ajfand
SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 19 No. 1
January 2019
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2019; 19(1):14113-14136 DOI: 10.18697/ajfand.84.BLFB1007

Borlaug LEAP Paper

Performance Incentives and Information Communication Technologies in Ugandan Agricultural Extension Service Delivery

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Abstract

Agriculture is the backbone of many countries in sub-Saharan Africa. Yet, lack of efficient extension systems to support agricultural development is widely seen as a missing link in agricultural transformation in the region. International development agencies have in the past four decades invested heavily in various extension models such as the Training and Visit and Farmer Field School systems in order to enhance the performance of extension workers. Despite such investments, the performance of extension agents does remain sub-optimal in many contexts. Studies in other sectors show that incentivizing worker performance through nudges such as incentive realignment schemes that tie worker performance to a pay/bonus system could enhance worker productivity. However, there is a lack of incentive realignment studies that estimate the performance of extension agents in sub-Saharan Africa. A potential hindrance to the application of such scheme to extension is the absence of monitoring mechanisms to track the performance of extension agents who often work across diverse local contexts to reach smallholder farmers with extension advice. This study empirically estimates the effect of an information communication technology (ICT)-based payment incentive system that tracks the performance of extension workers in rural Uganda. It undertakes a quasi-experimental ex-post impact assessment of a payment incentive realignment as an exogenous shift in the price of labor for extension services by Ugandan Community Knowledge Workers (CKWs) in 2011. This study applies a difference–in–difference with propensity score matching technique to estimate the effect of an ICT-based incentive re-alignment scheme in 2011, on the performance of 461 CKWs in rural Uganda. The study shows that CKWs in rural Uganda respond positively to an ICT-based performance incentive scheme that affects the price of labor. Results suggest that such performance systems can enhance the productivity of CKWs – an exemplar of rural extension agents in Uganda and elsewhere in developing countries. It also finds that younger CKWs respond more productively to higher incentives than their older counterparts. Therefore, the study suggests that extension policies that tie extension agents' performance to ICT-based payment incentives could enhance their performance and contribute towards the sustainable developments goals on food security, among others, through multiplier effects.

Key words: Agricultural extension, community knowledge workers, ICT-based performance incentives

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Introduction

Agricultural extension (henceforth, extension) has historically been a crucial part of agricultural development through outreach to farmers across rural communities (Garforth, 1982; Jarrett. 1985; Wellard *et al.,* 2013; Wossen *et al*., 2017). It remains a vital element of agricultural development in sub-Saharan Africa (SSA) where poverty and low agricultural productivity persist in the face of socio-economic and biophysical stressors (Moore and Harder 2015; IPCC, 2018; World Economic Forum, 2018). Rising global population and food demands also pose a challenge to agricultural development in SSA to balance excess food demands with food supply by 2050 (FAO, 2009, 2016). Thus, enhancing the productivity of extension components (such as the labor outcomes of local extension agents) as an important agricultural sub-sector, could enhance agricultural development. Efficient delivery of extension services to smallholder farmers could improve their agricultural outputs such as crop yields (Komarek and Ahmadi-Esfahani, 2011; Wellard *et al*., 2013; Wossen *et al*., 2017).

However, several institutional and structural problems limit the productivity of extension systems in SSA (Wellard *et al*, 2013). One important challenge is weak attribution due to poor monitoring mechanisms for tracking the performance of extension agents (Davis, 2008; Moore and Harder, 2015; Purcell and Anderson, 1997). This limits the precise measurement of the effects of extension on agricultural production (Anderson and Feder, 2004; Bindlish and Evenson, 1997). Poor monitoring mechanisms for extension agents further leads to weak extension systems (Anderson, 2008; Davis, 2008; Birkhaeuser *et al*., 1991), which limits agricultural production and economic development in the region. For instance, due to weak extension systems, the Green Revolution of the 1970s that occurred in Asia and caused huge national outputs for many agrarian economies never occurred in SSA despite large donor funding (Gollin *et al*., 2002).

To enhance agricultural development through improved extension systems in SSA, various formal and informal models of extension have been implemented in the past decades (Chowa *et al*., 2013; Davis, 2008). Formal extension systems are predominantly implemented by government ministries of agriculture in the public sector and agro-input dealers in the private sector. Popular extension approaches are the Training and Visit (T and V) system, Integrated Agricultural Development Programs (IADPs), and Farmer Field Schools (FFS), which have been popular in SSA and elsewhere (Bindlish and Evenson, 1997; Chowa *et al*., 2013; Davis, 2008).

Despite the popularity of these prior interventions, however, the outcomes of extension systems in SSA remained unsatisfactory and most extension models were unsustainable, thereby requiring a restructuring and reinvention of extension systems in the region (Anderson and Feder, 2004; Picciotto and Anderson, 1997; Davis, 2008). For example, models like T and V utilize top-down extension approaches wherein information flow mainly from government ministries of agriculture or agricultural colleges and universities, through extension agents, to farmers (Davis, 2008). Top- down models in many cases failed

DOI: 10.18697/ajfand.84.BLFB1007

to empower rural smallholder farmers (Gautam and Anderson, 1999; Wellard *et al*, 2013), which led to the need for pluralistic extension systems that presumably provide better access to extension for smallholder farmers (Chowa *et al*., 2013; Davis, 2008; Pritchett and Woolcock, 2004).

Pluralistic approaches are inclusive of a variety of information sources and stakeholders beyond just the formal top-down pathway. These may include private companies, NGOs, farmer-led cooperative organizations, informal social networks and ICTs (Chowa *et al*., 2013; Koehnen, 2011; Strong *et al*., 2014; Tata and McNamara, 2018). The extension system in the United States (US) is an example of a pluralistic system that was pivotal to the success of commercial agriculture in the US (Garret, 2001). Key among its facets was the dynamic linkage of colleges with rural communities through the land grant system. Extension workers, employed by the state, serve as conduits for disseminating critical innovative technologies and practices among farming communities, especially in rural areas (Garrett, 2001; Wellard *et al*, 2013). This top-down formal system is complemented by a host of companies and other organizations available to advise farmers on new strategies and respond to individual concerns. Although extension approaches in many developing countries are loosely based on this US extension framework, in many cases, these systems are yet to replicate the success of the US model.

Advances in information communication technologies (ICTs) present an opportunity for modernizing agricultural extension by incorporating ICT-based systems (Aker, 2011) such as the use of cellphones to provide extension advice to smallholder farmers (Koehnen, 2011; Strong *et al*., 2014; Tata and McNamara, 2018). There are two important ways that ICTs can improve agriculture. First, ICTs can improve farmers' access to extension advice in crucial aspects like market information, weather, and nutritional information, thereby increasing farm productivity and welfare outcomes (Aker, 2011; Anastasios *et al*., 2010; Barakabitze *et al*., 2015; Tata and McNamara, 2018). Second, ICTs can serve as a hub for agricultural and farmer records such as farm surveys and other critical information through the concept of digital agriculture (Shepherd *et al*., 2018).

Despite the rising opportunities for extension agents to optimize the use of ICTs to provide agricultural information to farmers and enhance agricultural productivity (Koehnen, 2011; Tata and McNamara, 2018; World Economic Forum, 2018), there is little evidence in the literature on the effects of ICT use in extension delivery in SSA. Moreover, there is limited information on how to efficiently improve extension systems in SSA and elsewhere in the developing world.

This study addresses the gap in the literature about inducing extension agents' performance through ICT-based monitoring schemes. It analyzes the effect of an incentive re-alignment scheme on the performance of community knowledge workers (CKWs) who work as rural extension agents in Uganda. It undertakes an ex-post impact assessment of the effect of an ICT-based monitoring incentive scheme introduced by Grameen Foundation in Uganda for

DOI: 10.18697/ajfand.84.BLFB1007

their CKW program in the rural areas of the country. In 2009, Grameen Foundation established the CKW program in Uganda to address weak extension performance in the country by using ICTs to enhance the provision of extension services (Amadu *et al*., 2015; McCole *et al*., 2014). To induce higher performance of CKWs, Grameen Foundation instituted a phased incentive re-alignment scheme in 2011, which sought to reward CWKs based on their monthly performance in reaching farmers with extension advice. During that time, extension agents in certain districts received a 50-percent increase in their salaries (Grameen Foundation, 2014).

The goal of this study is to determine whether the increased payment incentive caused a positive supply-response in extension delivery. It utilizes a difference-in-difference estimation and propensity score matching to estimate the effect of the incentive realignment on CKW performance in rural Uganda. It hypothesizes that CKWs respond positively to an upward shift in their performance incentives, which are tracked by an app called Salesforce, installed on their program cellphone. The article measures CKW performance by their monthly total searches recorded in Salesforce in 2011 and 2012.

This study contributes to the literature by performing an empirical analysis of the CKW extension system and determining the labor supply response of CKWs in such a fluid development setting as SSA. Thus, it contributes to opening the black box of extension management and administration through a component-by-component analysis of the system.

The next section of this article reviews related literature, followed by a section presenting the conceptual framework. Then we discuss the empirical and estimation strategy, and then present data and results.

Background information

Extension in Uganda and the Community knowledge Worker program

Extension in Uganda has undergone dramatic changes over the past fifteen years. In 2001, the Government of Uganda (GoU) revamped its national extension strategy and established a National Agricultural Advisory Service (NAADS), which utilized a public-private partnership approach. It decentralized extension services to district and sub-district levels, and promoted farmer organizations, by registering them into a system whereby they could access extension advice through NGOs and private entities, and to manage procurement for quality delivery through a monitoring and evaluation system (McCole *et al*., 2014).

Two studies (Benin *et al*., 2007 and 2011) found positive and statistically significant impacts of NAADS on extension delivery and a positive economic return by 49%; as well as establishing that NAADS enhanced the adoption of improved agricultural practices by facilitating access to new crop technologies and livestock activities, among others. Despite such positive impacts, NAADS was criticized for waste, corruption and inefficiency, and

DOI: 10.18697/ajfand.84.BLFB1007

farmers complained about poor access to inputs, such as credits and pest management advice (McCole *et al*., 2014). Due to such problems and other institutional challenges, the GoU disbanded NAADS and reconstituted the extension system as a national entity (McCole *et al*., 2014).

In 2009, Grameen Foundation, a joint winner of the 2006 Nobel Peace Prize along with its founder, Mohamed Yunus (Nobel Peace Prize, 2006), established the CKW program in Uganda. The CKW program is a participatory extension program that utilizes the interaction of ICT capabilities with local knowledge. Grameen Foundation does not require CKWs to have prior ICT or other technical expertise as prerequisite for their employment with the program. Instead, CKWs received training on the use of a smartphone containing an agricultural information database that extend community extension services to farmers (Grameen Foundation, 2014).

The CKW smartphones contain an app called CKW-Search, which stores agricultural advisory information (Van Campenhout, 2017). Each CKW mainly finds information for farmer-specific problems relating to their crops or animals. For example, when a farmer notices a yellow spot on his/her cassava leaves, he/she informs a CKW about the problem. The CKW in turn, searches the database in the smartphone for the solution to the problem, which in this case could possibly be cassava mosaic. They also use the search function to allocate market, price and weather-related information, which guides farmers' cropping and marketing decisions on a regular basis (Grameen Foundation, 2014). Thus, through CKW-Search, farmers can access state-of-the-art agricultural information in the most remote regions of Uganda, whether or not they personally own a cell phone. Performance measure for CKWs is the number of searches they perform for farmers on monthly basis. The number of searches done by each CKW is captured as a query after each interaction with a farmer in their locality (Amadu *et al*., 2015; Grameen Foundation, 2014).

Prior to the CKW program in Uganda, extension service delivery mainly occurred through the Ministry of Agriculture with some inputs from NGOs. However, diverse challenges with government operational systems, as described above, skewed the supply of extension services. For example, it is reported that services were skewed toward rich and affluent farmers (Van Campenhout, 2017; McCole *et al*., 2014). Moreover, poor infrastructure facilities hindered rural producers from realizing optimal gains from their agricultural products. For instance, Komarek and Ahmadi-Esfahani (2011) showed that the GoU had no direct regulation of prices. Instead, middlemen who served as the gateway to any high demand for agricultural commodities often got at least 38% of final sale price for products in urban areas, exacerbating the poverty situation of smallholders in rural areas (McCole *et al*., 2014; Svensson and Yanagizawa, 2009). The CKW model, therefore, serves to reduce this information asymmetry and disparity in wealth distribution between the urban and rural communities by providing farmers with access to pricing information and markets to sell their produce at competitive prices.

Community Knowledge Workers (CKW)-Search is kept up-to-date with appropriate crop, livestock, weather, and market price information. The updates are enhanced by collaboration with various institutions as service partners, including both local and regional research institutions, such as Makerere University, International Institute of Tropical Agriculture and MTN-Uganda as the leading cellular service provider in the country (Amadu *et al*., 2015). In addition to providing extension services, CKWs undertake farmer surveys and collect farmer-specific information that is transmitted to Grameen Foundation for service improvement. Information collected by CKWs is transmitted via a cloud-based server called Salesforce, which is managed by staff at the Grameen Foundation headquarters in Kampala.

For CKWs to provide uninterrupted extension services in rural communities where power is a major challenge, their operational CKW smartphones have solar panels which power a CKW's home[1]. As a back-up measure, the CKW smartphones can store daily transactions (for example search outcomes) during operation in an area with weak cellphone coverage. When the CKW comes within cellphone coverage, he/she can then transmit the information to Salesforce.

Being local farmers themselves, CKWs could utilize the agricultural information in the smartphones for their own farming practices. That way, they have a practical experience of the information they provide to other farmers. Thus, CKWs are often regarded as local farming experts in their communities. The CKW program operates on the premise that extension agents who live and work within their local communities are more efficient in delivering extension services in their communities compared to traditional extension workers who often are non-resident in the local communities they serve. Hence, unlike traditional extension workers, CKWs have ability to reach the *last mile* in extension delivery (Amadu *et al*., 2015; McCole *et al*., 2014). In addition to the CKW-Search, CKWs register new farmers on a monthly basis and give them appropriate identification cards (IDs). The registrations encourage farmer participation in the program as they are placed into farmer groups where they can collectively implement ideas from CKWs.

There is a regulatory system for CKW activities which monitors their daily operations, ensuring that each CKW-search conducted is captured in Salesforce. Like the farmers they register, CKWs have IDs. Each CKW-Search is thus submitted in Salesforce along with CKW and respective farmer IDs, the geo-spatial code, and the time the CKW-Search occurred. This helps Grameen to remotely validate the performance of CKWs (Grameen Foundation, 2014). The same process serves as a means of incentivizing CKW performance (based on the total monthly CKW-searches performed by respective CKWs). Staff at

[1] CKWs are allowed to use this solar panel facility to charge cellphones for community members for small fees, established by the community elders and Grameen. The tokens from the charging services belong to CKWs as an extra incentive. Such incentives are, however, not considered in this analysis

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 19 No. 1 January 2019 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Grameen Foundation headquarters in Kampala reviews each recorded query. Discrepancies are crosschecked and corrected normally by CKW coordinators, who provide an additional layer in the leadership hierarchy (McCole *et al*., 2014).

As stated above, Grameen Foundation implemented a phased incentive re-alignment in June 2011 in order to induce CKW performance. Performance is graded on an A, B, C and D basis, with a grade of an A being topmost. The monthly pay for top performance was raised by 50%. That is, any CKW who scores an A, gets an extra 50% of their monthly pay. The threshold for an A performance is a minimum of 48 CKW-Searches, 8 surveys and 15 farmer registrations in any given month (Grameen Foundation, 2014). Because Grameen Foundation usually conducted baseline surveys for agro-based and other rural development agencies (like World Food Program and East Africa Dairy Development) at a fee, they assign top-performing CKWs to those surveys for additional incentives (Grameen Foundation, 2014; McCole *et al*., 2014).

Conceptual framework

Various studies (Powers, 2009; Fehr and Goette, 2007; Card and Krueger, 1994) have analyzed the effect of wage variation on labor outcomes. For instance, using a natural experiment, Card and Krueger (1994) analyzed the effect of a minimum wage change policy on industry labor supply in New Jersey. They used a Difference–in –Difference analysis to examine the effect of a minimum wage raise policy on employment in the fast-food industry in the New Jersey, USA. Using Pennsylvania as the control, Card and Krueger (1994) found that contrary to the standard competitive economic theory, a minimum wage increase (and by extension, increase in the total cost of production for the fast-food industry) in New Jersey resulted in a drop in average employment in the state. They found that the minimum wage increase was transferred to fast food consumers through higher product prices.

Specifically, Card and Krueger (1994) found that fast-food prices rose drastically in New Jersey compared to corresponding prices in Pennsylvania. Building on Card and Krueger (1994), Powers (2009) analyzed the effect of a minimum wage increase in Illinois while holding Indiana as a control, and found some decline in the total amount of hours worked in the study area. In line with many studies on labor outcomes, the analyses of these two studies emphasize employers' response to a hike in minimum wage. However, literature on the effects of a wage hike on actual performance of agricultural extension workers remains largely unexplored, at least to our knowledge.

Although it is well known that workers tend to respond positively to an increase in wages by giving up more time in order to achieve a higher target wage, individuals can only offer so much time towards labor within their total time endowment. Therefore, like every other commodity, labor supply is finite (Cherchye and Vermeulen, 2008). We contribute to this topic by performing an ex-post impact assessment of the performance of extension workers in response to a wage hike in rural Uganda through the Grameen Foundation program.

DOI: 10.18697/ajfand.84.BLFB1007

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ISSN 1684 5374

Our conceptual labor supply model carefully follows Fehr and Goette (2007). We assume that within a given period of time (on monthly basis) an extension agent can choose to maximize utility of a time trade-off, denoted by:

$$\bigcup_t = \sum_{t=0}^{t} \delta^t \, \mathbb{u}(c_t, e_t, x_t), \tag{1}$$

subject to the following time allocation and budget constraints;

$$\sum_{t=0}^{T} \widehat{\mathbb{p}_t}\, c_t (1+r)^{-t} = \sum_{t=0}^{T} (\widehat{w_t} e_t + y_t)(1+r)^{-t} \tag{2}$$

where $\delta < 1$ represents a discount factor of time with total time denoted as t. Since CKW performance is measured on a monthly basis, t in this context represents total time in a month. The variable e_t denotes the total monthly effort, and measured by the number of valid monthly CKW-Searches. The general monthly consumption of a CKW is denoted by c_t, while x_t denotes a factor that influences how many hours of work s/he allocates towards extension in a given month. For instance, CKWs with larger households might have higher consumption spending demand and thus, higher incentives to work more in order to reach higher performance targets and obtain more pay. It is also possible that having a large household may reduce the total time available for work if events in the household such as illness constraint a CKW from working extra hours. Thus, for brevity, let x_t denote preference for work.

Moreover, since the CKWs are also farmers in their respective communities, we note that if a CKW allocates, say κ amount of time towards extension in any given month, s/he would have (n - κ) time left for own farm labor and leisure. In the constraint function, $\widehat{\mathbb{p}_t}$ represents prices for consumables such as staple crops. Since CKWs have monthly performance targets, let $\widehat{w_t} e_t$ be the wage/compensation per unit of effort (e_t) in a given month. Income from other sources (other avenues besides monthly compensation) is denoted as y_t. Assume that the utility function is strictly concave in c_t, e_t, and takes the form $\mathbb{u}_c > 0$, and $\mathbb{u}_e < 0$, the interest rate (which determines the real worth of wages received) is taken as given for the CKW economy.

Fehr and Goette (2007, p. 304) shows that in the given time period, the decision of a rational individual maximizing a time-separable concave utility function and subject to constraints, can be represented in terms of a linear one-time utility function.
We write the state utility function as:

$$v(e_t, x_t) = \lambda w_t e_t - g(e_t, x_t) \tag{3}$$

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"Where $g(e_t, x_t)$ is strictly convex in $e_t$and measures the discounted disutility of effort" (Fehr and Goette, 2007, p. 304). The variable, x_t captures the exogenous shift of effort disutility.

Since time can be used to improve wealth status from investments in assets accumulation, such as family plantation, and livestock, we denote the marginal utility of time as λ, and w_t to represent discounted monthly wage for top performance. Thus, $\lambda w_t e_t$ can be interpreted as the discounted utility of income arising from efforts in period t" (Fehr & Goette, 2007, p. 304). Thus, extension agents who choose efforts in accordance with the one-time utility equation, would respond positively with a higher effort, e_t, to a rise in w_t because "a rise in w_t increases the marginal utility returns of effort λw_t, which increases the effort level, e_t* that maximizes $v\ (e_t, x_t)$" (Fehr & Goette, 2007).

Empirical and identification strategy

This study utilizes difference-in-difference analysis to estimate the effect of an incentive-based wage re-alignment for extension agents in rural Uganda. Difference-in-differences constitutes a popular impact assessment technique in settings on policy changes such as social outcomes (Van Campenhout, 2017; Powers, 2009; Duflo *et al*., 2008). We posit that the total monthly performance of CKWs in Uganda varies linearly with a set of individual characteristics (both observable and unobservable) such as ability, family size, and age.

Let $\mathbb{Y}_{it}$ represent agents' performance in a given month in both the treated and controlled districts. Thus, we want to compute the average monthly performance ($\mathbb{Y}_{it}{}^{T}$) of any CKW when s/he resides in a treated district and $\mathbb{Y}_{it}{}^{C}$ for a CKW when s/he resides in a controlled district. Our interest is to determine the effect of the incentive re-alignment by computing $\mathbb{Y}_{it}{}^{T} - \mathbb{Y}_{it}{}^{C}$. However, since we cannot both observe a CKW with treatment and without treatment, we compute the average treatment effects of all CKW's per district. This is plausible because although every CKW has two potential performance outcomes (corresponding to both treatment and controlled scenarios), only one outcome per CKW is observed in reality (Duflo *et al*., 2008). Therefore, the expected average effect of incentive re-alignment on CKWs in the entire population of choice is $E[\mathbb{Y}_{it}{}^{T} - \mathbb{Y}_{it}{}^{C}]$. That is, the difference between the expected performances of a CKW in the treated district had he not undergone treatment. We estimate the basic empirical model thusly;

$$\mathbb{Y}_{it} = \Theta + \lambda X_t + \delta X_i + \xi_{it} \qquad (4)$$

Where $\mathbb{Y}_{it}$ denotes the monthly performance of an individual CKW at time *t*. The variable, Θ is a constant, and X_t is a vector of dummy variables that denote treatment status (equal to one if a CKW belongs to the treatment group, and zero, otherwise). The coefficient λ estimates the average incentive realignment effect while X_i represent individual-specific covariates such as age, education (and by implication, ability) for which we use the number

DOI: 10.18697/ajfand.84.BLFB1007

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of training sessions CKW has attended, as proxy. Furthermore, it is assumed that that the errors ξ_{it} are independent and identically generated.

The treatment group includes districts where the incentive re-alignment occurred in June 2011 whereas the control group consists of districts where incentive re-alignment did not occur in June 2011. By June 2011, Grameen Foundation had reached at least 15 districts in Uganda including the initial districts they started with during the pilot phase in 2008. We select a total of eight districts, including four treatment districts and four districts as the control group.

Treatment districts include two of the pilot districts, Bushenyi and Mbale, plus two additional districts, Pader and Loweru. The control districts are neighbors to the treated districts where the incentive raise did not occur in June 2011. Control districts include Kasese (neighbor to Bushenyi) in the Southwest, Masindi (neighbor to Loweru) in the Northwest to central Uganda, Kitgum (neighbor to Pader) in the North, and Kapchorwa (neighbor to Mbale) in the East. All the control districts are similar to the treatment districts in many aspects. For example, they share neighboring boundaries, similar agro-climatic zones and other important factors that affect transaction costs including proximity to urban markets such as Kampala.

Data

Data for this study come from administrative records of the monthly performance of 461 CKWs in 2011/2012 agricultural season in Uganda, to determine their supply response to the incentive realignment introduced by Grameen Foundation in 2012. Duflo *et al*. (2008) shows that using administrative data in such contexts as the present setting, introduces randomization in the analysis. In particular, this study assumes that the use of administrative data eliminates potential selection bias because CKWs had to decide on the selection process at the administrative level of the program in terms of program placement. The study utilizes monthly performance records for a 12-month period including January to December 2011. Of the total of 461 CKWs for which data was available, 238 come from treated districts while 223 are from the control districts.

Table 1 presents descriptive statistics of the main variables of interest including monthly agent performance in waves one and two across the control and treatment districts. It also includes individual characteristics of CKWs across the two groups over the two periods[2]. The total number of observations in our panel data set is 5532. In wave one, the average monthly agent performance in the control and treated districts corresponds to 37 and 35 search[3], respectively. The corresponding standard deviations are 9.41 and 10.25, respectively.

[2] Individual CKW characteristics variables are fixed across the two periods. Thus, DD analysis is mainly based on the monthly performance records of CKWs

[3] Note that performance is measured in terms of total monthly searches

In wave two, the average monthly performance in the control districts is 41, with a standard deviation of 7.63, while the average performance in the treated group is 49 with standard deviation 5.08. The average age of CKWs in the control and treated groups is 40 and 38 years, respectively. In wave 1 and wave 2, CKWs in the control districts have an average of four trainings compared to those in the treated districts having an average of five trainings. On average, there are two farmers' groups per CKW across the control and treated groups.

Individual characteristics across the control and treated groups are similar with minor variations. For example, average household size across the two sets of districts (control and treated districts) is 6, with similar standard deviations (1.79 and 1.8, respectively). The average number of children also in the two groups is 3 with standard deviations of 0.89 and 0.97 for the control and treated districts, respectively. In terms of asset[4] ownership across the two groups, the average dollar value of assets in the control districts is $3605, while the average dollar value of assets in the treated districts is $4157. The average amount of debt[5] (also measured in USD) across the two groups is $379 for the control group, and $359 for the treated group.

Educational attainment of agents is similar across the two groups. At least 80% of agents have basic education (high school education at the minimum). In terms of gender, 61% of agents in the control group are male, while 63% in the treated group are male. Terrain differences are also similar across the two groups. In particular, 29% of agents in the control districts work across hilly terrains compared to 32% of agents in the treated group.

The main farm commitment variable, which implies whether a CKW is fully involved in both crop production and livestock rearing as part of his/her household farming activities, or whether an agent fully engages in only one of either crops or livestock rearing as the main farming activity, is slightly different between the two groups. In the control group, 46% of agents undertake only crop farming, while 48% of the treated group reported cultivating crops only.

Transportation ownership in the form of bicycles constitutes a vital means of transport in the rural areas where public transportation facilities are lacking. During recruitment, CKWs usually receive bicycles on loan so as to facilitate their work in the communities. However,

[4] Family plantation, amount of livestock owned, or other forms of property such as mud brick housing, provide a measure of assets in this setting as in many rural communities in sub-Saharan Africa

[5] Most of the debt owed constitutes some of the valuable assets offered by Grameen on loan to CKWs, for which they make regular payments. For example, the bicycles (for those who receive bicycles), cellphones, and the solar panel with charger are all offered on loan to CKWs, as part of their recruitment package

DOI: 10.18697/ajfand.84.BLFB1007

due to the financial cost of having the bicycles, some CKWs prefer not to have a bicycle. Only 40% of agents in the control districts have a bicycle, compared to 44% in the treated districts for their activities. Moreover, most CKWs in the two groups are household heads. In particular, about 60% in the control group are household heads, and 67% in the treated group are household heads.

Table 1a: Descriptive Statistics Wave 1

	Control (n=669)				**Treated (n**=714)			
Variable	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Monthly performance	36.66	9.41	11	64	34.61	10.25	9	66
Age	40	12.38	21	67	38	11.30	18	67
No. training	4	1.37	3	7	5	1.28	3	7
No. children	3	0.89	1	5	3	0.97	1	6
Household size	6	1.79	1	9	6	1.80	1	10
Number farmers groups	2.46	1.38	1	8	2.45	1.33	1	7
Educational attainment	0.81	0.39	0	1	0.80	0.40	0	1
Assets (USD)	3605	4245	188	2182	4157	5590	188	4202
Debt (USD)	379	343	100	1812	359	332	40	1812
Male	0.61	0.49	0	1	0.63	0.48	0	1
Hilly terrain	0.29	0.45	0	1	0.32	0.47	0	1
Main farm commitment	0.46	0.50	0	1	0.48	0.50	0	1
Marital status	0.70	0.46	0	1	0.74	0.44	0	1
Bicycle ownership	0.40	0.49	0	1	0.44	0.50	0	1
Household head	0.60	0.49	0	1	0.66	0.47	0	1

Note: n= number of observations per wave.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 19 No. 1
January 2019
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1b: Descriptive Statistics Wave 2

	Control (n=892)				Treated (n=952)			
Variable	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Monthly performance	41.07	7.63	19	63	49	5.08	25	69
Age	40	12.38	21	67	38	11.30	18	67
No. training	4	1.37	3	7	5	1.28	3	7
No. children	3	0.89	1	5	3	0.97	1	6
Household size	6	1.79	1	9	6	1.80	1	10
No. farmers groups	2.46	1.38	1	8	2.45	1.33	1	7
Educational attainment	0.81	0.39	0	1	0.80	0.40	0	1
Assets (USD)	3605	4245	188	2182	4157	5590	188	4202
Debt (USD)	379	343	100	1812	359	332	40	1812
Male	0.61	0.49	0	1	0.63	0.48	0	1
Hilly terrain	0.29	0.45	0	1	0.32	0.47	0	1
Main farm commitment	0.46	0.50	0	1	0.48	0.50	0	1
Marital status	0.70	0.46	0	1	0.74	0.44	0	1
	0.40	0.49	0	1	0.44	0.50	0	1
Bicycle ownership								
Household head	0.60	0.49	0	1	0.66	0.47	0	1

Note: n= number of observations per wave.

Results and discussion

Table 2 shows the individual covariate effects on the probability of being receiving the performance incentive (the treatment regime) for a CKW in the research setting.

Table 2 shows that a one-unit change in the age variable decreases the probability of CKW being participating in the program by 1.5%. Thus, younger CKWs are more likely to take advantage of such schemes. One possible explanation for this result is that on average, younger CKWs might be more energetic, and thus better able to take advantage of higher incentive opportunities compared to their older counterparts. This possibility of supply response issue associated with age could make it necessary to adjust extension wage/incentive policies that favor the youths in SSA. Such a policy could significantly enhance rural development by reversing rural-urban migration, and stimulating economic development through youth employment and improved incomes of youths in the developing world.

DOI: 10.18697/ajfand.84.BLFB1007

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 19 No. 1 January 2019 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 2 also shows that larger households, depicted by having an additional child, have a higher probability of participating in the incentive realignment scheme (16%) on average than lower households. One possible explanation for this outcome is that in such settings (as it is with many rural areas across sub-Saharan Africa) in general larger household sizes facilitate labor for agricultural and other livelihood activities. For example, children could help with household chores as well as agricultural labor for the household. Therefore, having higher number of children could provide extra time for a CKW who is a parent, to perform community extension service. Another explanation is that children (especially toddlers) could present additional financial demands for a typical family. Thus, an additional child per household could induce a CKW to desire to maximize the opportunity of higher earnings associated with the incentive re-alignment.

Moreover, table 2 shows that household heads have a higher probability of participating in the CKW performance realignment program 17% compared to those who are not. One possible explanation for this result is that being a household head induces a CKW to maximize a performance-based incentive in order to meet family obligations.

Thus, performance-based incentives could be useful in stimulating higher productivity among extension agents in sub-Saharan Africa where extended family systems are common across the rural areas such as the present setting.

Although the estimates have a somewhat low Pseudo R-square value, the Log likelihood estimate has is statistically significant, indicating a good model fit.

DOI: 10.18697/ajfand.84.BLFB1007

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 19 No. 1
January 2019
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 2: Determinants of participation in the CKW incentive performance realignment scheme

Variable	Coefficient	P-value
Age	-0.015***	0.000
Number of children	0.161***	0.000
Household size	0.024	0.226
Number of farmers' groups	-0.026	0.311
Educational Attainment	-0.051	0.563
Asset in USD	0.000	0.035
Debt in USD	-0.000	0.030
Gender is male	-0.007	0.929
Working in hilly terrain	0.109	0.157
Main farm commitment	0.039	0.632
Marital Status	0.104	0.186
Bicycle ownership	0.077	0.355
Household status[6]	0.170**	0.027
Number of trainings	0.014	0.583
Pseudo R-square	0.0303	-
Log likelihood	-928.87**	-

**Inference: *** p<0.01; ** p<0.05; * p<0.1

Main result: Treatment effect

Table 3 presents the main estimates of the difference-in-difference results for this setting. It shows that the incentive realignment scheme increased CKW performance by about 10% on average. This estimate is statistically significant at the 1 percent level, and shows that the incentive realignment had a positive and statistically significant effect on the average monthly performance of CKWs in Uganda.

[6] This is a dummy variable that equals 1 if an extension agent is a household head, and 0 otherwise

DOI: 10.18697/ajfand.84.BLFB1007

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 19 No. 1 January 2019
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: Main estimates of difference-in-difference analysis for CKW performance in rural Uganda

Wave 1 (Baseline)				Wave 2 (Follow-up)			
Outcome	Control (n=666)	Treated (n=669)		Control (n=888)	Treated (n=89)	Diff	DD (n=3115)
Performance	36.67*** (0.55)	34.77*** (0.60)	-1.91*** (0.82)	41.01*** (0.44)	49.06*** (0.25)	8.06*** (0.50)	9.97*** (0.68)

Std. errors in parentheses; Significance levels *** p<0.01; ** p<0.05; * p<0.1; R-square: = 0.3223

Moreover, the main result is of the incentive re-alignment is depicted by figure 1. It shows the average performance of extension agents in the treated and control groups after the incentive re-alignment took effect. In particular, the average performance of CKWs in the treated group is higher than the average performance of their counterparts in the control group. This demonstrates that an incentive re-alignment policy through ICT-based monitoring system has a positive effect on the performance of extension agents in the research setting.

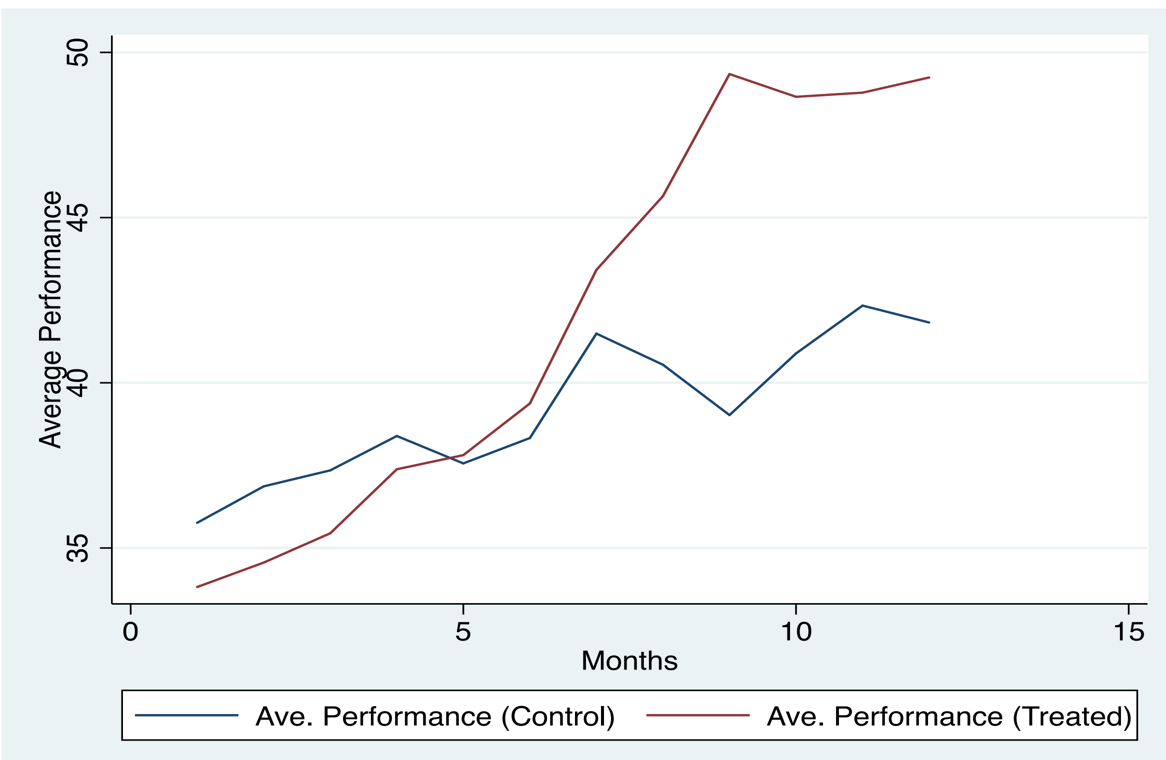

Figure 1: Average monthly performance showing in response to incentive raise

DOI: 10.18697/ajfand.84.BLFB1007

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
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ISSN 1684 5374

Robustness check

Robustness checks for the consistency of the main results in this study are presented in Table 4, which include difference-in-difference estimates with and without covariate, as well as with covariates but no matching (kernel matching estimates). It also includes single time period (point) estimates for performance in March 2011 and September 2011 corresponding to wave one and wave two, respectively. Note that March 2011 is exactly three months prior to the incentive policy change, while September 2011 is exactly three months after the incentive re-alignment policy took effect in June 2011.

Table 4 shows that the main result is not sensitive to specification or other omitted variable effects. The robustness estimates are similar to our main result, and thus validate the consistency of our main result.

Table 4: Robustness checks

	Wave 1			**Wave 2**			**Diff-in-**
Variable	Control	Treated	Diff.	Control	Treated	Diff	**Diff**
Performance with covariates but no PSM	37.56 (2.14)	35.70 (2.22)	-1.86** (0.80)	41.92 (2.15)	50.10 (2.14)	8.18*** (0.49)	10.04*** (0.66)
Point estimate with covariates and PSM	37.47 (0.55)	35.45 (0.61)	-2.03** (0.82)	39.07 (0.51)	49.46 (0.35)	10.39*** (0.62)	12.41*** (0.74)
Point estimate without covariates and PSM	37.35 (0.54)	35.45 (0.58)	-1.90** (0.79)	39.02 (0.48)	49.35 (0.34)	10.32*** (0.58)	12.23*** (0.72)
Observations	223	238	-	223	238	-	3115
R-square:							0.3495

Std. Errors in parentheses; **Inference: *** p<0.01; ** p<0.05; * p<0.1

Conclusion

This study has analyzed the effect of an incentive re-alignment scheme on the performance (in terms of labor outcomes) of community knowledge workers (CKWs), a special category of rural extension agents in Uganda. Despite the widely held view of agriculture's high importance in the economic transformation of sub-Saharan Africa (SSA), the lack of efficient extension systems to support agricultural development is a missing link. Various extension models, such as the Training and Visit system, have in the past four decades, received many international developmental support, in order to connect this missing link in the continent's agricultural transformation process. Some studies posit that incentives are critical for inducing the performance of workers. Moreover, information communication technologies (ICTs) have in the past decade, been widely applied in extension system. Yet, there is little empirical evidence of ICT-based extension incentive schemes in SSA.

Moreover, there is little evidence on the impacts of an ICT-based incentives on the performance of extension agents in the developing world, especially in SSA. The study utilizes a quasi-experimental technique in terms of difference–in–difference with propensity score matching (PSM) to estimate the effect of an incentive re-alignment on the performance of community knowledge worker (CKWs) in rural Uganda.

The main hypothesis was that an exogenous shift in the price of labor induces CKWs to increase labor supply in terms of their monthly performance (measured by monthly Search (CKW-Search). Result show that incentive realignment has positive and statistically significant effects on the performance of CKWs by 10% on average. In particular, the result suggests that rural extension workers in Uganda respond positively to a performance-based incentive system. Thus, the finding indicates that higher productivity of rural extension systems can be realized in rural Uganda through appropriate performance-based incentive schemes.

Determinants of CKW program participation include age of agents (by 1.5% points in favor of youths), larger family sizes (by 16%), and being a household head (by 17%). The result suggests that a performance-based incentive scheme could be more suitable for the youth population and thus, holds a promise of bringing the youth into agriculture through participation in incentivized extension schemes. Therefore, since the bulk of the farmers in the developing world are in rural areas and in dire need of agricultural extension services, a rural extension scheme that targets the youth could enhance rural employment, raise rural incomes, reduce rural urban migration, and lead to poverty reduction through multiplier effects.

This study contributes to the empirical literature on the performance of extension systems in the developing world. It opens the black box of performance evaluation for extension systems in SSA by empirically analyzing a unique ICT-monitored extension system in rural Uganda. Furthermore, by encouraging higher youth participation in extension through ICT-based incentives, many supply-side factors of extension systems could be improved. This could in turn enhance the productivity of smallholder farmers who immensely depend on extension advice for stimulating their agricultural production. It would consequently improve agricultural development and sustainable economic growth in SSA and elsewhere in the developing world.

Acknowledgements
This research was funded by the US Agency for International Development through the Norman E. Borlaug Leadership Enhancement in Agriculture Program (Grant number: AID Sub UC Davis 016258-128; Modernizing Extension and Advisory Services project (Grant number AID-OAA-L-10-00003), and Feed the Future Strengthening Agriculture and

Nutrition Extension project (Grant number AID-612-LA-15-00003, 2015) at University of Illinois.

We thank the Journal Editor and two anonymous reviewers for important feedback on an earlier draft. Their excellent comments significantly improved this article. We are also grateful to Alex Winter-Nelson and Kathy Baylis, Departments of Agricultural and Consumer Economics, University of Illinois, for meaningful feedback on earlier drafts of this article. Authors appreciate Grameen Foundation in Uganda for contextual information. We acknowledge Michael Culbertson for important help with data management. We take responsibility for any errors that may be found in this article.

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DOI: 10.18697/ajfand.84.BLFB1007

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 19 No. 1
January 2019
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ISSN 1684 5374

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