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THE (MARGINAL) COST OF TECHNOLOGY ADOPTION

A cost-effectiveness analysis of Digital Green's video-mediated agricultural extension approach in Ethiopia

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Since 2014, Digital Green and the Government of Ethiopia have been piloting a video-mediated approach to agricultural extension provision. The approach aims to increase the growth rate of yields and output for major food staples by encouraging farmers to adopt productivity-enhancing agricultural technologies and practices. The video-mediated extension approach is highlighted by three integrated components: production of short, localized video content, screening videos in group sessions facilitated by extension agents, and verification of the uptake of the target technologies and practices. A key tenet of this approach is its ability to increase adoption rates at a relatively low cost per farmer.

During the 2017 meher (rainy) season, IFPRI conducted a randomized controlled trial (RCT) of this video-mediated approach, specifically exploring its impacts on three priority crops (teff, wheat, maize) and three key agricultural practices (row planting, more precise seeding rates, and urea side dressing) in 347 *kebeles* from 30 *woredas*[i] located in Ethiopia's four most agriculturally important regional states. Using household- and farm-level data from a sample of 2,422 households belonging to development groups[ii] that were assigned to the RCT, results demonstrate that adding the video-mediated extension approach to the conventional approach is more effective than the conventional extension approach alone in achieving key outcomes (Abate et al., 2019). Specifically, we find that the video-mediated approach increases the reach of extension services to a wider audience and leads to higher levels of agricultural knowledge and uptake of technologies in *kebeles* selected for video-mediated extension.

Although our study joins others in demonstrating the impact of information and communication technologies (ICTs) in agricultural extension, there is still limited evidence from such studies on the cost-effectiveness of these programs[iii]. This project note presents results from a cost-effectiveness analysis (CEA) exercise conducted on Digital Green's video-mediated extension approach in Ethiopia. The CEA exercise uses marginal CEA analysis that draws on data from the RCT described above and Digital Green's cost data.

METHOD

The video-mediated extension approach is an intervention designed to augment the existing extension system. Therefore, we investigate the cost per additional adoption resulting from the video-mediated approach. Specifically, we measure marginal cost-effectiveness, which is the cost of an additional adoption that results from adding the video-mediated extension approach to the existing system.

We define the marginal cost-effectiveness ratio (MCER) as:

$$MCER_t^j = \frac{c_{tp}^j}{n_{tp}^j}$$

where c_{tp}^jmeasures the total costs of using video-mediated extension to promote technology j in year t in the sample of *woredas* and *kebeles* assigned to the intervention p. The term n_{tp}^j denotes the corresponding number of additional adopters, that is, those farmers who would not have adopted technology j had there been no video-mediated extension approach. We detail below our estimation of these parameters.

Components of marginal cost-effectiveness ratio

Costs used in our analysis include the incremental cost of Digital Green's video-mediated approach compared to the conventional extension approach, expressed as follows.

Costs $\left(c_{tp}^j\right)$

Drawing on Digital Green's own internal cost-effectiveness analysis manual and Mogues et al. (2017), we focus on project-level costs associated with the video-mediated approach. Digital Green's costs include personnel costs, training costs, operational costs, capital costs, and indirect costs incurred only in *kebeles* where video-mediated extension was conducted. We consider two cost scenarios: one which captures the marginal cost effectiveness of the intervention based on the coverage of the intervention associated with our RCT (the "Experimental Scenario"); and another which assumes that the intervention is targeted to all *kebeles* in the targeted *woredas*, and to all development groups in each kebele (a "saturation" scenario).

Table 1 summarizes all costs that we account for in this analysis. Several features of these costs are worth highlighting, as follows.

The costs analyzed here are the total costs incurred by Digital Green in promoting the video-mediated approach in this intervention over one meher season (2017), in 240 *kebeles* in 30 *woredas*.

Some costs are recurrent, such as personnel, operational, and indirect costs. For other costs such as equipment (computers, cameras, PICO projectors) and DA training costs, we assume a three-year lifespan, such that annualized costs represent one-third of the effective cost incurred during the one-year implementation of intervention.

Some costs are fixed at the *woreda*-level (see upper panel in Table 1). This implies that their contribution to the total cost is only affected by the number of *woredas*, not by the number of *kebeles* in each *woreda*. For example, extension staff need only one camera and one computer per *woreda* to produce and record videos, irrespective of whether one or all *kebeles* in a given *woreda* are targeted.

Some costs are fixed at the kebele-level (lower panel in Table 1). This means that their contribution to the total cost is affected by the number of *kebeles*, but not by the number of development groups targeted in each kebele. For example, extension staff need only one PICO projector per kebele to screen videos to farmers.

With regard to adoption, we take three technologies into consideration: row planting, more precise seeding rates, and urea side dressing. We assign the same weight to each technology in the absence of additional information on how to otherwise assign these weights. Thus, the cost per technology is obtained from dividing the total costs by three.

With this in mind, we let c_{tp}^j measure the yearly total costs of using video-mediated extension to promote technology j in 240 *kebeles* in 30 *woredas*.

Table 1 Annualized costs of the video-mediated intervention

Costs	Experimental scenario		Saturation scenario
Digital Green's Costs	**Costs in RCT *kebeles* (USD)**	**Annualized costs (USD)**	**Annualized costs (USD)**
***Woreda*-level costs**			
Personnel	31,416	31,416	
Training	137,645	45,882	
Operational	32,933	32,933	
Laptop (30 - 1 per *woreda*)	7,767	2,589	
Camera (30 - 1 per *woreda*)	43,096	14,365	
Indirect costs	76,782	76,782	
Total costs	329,639	203,967	
***Kebele*-level costs**			
PICO (240 - 1 per kebele)	52,235	17,412	
Total cost		221,379	269,261
Row planting		73,793	89,754
Lower seeding rate		73,793	89,754
Urea top dressing		73,793	89,754

Source: Authors' calculations, based on project cost data provided by Digital Green

Additional adopters $\left(n_{tp}^{j}\right)$

We measure the percent increase in the adoption rate of technology *j* attributable to the video-mediated intervention using the coefficient β on the treatment variable in the following specification:

$$y_i^j = \alpha + \beta^j T_k + Z_i' \delta + \pi_w + \varepsilon_i$$

where y_i^j denotes the level of outcome y measured at the household level i—whether or not the household has tried a given technology *j* (for example, row planting) for any one of the three focus crops. The variable T_k indicates the treatment status of *kebele* k where the household lives (with a value of 1 if household was treated and 0 if control). Z is a vector of household- and development group-level characteristics that account for baseline imbalances between groups and augments the over-all power of our estimates. These include a vector of variables such as distance to roads and services, and whether the household head received a formal education. We account for *woreda*-level stratification of our design through π_w, a set of *woreda*-level fixed effects. We also account for treatment assignment at the *kebele* level by clustering our standard errors at that level.

Since we use intent-to-treat (ITT) impact estimates, the coverage area consists of the development groups and their members list of farmers targeted by Digital Green in the treatment group that were targeted by the intervention. If we let N_t^j be the number of targeted households in the treatment *kebeles,* then the total number of additional adopters can be expressed as:

$$n_{tp}^j = \beta^j N_t^j$$

Corresponding estimates are provided in Table 2 below, under the column heading "Experimental scenario."

Table 2 Additional adopters

Coverage: N_t^j	Experimental scenario	Saturation scenario
Number of treated *kebeles*	231	450
Number of treated development groups per *kebele*	10	30
Number of treated farmers per development group	25	25
Number of farmers targeted	57,750	337,500
Impact estimates (ITT) on household head: β^j		
Row planting	0.043	
Lower seeding rate	0.078	
Urea top dressing	0.069	
Additional adopting farmers: n_{tp}^j		
Row planting	2,458	14,363
Lower seeding rate	4,516	26,391
Urea top dressing	4,000	23,375

Source: Authors' calculations.

Marginal CEA

The marginal cost-effectiveness ratio described above can now be calculated as:

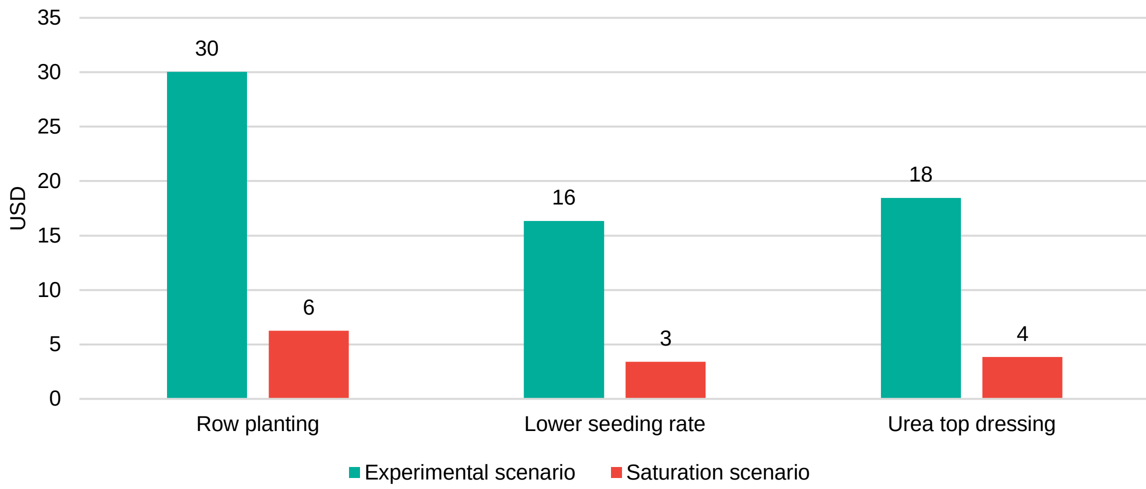
$$MCER_t^j = \frac{c_{tp}^j}{n_{tp}^j} = \frac{c_{tp}^j}{\beta^j N_t^j}$$

FINDINGS

In Figure 1, we report the marginal costs of adoption for each of the three technologies considered. Under the experimental scenario, the cost of each additional adoption of row planting was USD 30 (ETB 691)[iv]. Similarly, for lower seeding rate and urea top dressing, the cost of each additional adoption was USD 16 (ETB 376) and USD 18 (USD 424), respectively.

In Figure 1 we also report estimates of MCER under the saturation scenario. The corresponding increase in coverage is shown in column 3 of Table 2. On the cost side, as shown in column 4 of Table 1, those that are fixed at the *woreda*-level are not affected by the increase in per-*woreda* coverage. However, all kebele-level costs increase with the number of additional *kebeles* that are included. To account for the potential difficulties of reaching all development groups in a kebele with one PICO projector, we account for two PICO projectors per kebele in the saturation scenario.

Figure 1 Marginal cost-effectiveness ratios of video-mediated agricultural extension



Source: Authors' calculations.

Given the importance of fixed costs at the *woreda* level, the associated MCERs under full saturation are much lower than that of the experimental scenario. Securing one additional adoption of row planting costs just USD 6 (ETB 144); recommended seeding rates just USD 3 (ETB 78), and urea side dressing costs just USD 4 (ETB 88). Table 3 presents the MCERs in US dollars (USD) and Ethiopian birr (ETB).

Table 3 Marginal cost-effectiveness ratios in USD and ETB

Technology	Experimental scenario		Saturation scenario	
	USD	ETB	USD	ETB
Row planting	30	691	6	144
Lower seeding rate	16	376	3	78
Urea side dressing	18	424	4	88

Note: Calculated at the 2017 exchange rate of 23 ETB/USD.

Source: Authors' calculations.

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[i] The kebele is the primary level at which both administrative activities and agricultural extension is organized in Ethiopia; a *woreda* is comprised of multiple *kebeles* and is most similar to districts or counties in other countries and contexts.
[ii] In 2007, a small-scale randomized controlled trial conducted in India suggested that Digital Green's approach was ten times more cost-effective than training-and-visit approaches in terms of promoting farmers' adoption of technologies (Gandhi et al. 2007).
[iii] We discuss below how a saturated intervention in a given kebele may require two PICO projectors per kebele.
[iv] At the time this study was conducted and the intervention was implemented in 2017, the exchange rate was approximately 23 ETB/USD.

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