Mobile Apps to Deliver Extension to Remote Areas: Preliminary Results from Mnt Elgon Area

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Abstract

Rapidly increasing mobile phone coverage provides innovative ways to reach farmers in isolated, hard to reach places. We study how smart-phones are used to provide extension services in the mount Elgon Area in Uganda. Community Knowledge Workers can consult a mobile app on the smart-phone to answer any question related to farming. We find that the introduction of a Community Knowledge Worker within the area led to a significant increase in the price farmers receive for maize. We also find effects on farmer's knowledge, their attitudes toward information and extension and farming practices. We also find that there is no additional effect of repeated interactions between a farmer and a CKW.

Introduction

A few years ago, the Grameen Foundation initiated an innovative project to deliver extension and marketing information to smallholder farmers in rural villages in Uganda. They equipped locally recruited individuals (called

Community Knowledge Workers (CKWs)) with an Android smart-phone, pre-loaded with a specific mobile application called “CKW search”. CKWs can use this in-house developed app to search for up to date and location specific information related to farming and product marketing. The idea is to build a self-sustaining, scalable network of rural information providers who use smart-phones to help close critical information gaps facing poor, smallholder farmers. They will strengthen the information link to poor farmers by disseminating and collecting relevant information in these under-served communities.

The use of information and communication technology (ICT) in development has attracted considerable attention in development policy and research circles. There are different reasons as to why expectations are high. ICT, and cell phone based technology more in particular, is growing extremely fast in developing countries. While mobile phones have a social function in developed countries, large transaction costs give mobile communications comparative edge in developing countries. Mobile phone operators are also developing new products and services (such as money transfer services) at breathtaking speed, stimulated by the fierce competition that often exists in these markets. The technology is also well adapted to situations where power supply is erratic. Increasingly, both private and public initiatives start to use this infrastructure to provide extension services and disseminate information to those who can benefit from it.

While there is building agreement that ICT changes the general equilibrium conditions through the reduction of transaction costs [Aker, 2010, Jensen, 2007], it seems to be much more difficult to pin down the gains for smallholders. Recently, four studies have tried to assess the impact of similar projects [Fafchamps and Minten, 2012, Camacho and Conover, 2011, Cole and Hunt, 2010, Mitra et al., 2012]. None of these studies find a significant change gains or in behaviour caused by the intervention. This is surprising, given the vast amount of anecdotal evidence and the predictions of economic theory. In addition, farmers themselves repeatedly point to the lack of information as a constraint to increased market participation.

The above may mean there simply is no information deficiency amongst smallholder farmers[1]. Alternatively, it may be that farmers can not act upon this information due to various market failures. This impact assessment will therefore also try to see if the CKW model, which differs from the models

[1] Still, this leaves the farmers’ self assessed hunger for information unexplained.

used in the other studies in several ways[2], has a detectable impact, not only on the final outcome, but also on a range of intermediate outcomes. Such an approach is more likely to identify key assumptions underlying the model and can suggest complementary interventions, services of products.

This paper looks at the causal impact of the CKW model in terms of knowledge, attitudes, practices and outcomes using a difference-in-difference methodology. We will build the evaluation on a subset of farmers on which we have baseline data on a range of interesting intermediate and final outcome variables. These same farmers will be interviewed again to look at changes brought about by the CKW intervention. This change over time will be contrasted to the change over time for a control group. The baseline data for this control group will be reconstructed on the basis of an econometric model and a set of household and community characteristics.

We find a significant positive impact of the project over a range of outcome variables. There is a significant increase in knowledge associated with CKW intervention. CKWs are used for market price information at the expense of SMS services, while NAADS also seems to benefit from the project. CKWs cause a shift on crops grown to more market oriented produce. The evidence also suggests farmers bring the information of CKW into practice. The CKW project also leads to higher maize farm-gate prices for farmers and more access to extension services. We do not find an effect on maize productivity. Interestingly, we find that there is no extra effect of the number of interactions between a particular farmer and a CKW. It appears that access to a CKW is sufficient to generate the effect.

The article is organised as follows. The next section sketches the CKW model and details how it differs from similar interventions. After that, we define research questions that will allow us to identify also changes in knowledge, attitudes and practices. We then present the difference in difference method, followed by a description of the sources of data. We then present the results of the analysis. We conclude with some suggestions on how the study can be improved upon.

[2] These dimensions include trust issues, appropriateness of information and motivational issues.

The CKW model

The CKW project was designed to improve the lives of smallholder farmers by improving access to information and extension services. Villagers are asked to choose an individual from amongst them they deem suitable to take up the role of a CKW. This person is then screened by Grameen, provided with and Android smart-phone and trained on how to use it. This smart-phone is preloaded with three custom mobile applications: CKW Search, CKW Survey and CKW Pulse[3]. In this study, we will only be concerned with the CKW Search app. This app allows CKWs to submit questions from farmers about farming and crop marketing. These questions range from local weather info over market prices to crop and livestock management.

The CKW model differs from other interventions that use ICT as a mode of information transmission in several ways[4]. First, it aims to provide farmers with a comprehensive data package. For instance, while some initiatives may deliver price data to farmers, it may not be possible for farmers to act upon that information because they lack access to transport. The CKW app therefor also has a directory of traders in different regions. Behind this is the idea of network effects: a phone becomes more useful as other phones become available to you (either through more people buying phones or equivalently through making phone numbers known).

Another characteristic feature is the fact that the information is delivered to a person that is and has been living in the community for many years. He/she knows the local context and is able to contextualize the information obtained through the phone. It is expected that this results into a less technical approach to extension provision. The CKWs are assumed to employ a more holistic approach to agricultural extension, factoring in things such as for instance the client's ability to deal with risk. Again, the idea is to increase chances that farmers act upon information. They will not only provide information but encourage farmers to do something with it.

Then there is also the two way nature of the information flow. The information exchange between farmers, CKWs and the headquarters means

[3]The apps can be downloaded from the google play market for free on Android 2.3 (Gingerbread) devices. CKW Survey is used for simple data collection by CKWs in the field. CKW Pulse is an app that allows CKWs to communicate with the headquarters.

[4]When we think of other similar interventions, we may be disproportionately referring to SMS base price dissemination services. This is because they are the most widely used mode of information delivery in Uganda, and probably the rest of the developing world.

that information from the field can be incorporated in the information base. One example is traditional farming knowledge, that is often preferred by farmers because the costs are lower than modern methods that require inputs that are often hard to find. There is also a pilot project that gather market information at a sub-regional level, as it is found that these prices are often more relevant to farmers. Eventually, the two way information exchange should enable producers and consumers to find each other directly “on line”, substantially reducing transaction costs.

The setup is also ideal for last mile extension. The setup, relying on information exchange through mobile phones and resident CKWs is able to reach many farmers for a relatively low cost. The cost stays constant even in the most remote locations. This is different from extension officers that are based in towns and are required to regularly visit communities. The value of information is likely to increase with remoteness.

More of a technical nature is the fact that smart-phones use mobile package data (through 2G or 3G), which means that information is sent and received instantly. This is different from most existing initiatives that rely on SMS. The use of SMS is itself attractive for several reasons: it works on almost any mobile phone and it is easy to charge for services (eg. X UGX per message). But one of the major problem faced by SMS based models, at least here in Uganda, is the fact that often messages are not delivered instantaneously by mobile phone operators. Clients then complain that they needed the information at the time of the request. By the time the network operator released the reply messages, the information as of little use to the farmer. It has also been noted that smart-phones are able to show pictures.

Research Questions

The research will limit itself to assessing the impact of the information dissemination aspect of the project (i.e. the CKW Search app). Even if we limit ourselves to this aspect, the services given are still a bundle of different services (price information, crop management, animal husbandry, directories,...) with potentially different outcomes on different outcome variables. Since the bundling of information and contextualization by an intermediate is assumed to improve upon existing modes of ICT4D models, we will treat the treatment as the whole package. In other words, we consider as treatment the presence of a CKW in the area.

Various recent studies have looked for a direct relationship between projects that are (at least in part) similar to the CKW model [Fafchamps and Minten, 2012, Camacho and Conover, 2011, Cole and Hunt, 2010, Mitra et al., 2012]. Most of these studies find no or only weak effects of information dissemination on directly measurable outcomes such as the price received for products, area under cultivation, etc. In our study, we will also consider the effect of CKWs on final outcomes. However, we also want to learn through which channels these observed changes (if any) come about. Hence, we will also look at a range of possible intermediate outcomes, concentrating in particular on outcome variables that are likely to put a farmer in an advantageous position to increase final outcomes.

A first intermediary outcome is knowledge. Obviously, extension services are all about providing information to farmers on farming methods, crop diseases, animal husbandry, etc. As such, one of the first measures of success of the CKW model is a causal increase in farmer knowledge related to farming. But CKWs also provide market information. As such, we also expect that a CKW has an increased price knowledge.

A second topic we will explore is whether a farmer's attitude changes due to the presence of a CKW. In particular, we will see if the intervention led to a change in which sources farmers rely on for information. We do this again separately for market information and general extension information. We expect that in both cases, the intervention causes CKWs to become a significant source of information. These questions will also allow us to look at the effect of the intervention on other sources of market and extension information.

Next, we will look at induced changes in practices. We first look at the effect of the intervention on the crops farmed by the average farmer. We expect that CKWs will motivate farmers to grow higher yielding crops, both in terms of nutrient content and monetary value. Second, we also looked at a few simple practices that are advocated by CKWs. We expect that the intervention leads to a significant increase in farmers adopting these practices.

Finally, we will also look at a few key outcomes. The intervention was designed to improve access to market information and extension services. We therefore check if the intervention resulted in proportionally more farmers stating they have access to extension services. In addition, we expect that a farmer that is equipped with better price information has a much better bargaining position when he or she sells crops to a trader. We therefore expect to find a significant positive impact of the CKW project on the average farm-gate price received. Finally, the agricultural extension is likely to lead to higher yields per acre. We thus also measure the effect of the project on the average productivity of the farmers in our sample.

Research Method - Double Difference (DD) and Fixed Effects (FE)

The impact of a development intervention such as Grameen Foundation's CKW project (in a generic impact assessment analysis in development studies often referred to as *treatment* these days) can be calculated as the difference in the average outcome between a *treatment* that received the intervention and a *control group* that was not exposed to the intervention [Ravallion, 2009]. But in most development interventions, simply comparing outcomes between *treated* and *untreated* groups of farmers will not tell us the true effect, since each of these two groups will be more or less likely to be included in one of these two groups. For example, it may be that Grameen Foundation tries to optimize the expected benefits of the CKW project by searching for locations that are particularly isolated from the rest of the world. In this case, the treated group is likely to be disadvantaged as measured on the outcome variable *to begin with.* The fact that a particular project will "attract" particular groups is what is known as selection bias[5].

There are different research designs that aim to eliminate, or at least reduce, this selection bias. The most convincing is randomization, where exposure to the treatment is randomized. The regression discontinuity design is the quasi experimental research design closet to a real experiment. Difference in difference designs, which we will use here, are considered to be somewhere between regression discontinuity designs and statistical matching techniques [Card and Krueger, 2000].

For this study, we will start from the simplest difference in difference specification we can imagine. In this case, the treatment is assumed to be "the presence of a CKW", and the outcome variable is some objectively measurable

[5] Unless admission to the treatments was randomized. Randomization eliminates selection bias. However, in development projects, randomization may be constrained by the mission of the implementing organization to serve certain subgroups of the population, which is often defined on the basis of a continuous variable (eg. "the poorest of the poor"). Randomizing a treatment among "the poor" clearly conflicts with "serving the poorest first".

indicator derived from the program theory model and the research questions.

The aim is then to decompose the outcome variable into average outcomes within groups by treatment and over time (and especially, the interaction):

$$y_{ist} = \gamma.D_s + \tau.D_t + \theta.D_sD_t + \varepsilon_{ist} \tag{1}$$

In this equation, i denotes individual farmers, s is a treatment status index and t is a time index. y is the outcome variable defined for each of the research question formulated above. D_s is an indicator variable taking the value of 1 if the farmer resides in an area served by a CKW and zero otherwise. D_t is an indicator variable that takes a value of 0 in the baseline and 1 otherwise. The effect we are particularly interested in is θ, which gives the causal effect of "the presence of a CKW" to the outcome variable y.

We will contrast this equation to a disaggregated versions specified as follows:

$$y_{ist} = \gamma.D_s + \tau.D_t + \theta.D_sD_t + \varphi.D_sD_t.V_{ist} + \varepsilon_{ist} \tag{2}$$

Finally, $V_{ist}$is the number of interactions between individual i and the CKW[6]. Equation 2 allows us to test question if there is an additional effect of interacting with a CKW. if θ becomes insignificant, this means that services from the CKW should be considered private. If, on the other hand, φ turns out to be insignificant, and the θ is equal to the one from the previous regression (which can be tested using a standard F-test), this indicates that information provided by the CKW is shared within the community. Obviously, we expect reality will lie somewhere in between these two extreme scenarios.

When we think about the intervention as actual contacts between the CKW and the farmer, the omitted variable bias may be situated at the individual level. Put differently, when the intervention is interpreted as the frequency at which a particular farmer solicits information from the CKW, the sample selection bias may be situated at the individual level, instead of at the treatment/non treatment group level as assumed above. For example, a farmer that requests lots of information from a CKW may typically be one that is commercially oriented, or has higher education, or comes from a family

[6]It may be that a household resides in a parish that has a CKW allocated to it, but has never been registered by a CKW. In this case $D_sD_t = 1$ and $V_{ist} = 0$. V can be modelled as a continuous variable, or as a categorical variable. In the latter case, this would result in another set of shifters.

of traders, etc. These are all individual specific time invariant characteristics that can be eliminated using a fixed effects panel data regression. To sum up, a fixed effects regression controls for the fact that some of the farmers that use the CKW more than others are having outcome variables that are higher (lower) in the first place. Not doing so would overestimate (underestimate) the effect of the project.

In other words, it may be that certain individuals are more likely to contact the CKW because of individual specific time invariant unobserved characteristics (eg. a particular farmer likes the stay current on market prices, because his deceased father taught him the importance of this information when bargaining). To control for this, we can include fixed effects for the individuals in our sample.

$$y_{ist} = \alpha.D_i + \tau.D_t + \theta.D_s D_t + \varphi.D_s D_t.V_{ist} + \varepsilon_{ist} \tag{3}$$

Again, if φ turns out to be insignificant, this means the benefits of a CKW is shared within the community.

Data Requirements and Collection

A difference-in-difference approach mandates a baseline and end-line survey on both the project group and a control group. As is often the case, there was no dedicated baseline survey carried out at the start of the project, either for the treatment or the control group. Therefore, we will need to reconstruct a baseline survey for both treatment and control group. Our preference will be to use secondary data as the baseline for the treated population, but this means we still need to decide upon a suitable control group and reconstruct the baseline for this control group. Finally, an end-line survey needs to be conducted in both the treatment and control group.

The most obvious way to reconstruct a baseline for both the treatment and the control group would be to use recall. Recall data has its problems. While recall estimates are frequently biased, the direction, and sometimes the magnitude, of the bias are often predictable [Bamberger et al., 2004]. The two most common sources of recall bias are the underestimation of small and routine expenditures and telescoping of recall concerning major expenditures. In general, it has been found that recall produces a systematic under-reporting. There are various techniques that can be used to reduce potential bias in recall methods [Schwarz and Oyserman, 2001].

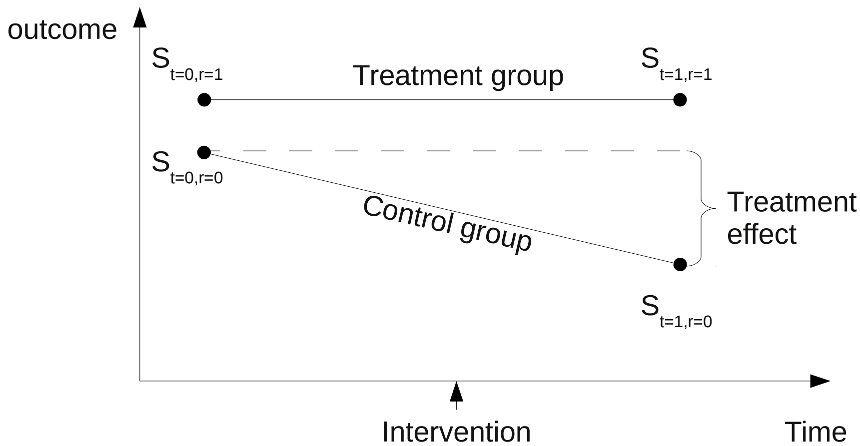

Figure 1: The difference in difference model

In a difference in difference setting, recall bias may be less of a concern. If we can assume that the bias will be independent of treatment status, the bias will have no impact on the difference in difference results. A farmer that did not benefit from a CKW will be equally likely to be more pessimistic or optimistic about the past then a farmer that did benefit. A first way to reconstruct our baseline for both the treatment and control group is therefor to ask about the situation before the intervention.

Another way to reconstruct the baseline is to rely on previously collected secondary data. By far the most useful prior information we have at our disposal comes from a baseline survey carried out in 5 districts at the start of the project by the World Food Program (WFP baseline survey). This survey was done as a baseline for a WFP project involving post harvest practices. As such, the survey asks a range of questions on various topics relevant to the CKW project, like marketing methods, crop portfolios, knowledge and practices, etc. All individuals interviewed during this baseline were registered by a CKW, and from that moment onward, the CKW started to be active in the parish. So instead of relying on recall for the treated group, we can use this survey as the basis of our end-line survey, asking most of these questions again to the same people (or a random sample thereof) as an end-line survey.

So for the treated population, we have two sources of data that we will combine. A subset of questions in the end-line survey will be the same as a subset of questions that were asked in the baseline WFP survey. This will allow us to calculate within differences based on objective baseline data that is unaffected by factors such as those that make recall problematic. We will also include new questions (that do not feature in the WFP baseline) in the end-line which will only have a recall counterpart in the baseline. This will allow us to investigate a larger set of outcomes than those included in the WFP baseline. But we will also ask the questions that are in the WFP baseline as recall questions, as this will allow us to check if there is recall bias in the treated population.

Even though we have identified a suitable baseline for the CKW project, we are still faced with the problem of a complete absence of a control group. As such, for the end-line survey, a control group will need to be identified and interviewed. Similarly for the baseline, a control group will need to be identified and the baseline for this group will have to be reconstructed. There are again two ways in which the baseline of a control group can be reconstructed. One is simply interviewing a control group and using recall data. The second way would be to use a model to predict the outcomes for the control group before the intervention using a statistical model. More in particular, we can regress each outcome variable on a set of household and community characteristics using the baseline survey data of the treated population. We can then use this model to predict these outcome variables on the basis of household and community characteristics of a control group. The household and community characteristics will be sampled from the 2009/10 Uganda National Household Survey (UNHS).

One of the attractive features of a difference-in-difference study is that it not necessitates panel data [Meyer, 1995]. Since one assumes the omitted variable bias is at the aggregated level (the treated group versus the non-treated group) one can simply compare the aggregates (eg. the means or medians of the two groups). This can be done with repeated cross-sections, as long as the before and after control groups are comparable. We propose to construct a control group from using the sampling frame from the 2009/10 UNHS. This control group will then be administered the questionnaire. This will give us the actual end-line outcome variables for the control group and recall values for the control group before the intervention. In addition, similar to what we did for the control group in the baseline, we can predict the outcomes for the control group using the characteristics collected in the end-line control group survey. We can then compare the actual outcomes of this group to the predictions and get a sense of the prediction error. This can then be used to adjust the baseline control predictions before calculation of the difference in difference.

The decision to use repeated cross-section in the control group obviously reduces on tracking costs. In addition, it eliminates the problem of panel attrition. On the other hand, it prevents us from controlling for individual specific time invariant (potentially unobservable) effects. This is not such a problem in the control group. In the treatment group, we will also look at treatment intensity, so the treatment becomes heterogeneous at the individual level. Here we need to include individual level fixed effects to eliminate confounding factors at this level[7].

Figure 1 illustrates the process. $S_{t=0,r=1}$ represents the baseline survey at baseline *(t=0)* for the treated group. The main source of data for this will be the WFP baseline, but for some questions that were not in the WFP baseline, we will use recall. $S_{t=0,r=0}$ represents the baseline survey at baseline *(t=0)* for the control group. The main source of data will be the predicted outcomes based on explanatory variables taken from the UNHS 2009/10. In most cases, we will also present the results for a baseline reconstructed on the basis of recall. $S_{t=1,r=1}$ represents the end-line survey for the treated group. The data for this will be gathered by re-interviewing (a random sample of) the same farmers that are in the baseline. Finally $S_{t=1,r=0}$ represents the baseline survey at end-line *(t=1)* for the control group. This data will also be gathered using a survey.

The WFP baseline was done in the 2009/2010 agricultural season. We will restrict ourselves to one of the 5 districts where the survey was done, namely Kapchorwa in the East of Uganda. Kapchorwa is on the slopes of Mount Elgon, bordering Kenya, but also covers the extensive Kapchorwa plains. The area is poorly accessible, especially during rains, when bridges in the mountains frequently wash away and the plains become flooded. As a control area, we selected Sironko, a neighbouring district that shares the same geology as Kapchorwa.

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[7] For a discussion on the relationship between difference and difference and fixed effects, see Angrist and Pischke [2009]

Results

This section presents the results of the difference in difference analysis. We will structure this section by looking at indicators for a farmer's knowledge, his attitudes toward sources of information and practices. We will also look at outcomes such as access to extension, price received during bargaining and productivity.

Changes in knowledge

As a first test to see if CKWs increased knowledge of farmers, we use self reported knowledge of prices in the market. More in particular, we ask if the farmer has in general a good idea about the prices of his produce in other markets. This question was also asked in the baseline survey done in the treatment population. The proportion of farmers that answered they had good knowledge about the prices in the treated group before treatment was 39 % (see the difference in difference matrix in table 1) out of a group of 444 farmers. We present the results for two different control groups, depending on how we reconstructed the baseline. When we predict if farmers would know the price given their characteristics, we find only 7.7 percent of our control group (of 117 farmers) knows the price, suggesting a large difference between treatment and control group before the intervention. If we use recall in the control group as the baseline, the proportion goes up to 23.4 percent (of 158 farmers), but this is still about 15 percentage points lower than the pre-treatment proportion in the treated population.

If we calculate the proportion of farmers who report to have a good notion of prices in 2011/12, that is after the introduction of CKWs, we see a general increase. In the parishes where no CKW was introduced, the proportion that reports to have price knowledge increased to about 31 percent (out of a sample of 158 farmers). In contrast, 81 percent of farmers that were served by CKWs report to know prices (out of 173 farmers). This represents an increase over time of 42 percentage points. This increase is much higher then the increase registered in the control group, irrespective of how the baseline has been reconstructed. The difference in this difference is 20 % if we rely on the predicted baseline for the control group and 35 % if we rely on recall. As a robustness test, we also run propensity score matching and found an impact of 45 percent. Taken together, the results suggest that the CKWs have a positive and large impact on price knowledge.

	2009/10		2011/12	within effect		
	pred	recall		pred	recall	PSM
parishes with CKW	0.390	0.390	0.815	0.425	0.425	
parishes without CKW	0.077	0.234	0.310	0.233	0.076	
between effect	0.313	0.155	0.505	0.192*	0.349**	0.451**

Table 1: The effect of CKWs on price knowledge

As a more objective measure than self reported knowledge, we also included a series of questions to test knowledge[8]. We asked 6 different questions that varied in difficulty and subject (The subjects were general crop management, pests and diseases, and animal husbandry. The answers to these questions could be found in the information to which CKWs have access through their phones). If the farmer was able to answer the question correctly, he/she got one point (zero otherwise). We simply divided the sum of point by six to get a sense of the general knowledge level. One problem we have is that these questions were not asked during the baseline. We therefore can not but rely on recall for both treatment and control group.

Table 2 presents the results for the final score on the average of the six questions. Before the introduction of CKWs, farmers scored about 36 percent (or about two correct answers). There is very little difference between the group of farmers that will eventually get access to a CKW and those that will never benefit from the intervention. In 2011/12 we see that knowledge has increased in both groups. In the control group, farmers score on average about 10 percent higher. In the treatment group, the increase is again much larger. In this group, farmers are now able to correctly answer more than four out of the six questions. The effect over and above the general increase in knowledge is estimated to be 17.3 percent, which is attributed to the CKWs presence. Propensity score matching confirms this effect.

Changes in attitudes

We start by investigating on what sources farmers rely to get information with respect to market prices. Figure 2 shows the estimated difference in difference effects for the proportion of farmers responding to rely on each of

[8] Cole and Hunt [2010] also investigate if an intervention on futures prices in India changed knowledge. They also do this on the basis of self reported knowledge and a series of questions.

	2009/10	2011/12	within effect	PSM
parishes with CKW	35.6%	62.6%	27.0%	
parishes without CKW	36.3%	46.0%	9.7%	
between effect	-0.7%	16.6%	***17.3%***	***19.2%***

Table 2: The effect of CKWs on farming knowledge

six categories. The whiskers represent the standard error of the estimate of the effect in a standard difference in difference regression. Not surprisingly, the largest positive effect of the presence of a CKW is on people reporting to use CKWs as their source of information. This means that, once CKWs are deployed they are also used by about half of the treated population as a source of market prices.

What is more interesting is that the proportion of farmers reporting to use SMS as a source of price data decreases due to the presence of CKWs. In Uganda, there are different organizations that offer price information through SMS. These are services that have to be paid for. Users have to SMS the name of a market and crop to a specific number and then they receive an SMS back with the current market price for the corp in that market. It seems that when CKWs come in, which basically give farmers access to free up to date market price information, farmers are less likely to pay for this information. CKWs appear to crowd out private sector initiatives that provide market information.

Another interesting finding is that after the intervention, more farmers report to rely on friends for market information. This may suggest that market information that is freely obtained from a CKW is regarded as a public good within the community. This finding raises interesting questions as to what this means for competition between the farmers themselves. Farmers that have an advantage in terms of information will use this in their interactions with traders, but also with other farmers. For instance, given that the price a trader will pay is a negative function of the revealed volume within the village, a farmer that knows the price may have an incentive to keep the information private until he has closed a deal with the trader.

A second set of indicators of changing attitudes are the reported sources of extension information and training. These are shown in figure 3 in a similar way as the sources of price information. As can be seen, CKWs seem to have replaced reliance on extension provision through NGOs and through the government. NAADS extension services seem to be complementary to

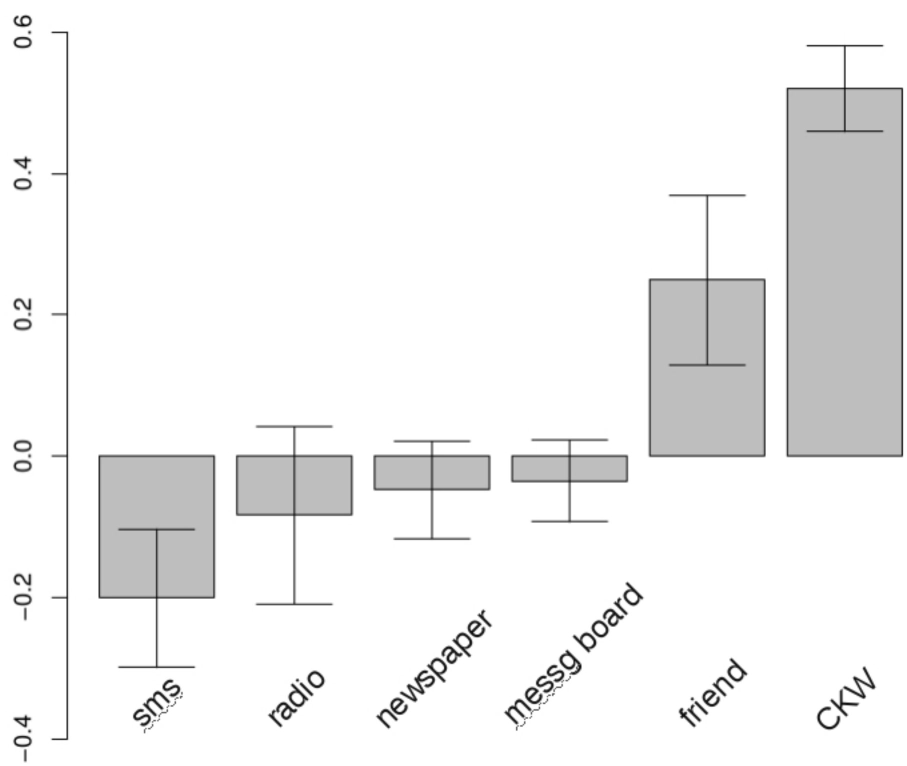

Figure 2: Source of price information

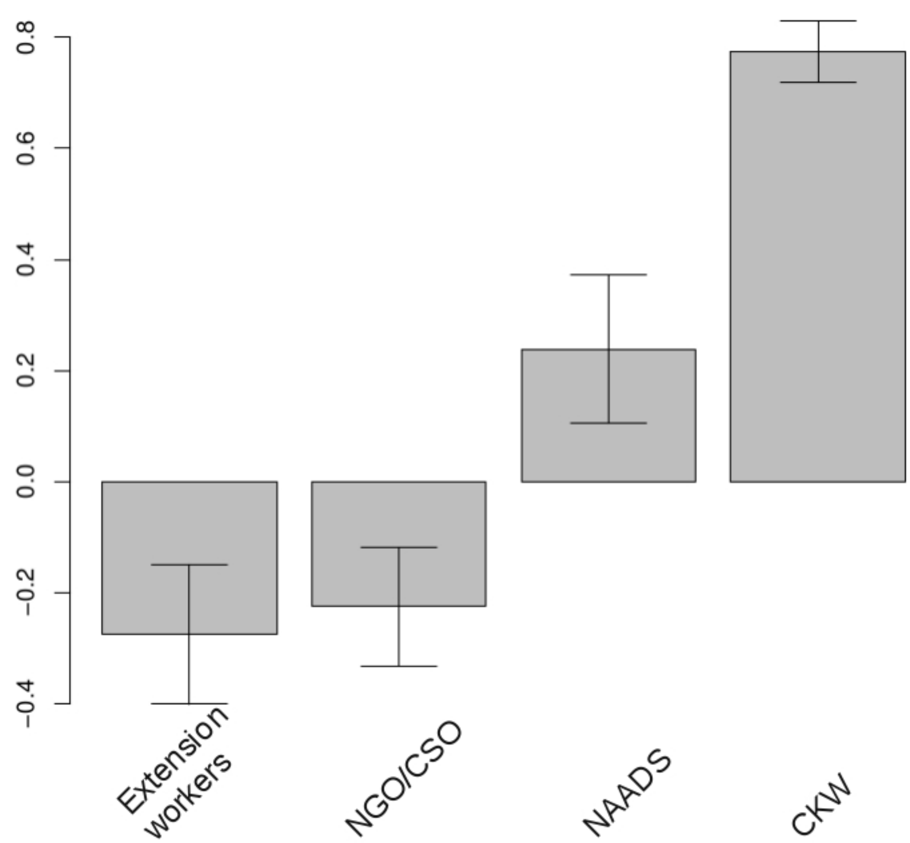

Figure 3: Sources of extension information and/or training

the CKWs.

Changes in Practices

One way to assess changes in practice is to look at how the crop portfolio is adapted after a CKW is deployed. We asked farmers which crops they cultivated. The difference in difference estimates of the effects are displayed as the bar charts in figure 4, with the whiskers indicating the standard errors of the estimates. There seems to be a tendency to move away from low risk low return crops to more risky but more commercially oriented crops. The

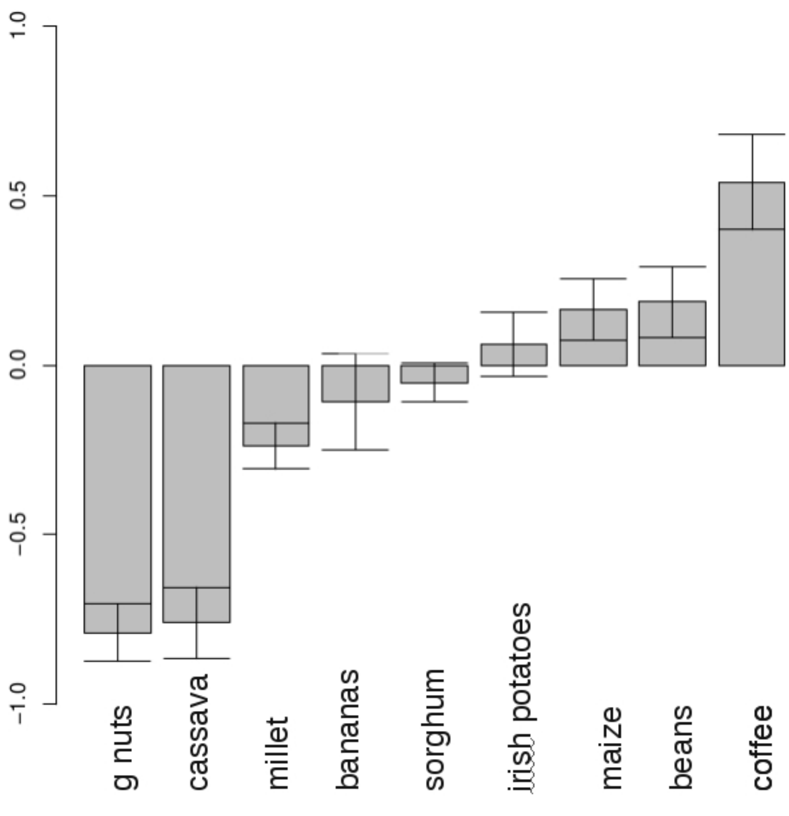

Figure 4: Change in proportion of farmers reporting to grow crop attributed to CKW

increase in the proportion of farmers cultivating maize and beans can also be explained by the fact that the CKWs where enrolled as one element of the WFP project which also aimed at procuring maize and beans in the area. This would increase demand and hence prices. The CKWs were assumed to be increasing post harvest practices of farmers.

We also directly asked questions on changes in farming practices. One of the easiest farming practices advocated by CKWs is planting in rows, as this greatly reduces weeding. Obviously, weeding during the growing season significantly increases crop performance and yields. Another practice that CKWs promote is the use of organic manure, especially for matooke, a crop that is grown by almost every farmer because of its prominence in the Ugan-

	2009/10	2011/12	within effect	PSM
	crop spacing			
parishes with CKW	0.410	0.792	0.382	
parishes without CKW	0.278	0.386	0.108	
between effect	0.132	0.406	***0.274****	***0.381****
	manure application			
parishes with CKW	0.416	0.734	0.318	
parishes without CKW	0.323	0.329	0.006	
between effect	0.093	0.405	***0.312****	***0.387****

Table 3: Effect on crop spacing and manure application

dan diet. The results can be found in the form of a difference-in-difference table in table 3. Again, we find a significant and positive impact of CKWs on both the proportion of farmers reporting to use crop spacing, as well as on the proportion of farmers reporting to apply manure to their crops.

Changes in outcomes

The main aim of the CKW project is to provide extension services to hard to reach farmers. One of the most important outcomes would therefore be that farmers have effective access to information. Having access to information is different from knowledge. As such, we would argue that knowing the price is different then having access to price information. This is why knowing the price is categorized under the changes in knowledge section. The first indicator we will investigate here is the answer on the question if one has access to extension information and/or training.

Table 4 shows a difference in difference table for the proportion of farmers reporting to have access to information and/or training from extension workers. While there is no significant pre-intervention difference between the treated and the control populations, after the treatment, the treated population reports more access to extension. Even more, over time, it seems that in the control population access to extension services has reduced. Taken together, this means that the actual impact of CKWs on access to extension services is likely to be higher then the 22 percent increase registered in the treatment group. The total effect of CKWs on access to extension is therefore estimated to be about 34 percent. When we use propensity score matching, we find a slightly lower effect.

	2009/10	2011/12	within effect	PSM
parishes with CKW	0.601	0.821	0.219	
parishes without CKW	0.632	0.513	- 0.120	
between effect	-0.031	0.308	***0.339*****	***0.304*****

Table 4: The effect of CKWs on access to extension

Another key outcome related to the price information that is disseminated by CKWs is the price they receive for the products they sell. Below, we provide a difference in difference table for the average price for maize received by the farmer. On average, the highest price farmers received upon selling maize was about 354 UGX per kg. This point estimate is slightly higher in the control population. If we predict the average sales price of maize in the control population using an econometric model, we find it is 360 UGX per kg. If instead we rely on self reported recall prices, we find the average price to be 375. However, in both cases, pre-intervention prices are not significantly different between treatment and control group.

In 2011/12, prices have increased substantially. On average, the price more than double over this three year span, from 354 UGX per kg to 721.74 UGX per kg. However, the increase over time was significantly lower in the control population. Depending on how the baseline was reconstructed, the difference between price changes in the treatment and control populations is 133 and 149 UGX per kg. In other words, over and above a general price increase, there is an additional price premium in parishes served by CKWs. The estimate using propensity score matching is similar to the difference in difference estimates.

Similarly to the analysis for the price received by farmers, we also ask ourselves the question if CKWs have improved maize productivity. To do so, we compare amounts harvested per area of cultivation before and after the intervention. We again use baseline data for the treatment group from the WFP survey. We predict productivity in the control group using Tobit models. The results indicate that, compared to the predicted counter-factual, farmers in parishes with and without a CKW have increased productivity significantly. The fact that the rise occurred in both parishes means we can not attribute the effect to CKWs. Propensity score matching leads to the same conclusion: the difference between treated areas and control areas are not large enough. We do find a significant effect if we rely on recall data. The apparent reduction of productivity in the control population contrasted

	2009/10		2011/12	within effect		
	pred	recall		pred	recall	PSM
parishes with CKW	354.38	354.38	721.74	367.36	367.36	
parishes without CKW	359.45	375.48	593.76	234.31	218.21	
between effect	-5.07	-21.10	127.98	***133.05*****	***149.08*****	***143.09*****
	pred	recall		pred	recall	PSM
parishes with CKW	745.7	745.7	1318.5	572.8	572.8	
parishes without CKW	555.9	1221.4	917.1	361.2	-304.3	
between effect	189.8	-475.7	401.4	***211.6***	***877.1*****	***378.65***

Table 5: The effect of CKWs on highest price received for maize and productivity

with the rising productivity in CKW areas results in a significant effect.

There are various reasons as to why we find a significant impact on prices and why we do not find an equally convincing effect for productivity. First of all, productivity is difficult to measure. In our case, we did not use GPS to measure area of cultivation. Some researchers argue that a farmer's ability to estimate land area may be related to other outcome variables [Carletto et al., 2011]. In addition, while information on prices can be used directly, it may take some time before the impact of extension information is reflected in outcome variables such as productivity. It may take several years of manure application before soil regains sufficient ... to lead to significantly higher yields. Or it may simply be that price information is valued higher by farmers, especially in times of sharply increasing and/or highly volatile prices. See also log files???

Figure 6 investigates if there is an additional impact from direct, personal interaction with a CKW, over and above the one found above. Column (1) re-estimates the difference in difference model for the price of maize sold, reported in the upper panel of table 5. The estimates are slightly different because of missing values for the frequency of interactions. This number of interactions with the CKW is introduced in column (2), as an interaction term with the effect as an explanatory variable. The estimate is not significantly different from zero, signifying that what matters is that one lives in an area served by a CKW, not how often one interacts. This suggests substantial spillover effects. There are different ways in which these effects can come about. Information may be perceived as non-rival and public, and information looked up on the smart-phone during a one off CKW farmer

	(1)	(2)	(3)	(4)
year	234.3***	234.3***	340.3***	348.8***
	(14.97)	(14.98)	(34.91)	(37.12)
treat	-6.692	-6.692		
	(9.354)	(9.360)		
effect	143.2***	131.9***		
	(35.67)	(39.57)		
effectXfreq		3.133		-1.068
		(3.590)		(0.650)
Constant	359.5***	359.5***	379.3***	378.3***
	(5.443)	(5.447)	(16.43)	(16.15)
Observations	691	691	238	233
R-squared	0.417	0.419	0.516	0.519
Number of ID			148	143

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6: Treatment intensity

interaction may be shared within the communities very quickly. It may also be that farmers that interact with CKW are seen as model farmers and their practices are imitated by other farmers.

The last two columns check if the failure to find a significant individual effect of the CKW farmer interaction is due to the fact that the selection bias does not work on the parish level, but at the individual level. For example, within the parish, a CKW may target farmers with particular characteristics. If these farmers get lower prices on average to start with, this may lead to an underestimation of the true effect that a CKW interaction has. We can control for individual specific characteristics by comparing at differences in outcomes within farmers. That is, have farmers that interacted more with CKWs significantly changed as measured by outcome variables over time compared to other farmers? This is essentially a fixed effects model. The results indicate no significant effect of the frequency of interactions in the treated population, further strengthening our conclusion that the benefits of CKWs are shared by all farmers within the community.

Conclusion and Suggested Follow Up

In 2009/2010, the Grameen Foundation rolled out an innovative way to deliver extension and marketing information to smallholder farmers in rural villages in Uganda. They essentially equipped locally recruited individuals with an Android smart-phone. These smart-phones were running a specific mobile application called "CKW search" that can be used to search for up to date and location specific information related to farming and product marketing. While ICTs and mobile phones in particular have been used for disseminating and collecting information in several other development projects, the Grameen Foundation's model tries to increase the chances that farmers act upon information by positioning a knowledge worker at the ICT-farmer interface. The knowledge worker is assumed to be better able to contextualize the information, increasing the chances that farmers also act upon it.

This paper reports on the results of a difference-in-difference study that assesses the effect of CKWs on a range of intermediary and final outcome variables that are likely to improve farmer well-being. More in particular, we looked for changes in farmers knowledge with respect to farming and marketing. In addition, the effect of CKWs on attitudes toward information providers was assessed. We also investigate if CKWs lead to changes in farmers practices and eventually affect key outcomes such as prices received at the farm gate and crop productivity.

We find a significant positive impact of the presence of a CKW in the community on the proportion of farmers reporting to know prices in surrounding markets. Using a more objective method then self reported price knowledge, we also subjected the farmers to a series of questions on farming practices. Also on this measure of knowledge, we found a significant positive impact of the CKW intervention. CKWs on average increase farming knowledge by about 17 percent.

We also looked at how the presence of a CKW changes on which sources farmers rely to obtain price information, as well as agricultural extension information and training. For price information, the presence of a CKW resulted in a significant drop in farmers reporting to use SMS based price information dissemination services. Interestingly, the intervention also increases the proportion of farmers reporting to rely on friends and neighbours for price information. Other sources of market information, like radio and newspaper, are not affected by CKWs. For sources of extension information, traditional extension services from the government and extension through NGOs or CSOs become less important if a CKW is deployed. It seems, however, the presence of a CKW also has a catalysing effect on NAADS as a source of agricultural extension information.

For changes in practices, we first look at shifts in the crop portfolio of the average farmer. We see that a CKW is associated with an increase in the proportion of farmers that grow maize, beans and especially coffee. At the other end, we see a significant reduction in the proportion of farmers growing groundnuts, cassava and millet. In other words, there seems to be a shift away from low-risk low-return crops due to CKWs. We also looked at the impact of CKWs on the adoption of basic farming techniques. For instance, we find a significant causal effect of CKWs on the use of recommended crop spacing and the application of manure to crops.

Finally, we also consider some outcomes. First, and at the most basic level, we find a +30% impact on farmers reporting to have access to extension services. We find that access to a CKW significantly increases the average price a farmer gets for his maize. While there is general inflation between the baseline and end-line surveys, areas that are served by CKWs are able to sell their maize for, on average, 133 UGX per kg, or about 22 percent more. On the other hand. We do not find a significant impact on maize productivity, defined as kg harvested per acre planted.

While the main focus of this study is on the parish level as the experimental unit, we also investigated if there is an additional effect of the number of actual interactions with a CKW. We find this not to be the case. Taken together with the changes in attitudes where people rely less on costly SMS services and more on friends for marketing information, this may suggest (marketing) information is regarded as a public good within communities. This crowding out of private market information initiatives is certainly something that deserves further attention.

Overall, our impact study suggests large positive effects. This is different from findings of studies that use RCTs for similar projects. It may be because of the particular nature of the CKW project, where both attention is given to productivity enhancing extension information and marketing information. Alternatively, our results may be specific to the area. The mount Elgon area is a rather inaccessible area, where market price information may be more valuable than in more general settings. This could simply be tested by extending our study to Gulu, where another 4 districts were surveyed by WFP in 2009/10 that can serve as a baseline.

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