservation farming
  - Explain differences between conservation agriculture and conservation farming
  - Explain options in conservation agriculture
  - Explain advantages of conservation farming
- Make a summary of session presentation
- Teach technical guidelines for pit planting
- Demonstrate on pit planting

4.0 Methodology

- Lecturette
- Demonstration

5.0 List of Training Materials

- Chalk board/Flip chart
- Chalk / Pental pen
- Previously made compost manure
- Equipment and tools
  - Stone for hammering
  - Pegs
  - Hoes
  - Measuring stick
  - Measuring string
  - Pail/bucket

Appendix F: Technical Guidelines for Nutrient Management

The following are the guidelines to the nutrient management strategy the project will employ. These guidelines were developed by the MoAFS Department of Agricultural Research.

Step 1: Materials for compost

The following materials are appropriate for making compost: leguminous crop residues (Groundnuts and Soyabean), fresh leaves of leguminous trees, chopped maize stover (about 6 inches long), animal or chicken manure (optional)

Step 2: Preparation of compost

Mix three parts of leguminous biomass (crop residues and/or fresh leaves) to two parts maize stover.

Put a layer of legume crop residue followed by a layer of stover then a layer of green leaves of legume tree repeat making the layers until the heap is 120 cm high. After constructing a set of three layers add 5 liters of water to moisten the materials.

After constructing the heap smear the wet earth around the heap covering the biomass. The materials should be kept moist throughout the composting period. After 60 days the manure is ready, remove the manure and keep them under shade.

Step 3: Application method

Apply the manure at least two weeks before planting. Apply 3 kg of manure applied per 10 m ridge. Split open the ridge about 4 cm deep, spread the manure on the open ridge then bury the manure thus reconstituting the ridge.

Step 4: Planting

At the rain onset plant maize, one maize seed per planting hole on the ridge at a distance of 25 cm between planting holes.

Step 5: Use of Inorganic Fertilizer (optional, depends on availability)

Use 23:21:0+4S for basal dressing. Apply fertilizer as dollop; make a hole about 3 cm deep between the maize planting hills.

- Apply 23 kg N/ha of 23:21:0+4S at a rate 2.5g per hole (cups to be calibrated to measure 2.5 g fertilizer).
- Apply 37 kg N/ha of Urea at a rate of 2g per hole (cups to be calibrated to measure 2g fertilizer)

Apply the inorganic fertilizer one (1) week after maize germination. Note that cups must be carefully calibrated; using a bottle cap will result in fertilizer overdose.

Monitoring and Evaluation Indicators:

The following indicators will be used to determine farmer's adoption of NM technology:

- Compost materials used (should exclude grass)

- Time and method of manure application
- Quantity of inorganic fertilizer applied
- Number of compost heaps per farmer (should increase in the second season)
- Expansion of area of land planted using the intervention (land area should increase in the second season)

HANDOUT: MAKING CHANGU COMPOST OR *CHANGU*

This is the type of compost where the organic materials decompose relatively fast hence the name "Changu."

Making of this type of manure undergoes several steps which are outlined as follows:

- Site selection

The best site for the Changu compost is

  - Near the garden where the compost is to applied, to minimize labour and time in transportation, preferably on the edge of the garden to avoid disrupting cultivation operations in the garden.
  - This should be under shade, on a fairly flat ground.
  - Near the source of materials and water
  - Away from dwelling houses with chickens and goats

- Materials required
  Composting materials
  - Grass
  - Crop residues
  - Maize stover
  - Leaves of various plants

- Booster (Khola manure, previously made compost manure, green fresh matter, leguminous leaves, top soil)
- Water
- Equipment and tools
  - Bricks
  - Stone/logs
  - Poles
  - Hoes
  - Measuring stick
  - Pail/bucket

Procedure for Construction

The process for construction of Changu compost heap is as follows:

- Clear the surface of the ground in at least 2m diameter for easy marking
- Measure a 1.5m to 2m diameter circle by using a peg and a string
- Heap 20 – 30 cm thick layer of composting material over the area marked, which will form as the base of the compost heap
- Water the heap adequately until it just oozes out when materials are squeezed to induce decomposition.
- Add a booster (Khola manure, previously made compost manure, green fresh matter, leguminous leaves, top soil) on top to a height of 3 – 5 cm thick
- Water the booster layer adequately
- Repeat the above process with the diameter of each subsequent layer reducing until the heap is 1.5m high, thereby achieving a conical shape
- Cover the heap with grass to reduce evaporation

Procedure for turning

After two to three days the heap will have formed three distinctive layers.

- Insert a stick into the compost heap to check if decomposition has started
- If the stick is warm, it shows that there is microbial activity and decomposition has started.
- Where decomposition has started turn the heap after 3 to 4 days and there after every 4 to 5 days to speed up decomposition.
- During the turning process remove the outer layer (A) from the heap and separate the middle layer (B) from the inner layer (C).
- In the process of rebuilding the heap
    - Put layer A at the bottom
    - Water adequately
    - Put layer C in the middle
    - Water adequately
    - Lastly, put layer B on top/outside the heap.
    - Water and cover the heap with grass

The process of noted undecomposing heap

This is determined if the stick inserted into the heap is not felt to be warm.

This could be solved by dismantling the heap and remaking the compost, using a different booster, adding more water if the material looks dry.

Duration of composting for this method

The heap will mature after 30 to 40 days depending on the nature of composting material used.