Africa Development, Volume XLVIII, No. 1, 2023, pp. 213-244
© Council for the Development of Social Science Research in Africa, 2023
(ISSN: 0850 3907) (https://doi.org/10.57054/ad.v48i1.3039)

Effective Knowledge Transmission and Learning in Agriculture: Evidence from a Randomised Training Experiment in Ethiopia

Hiwot Mesfin*, Yohannis M. Tessema**, Nyasha Tirivayi*** & Eleonora Nillesen****

Abstract

In this article, we discuss a study to identify an effective agricultural knowledge transfer channel for smallholder farmers in Ethiopia, using a randomised training experiment together with focus group discussions, key informant interviews and a survey. We also examine the factors that determine learning among smallholder farmers. Our results revealed that involving extension agents and model farmers leads to above-average knowledge transfer. However, learning from extension agents is significantly more effective than learning from model farmers. Additionally, we found that trust, effort, and locus of control are important determinants of learning. On the other hand, we found no evidence that farmers exert more effort when they are trained by extension agents, hence this rules out effort as a mechanism for higher learning from the extension agents. Based on these results, we conclude that, on average, the extension agent system is more effective at conveying agricultural knowledge than model farmers are and that policy-makers can use the two channels as complements rather than substitutes.

Keywords: Knowledge communication, learning, agricultural extension service, model farmer, training experiment, Ethiopia

* United Nations University – UNU MERIT, Maastricht University, The Netherlands. Email: mesfin@merit.unu.edu

** Independent Researcher, Ethiopia. Email: yohannism@gmail.com

*** UNICEF Office of Research, Innocenti, Italy. Email: yohannism@gmail.com

****UNU-MERIT, Maastricht University, The Netherlands. Email: nillesen@merit.unu.edu

Résumé

Dans cet article, nous discutons d'une étude visant à identifier un moyen efficace de transfert de connaissances agricoles pour les petits exploitants agricoles d'Éthiopie, en utilisant une expérience de formation aléatoire ainsi que des discussions de groupe, des entretiens avec des informateurs clés et une enquête. Nous examinons également les facteurs qui déterminent l'apprentissage chez les petits exploitants agricoles. Nos résultats ont révélé que l'implication d'agents de vulgarisation et d'agriculteurs-modèles mène à un transfert de connaissances supérieur à la moyenne. Cependant, apprendre d'agents de vulgarisation est beaucoup plus efficace qu'apprendre d'agriculteurs-modèles. De plus, nous avons constaté que la confiance, l'effort et le locus de contrôle sont d'importants déterminants de l'apprentissage. D'autre part, nous n'avons trouvé aucune preuve que les agriculteurs déploient plus d'efforts lorsqu'ils sont formés par des agents de vulgarisation, ce qui exclut donc l'effort en tant que mécanisme d'apprentissage supérieur de la part des agents de vulgarisation. Sur la base de ces résultats, nous concluons qu'en moyenne, le système d'agents de vulgarisation est plus efficace dans la transmission de connaissances agricoles que les agriculteurs-modèles, et que les décideurs politiques peuvent utiliser les deux canaux comme des compléments plutôt qu'en tant que substituts.

Mots-clés : transmission de connaissances, apprentissage, service de vulgarisation agricole, agriculteur-modèle, expérience de formation, Éthiopie

Introduction

Agriculture plays a vital role in the economy of most low-income countries. It is their main source of employment, national income, and foreign currency, among other outcomes. Particularly in Ethiopia, the agriculture sector employs 72 per cent of the population, constitutes 35 per cent of the Gross Domestic Product (GDP) and contributes 90 per cent of the foreign earnings (CIA 2020). Hence, increasing the production of the agriculture sector can serve as an engine of economic growth (Awokuse 2009).

Increasing agricultural production requires using improved techniques (technology) and the accumulation of factors of production as well as raising the efficiency of factors of production for a given technology.[1] However, given the limited extent to which arable land can be expanded, technological innovation and adoption is the main pathway for sustained growth of the agriculture sector and, concomitantly, overall economic development. Nonetheless, the adoption of improved technologies, especially in the agriculture sector, remains very low in developing countries (Duflo, Kremer and Robinson 2008; Rashid et al. 2013).

One of the main starting points for technology adoption is information and knowledge. In order to address the information and knowledge constraints that farmers face in Ethiopia, the government has established and run one of the most extensive publicly funded agricultural extension services (AES) in Africa. However, its effectiveness remains controversial and has been criticised for its hidden political motive. For example, Berhanu and Poulton (2014) argue that the Ethiopian government's commitment to the extension service emerges from its interest in securing the political support of the rural population. They further argue that the extension service's political orientation negatively affects the efficacy of the service in attaining its main role, which is to increase the productivity of farmers by providing knowledge and information and promoting new technologies.

Moreover, given its high costs, the sustainability of the Ethiopian AES has been questioned. As a remedy, recommendations have emerged, suggesting that the government can leverage social (peer) learning and reduce its investment in the AES. Theoretical studies show that there is a huge potential for peer effects in knowledge and innovation diffusion (Rogers and Shoemaker 1971; Young 2009). As a result, the Ethiopian government, as with its many other African counterparts, has institutionalised peer learning by introducing the model (lead) farmer approach. Ideally, the model farmer is a farmer who serves as a role model by taking the lead in adopting new technologies. Additionally, the model farmer is expected to transfer the knowledge he or she obtains from the extension agents to fellow farmers and convey feedback from farmers back to the extension agents.

However, the empirical literature shows limited support for the effectiveness of the lead farmer approach. For example, in their investigation of the effectiveness of model farmers in disseminating knowledge about soil and land management techniques (SLM) in Mozambique, Kondylis, Mueller and Zhu (2017) found that although the lead farmers largely adopted SLM themselves, their impact on other farmers' adoption behavior was negligible. Similarly, Ragasa (2019) found that exposure and interaction with model farmers in Malawi leads to neither awareness nor adoption of new technologies. However, she found that the quality of the model farmers, measured by the regularity of the training they received and their adoption behaviour, leads to increased awareness and adoption by fellow farmers. A study by BenYishay and Mobarak (2019) also compares the effectiveness of different communication channels in Malawi – extension agents, model farmers and peer farmers – and examines the role of incentives in facilitating learning. They show that incentivising peer farmers leads to a larger diffusion of knowledge. Interestingly, they found that the diffusion of knowledge via model farmers was negligible with or without incentives. Similarly, another study in Ghana showed that peer learning can only be effective after the information is made available about new technologies, meaning that some expert training is required to initiate the diffusion of knowledge and innovation (Conley and Udry 2010). On the other hand, a study by Savastano and Feder (2006) ascertained the importance of the relatability of information sources in agricultural knowledge diffusion through social networks.

Given the inconclusive evidence in the existing literature, we aim to contribute to a better understanding of effective knowledge communication in agriculture. In addition, we examine the factors that affect learning. To this end, we used a randomised controlled training experiment to investigate the effectiveness of the two most common agricultural information sources – the extension agents and model farmers – in transferring knowledge in the Ethiopian context. Moreover, to obtain a deeper understanding, we also employed focus group discussions, key informant interviews and a survey to collect qualitative and quantitative data, respectively.

The existing empirical studies in Ethiopia are based on a geospatial formulation of social networks, which assumes that learning occurs through geographic proximity. For example, a study by Tessema et al. (2016), demonstrated a positive neighbourhood effect on the adoption of conservation tillage among Ethiopian farmers. A similar spatial study by Krishnan and Patnam (2013) also suggested that social learning is more effective than learning from agricultural extension agents, to bring about a wider diffusion of technology, whereas extension agents are more effective at initialising diffusion. Because these studies rely on observational survey data, their findings may suffer from endogeneity bias, limiting them from identifying causal impacts. In addition, we are not aware of any other experimental study in Ethiopia – a case we believe is interesting for its unprecedented level of investment in the extension sector but still achieving below the desired level of technology adoption.

Against this backdrop, we aim to answer the following questions:

1) Do farmers learn better from extension agents or model farmers?
2) What are the potential mechanisms?
3) What factors determine learning about agricultural technologies?

To answer our research questions, we conducted a randomised training experiment where one group of randomly selected farmers received training from extension agents and another group from model farmers. To avoid contamination due to existing knowledge, we selected a brand-new technology, namely, 'push-pull' farming, a promising technology devised to fight stem borers and Striga, a pervasive and devastating parasite and weed in the study area. Our results showed that, on average, farmers learn better from extension agents than from model farmers. We tested whether effort is the mechanism that leads to higher learning from the extension agents (EAs). However, our results failed to provide evidence to support this hypothesis. Additionally, our results showed that trust, effort, and locus of control positively affect learning.

The remainder of this article is organised as follows. The next section provides a detailed review of related literature. We then present the research methodology, and show and discuss the results. The final section concludes with a summary and recommendations.

Related Literature

The agriculture sector, in most developing countries, is uniquely positioned for poverty reduction. This is because enhanced agricultural productivity helps smallholder farmers to move out of poverty while supplying staple crops at lower prices for the urban poor. The growth in the agriculture sector also creates a multitude of job opportunities along the agribusiness value chain and creates forward and backward linkages with the non-agricultural sectors, and thus serves as an engine for economic transformation (Christiaensen, Demery and Kuhl 2011; Pingali 2012). Conversely, this means that low productivity in agriculture could mean an inability to feed the population or produce adequate industrial raw materials, constraining the whole economy. Therefore, the development of the agriculture sector by increasing its productivity is vital for developing countries' economies. Increasing agricultural production requires the adoption of yield-enhancing technologies, which in turn requires information and know-how about new technologies (Ryan and Gross 1950; Weber 2012).

Unfortunately, the reality is that most African countries lag in their agricultural productivity and agricultural technology adoption. For example, the average cereal yield in Africa is about 1.5 tons per hectare, whereas it is about 3 tons per hectare in South Asia and 6 tons per hectare in East Asia. When we look at technology utilisation, we observe that, in 2016 for example, fertiliser use per hectare in sub-Saharan Africa was about 16 kilograms per hectare whereas in South Asia and East Asia and the Pacific it was 160 and 331 kilograms per hectare, respectively (World Bank 2020).

Many studies have been conducted to understand the low adoption of agricultural technologies. These have shown that the main challenges are embedded in the complexity of the adoption process, which constitutes discovery and learning, cost, resource constraint and risk, and other behavioural factors. For example, Liu (2013) found that risk-averse farmers delay adoption whereas risk-takers adopt early. Other behavioural factors covered in the literature include farmers' locus of control, where internally controlled farmers have a higher adoption rate of agricultural technologies compared to those who are externally controlled (Abay, Blalock and Berhane 2017). Another factor is procrastination, where impatient farmers keep postponing the purchase of profitable inputs until the last minute and end up not purchasing them (Duflo et al. 2011).

Studies also show that resource constraints hinder the adoption of agricultural technologies. For example, Asfaw et al. (2011) found that wealth (proxied by livestock ownership and land size) and availability of labour positively drive the adoption of improved agricultural technologies. Similarly, Croppenstedt, Demesche and Meschi (2003) revealed that a lack of credit and liquidity hinder the adoption of chemical fertiliser. Additionally, in their review of the literature, Smucker, White and Bannister (2000) conclude that tenure security increases the adoption of technologies.

Information constraint, the focus of this study, has also received extensive attention in the literature. For example, the pioneering adoption study by Ryan and Gross (1950) shows that the early adopters of a high-yielding corn variety in Iowa were more educated, 'cosmopolitan' and had salesmen as their source of information.[2] The late adopters, on the other hand, used neighbours as their source of information and persuasion. Within thirteen years the corn variety was almost entirely adopted because of its superiority in yield and drought resistance. Subsequent studies have affirmed the role of education in technology adoption (for example, Croppenstedt et al. 2003; Asfaw and Admassie 2004). Similarly, learning from successful neighbours has been documented among farmers in Ethiopia and Ghana (Tessema et al. 2016; Conley and Udry 2010).

To overcome the information constraint, the Ethiopian government provides an agricultural extension service to farmers, to supply information, knowledge, and technical skills free of charge.[3] In Ethiopia, the agricultural extension service began in the early 1950s (Gebremedhin, Hoekstra and Tegegne 2006). The current government, the Ethiopian People's Revolutionary Democratic Front (EPRDF), has focused on expanding the service, creating one of the largest agricultural extension services in the world, with the lowest farmer-to-agent ratio. According to the Ministry of Agriculture's agricultural extension strategy document (2017), there are 56,000 extension agents and 18,000 farmer training centres (FTCs) spread across the country. As we discuss in the introduction to this paper, the government uses both trained agricultural extension agents and model farmers to disseminate information among farmers. However, as pointed out, the service may have an additional objective, to politically influence the rural population (Berhanu and Poulton 2014; Hailemichael and Haug 2020). This aim may have a negative effect on the effectiveness of the extension service to achieve its primary objective, which is to increase technology uptake and the productivity of farmers. If farmers are sceptical of the motives of the extension agents, they might trust them less and hence could be reluctant to seek information from the agents or participate in field demonstrations of technologies. In such cases, it is imperative to look at alternative ways to communicate knowledge and information with farmers. Also, farmers might be inclined to learn from other farmers because they share similar interests, risks, and constraints, unlike those of the extension agents (BenYishay and Mobarak 2019).

Studies have evaluated the impacts of the AES, despite being constrained by the identification problem due to the non-random assignment of the extension service and potential self-selection associated with it. For instance, Dercon et al. (2009) found that AES increases consumption and reduces headcount poverty among Ethiopian farmers. They argue that improved agricultural practices and fertiliser application followed the recommendations by the AES. Similarly, Feder and Slade (1986) showed a positive impact of the Indian training and visit extension programme on the knowledge of farmers regarding high-yielding varieties of crops. Also, a review by Birkhaeuser, Evenson and Feder (1991) concluded that there is a positive relationship between knowledge acquisition and technology adoption following an extension service on both, but advise against interpreting the findings as causal. Owens, Hoddinott and Kinsey (2003) showed a positive effect of the extension service on agricultural productivity in Zimbabwe. Moreover, Pan, Smith, and Sulaiman (2018) found a positive effect of the extension service in agricultural production and savings in Uganda. Furthermore, Cole and Fernando (2012) indicate that providing farmers with continuous and demand-driven agricultural advice improves input utilisation, results in the cultivation of more profitable crops, and reduces old and ineffective pesticide utilisation. Similarly, Godtland et al. (2004) could show that farmers who attend farmers' training schools exhibit a better knowledge of integrated pest management practices and thus achieve higher productivity than those who do not attend the FTS. The literature concludes that the impact of AES is highest at the earliest stages of technologies than at later stages (Anderson and Feder 2004; Conley and Udry 2010; Krishnan and Patnam 2013).

Methodology

In this section, we present the experimental design, some descriptive statistics and the empirical estimation strategies.

Experimental design and data

To identify an effective knowledge communication channel in agriculture, and examine the roles of trust, effort, and locus of control in learning, we conducted a randomised training experiment together with focus group discussions, key informant interviews and a survey data.

We conducted the study in the lowland parts of the North Shewa zone, Amhara regional state, Ethiopia. Given its agroecology, sorghum is the main crop produced during the main rainy season. However, sorghum production is challenged frequently by stem borer and infestation by the invasive Striga plant.

Figure 1: Stem-borer larvae attacking a sorghum plant

Photo: Shumet Chakel (This picture was taken in a sorghum plot during the fieldwork in Ethiopia)

For example, stem borer and Striga account for a 30 to100 per cent yield loss in the Lake Victoria basin (Khan et al. 2000). Our survey results showed that 90 per cent and 86 per cent of the sampled farmers are affected by stem borer and Striga, respectively (see Table 1). The survey further indicated that many farmers rely on chemical application to control the pervasive pest and weed in maize and sorghum farms. The International Centre of Insect Physiology and Ecology (icipe), in collaboration with funding partners, introduced a farming strategy (agronomic practice) known as 'push-pull'. The practice involves companion planting, where one of the plants (namely, Desmodium) produces chemicals that repel stem-borer larvae from the maize/sorghum plant while the second plant (Napier grass) attracts the larvae, traps and kills them – hence its name, push-pull. Additionally, these plants prevent the Striga weed from growing and attaching itself to the roots of the maize/sorghum plant.

Figure 2: Striga weed crowding a maize plant and stunting the maize
Source: Plantwise Knowledge Bank (2014) (The picture is taken in Uganda)

Table 1: stem borer and striga infestation and solutions used by farmers in the study area

Variable	Mean	Std. Dev.
Stem borer		
In the past 3 years, have you … had stem-borer infestation? (yes 1; no 2)	0.903	0.296
… sprayed chemicals (yes 1; no 2)	0.893	0.31
… used traditional solutions (yes 1; no 2)	0.066	0.249
… used a combination of chemicals and traditional solutions (yes 1; no 2)	0.055	0.229
I had no solution (yes 1; no 2)	0.041	0.198
Striga weed		
In the past 3 years, have you … had Striga weed infestation? (yes 1; no 2)	0.86	0.348
… sprayed chemicals (yes 1; no 2)	0.085	0.28
… used traditional solutions (yes 1; no 2)	0.062	0.242
… used a combination of chemicals and traditional solutions (yes 1; no 2)	0.027	0.163
.. weeded manually (yes 1; no 2)	0.973	0.163
I had no solution (yes 1; no 2)	0	0

The fact that the farmers in the area have been actively seeking an effective way to tackle the stem borer and Striga, coupled with the newness of the technology, provided us with a perfect setting to study the effective means of communicating knowledge regarding new technology to farmers. Note that, according to the results in Table 1, all of our respondents confirmed never having heard of the technology before the training. Taking advantage of this setting, we provided training on the operation of a push-pull farm plot using two communication channels: the Extension Agent (EA) and the Model Farmer (MF). The Ethiopian agricultural extension system heavily hinges on extension agents and model farmers to disseminate information and knowledge to highly scattered smallholder farmers. This was the main reason why we selected them as the trainers of the push-pull technology in our experiment.

For this training experiment, we first provided training of trainers (TOT) to the EAs and MFs. The training was done by agronomy researchers who specialise in sorghum and maize, at the Debre Birhan Agricultural Research Centre, Ethiopia. The training involved teaching the details of the push-pull technology, setting up successful push-pull plots, and learning about the economic benefits of the push-pull practice. The training manual was first translated into the local language (Amharic), and both the TOT and the main training were conducted in Amharic. The agronomists trained twelve EAs and twelve MFs from twelve, randomly selected Gots, in two districts: Shewa-Robit and Ataye, North Shewa Zone, Ethiopia.[4] The trained MFs and EAs then trained twelve or thirteen farmers in their respective Gots. Immediately after the completion of the training, enumerators assigned to each of the training venues administered ten-item multiple-choice questions to gauge the knowledge the farmers had acquired from the training. Next, the enumerators gathered demographic and socioeconomic information about the respondents, and information on their access to public services, including the extension service and their trust and level of satisfaction in public services. The following section presents and discusses the estimation strategy.

Figure 3: Sorghum field damaged by stem borer
Photo: Shumet Chakel (This picture was taken during the fieldwork in Ethiopia)

Estimation strategy

We start by showing our strategy for identifiying the effective knowledge transmission channel and proceed to show the strategies used to study the effects of trust, effort and locus of control. We conclude the section by showing the strategy we used to identify the determinants of trust, effort and locus of control.

Effective knowledge transmission channel, trust, effort and locus of control (LOC)

To identify the more effective knowledge transmission channel, as well as the effects of trust, effort and locus of control in learning, we used ordinary least squares (OLS) regression as specified in equation 1:

$$Knowledge_i = \beta_0 + \beta_1\, Treatment_i + \beta_2\, Trust_i + \beta_3\, Effort_i + \beta_4\, LOC_i + \sum_{(i=1)}^{14} \beta_i X1_i + \mu_i \qquad (1)$$

where, $Knowledge_i$ is the knowledge retained by the farmer *i*; β_0 is the constant term; $\beta_1 - \beta_4$ represent the coefficients of interest; $treatment_i$ is the treatment status of farmer *i* such that $treatment_i = 1$ if farmer *i* is trained by an EA, 0 if trained by model farmer; is an indicator for whether farmer *i* trusts the extension service; $Effort_i$ is a dummy indicator of farmer *i*'s effort to learn.

We measured effort by asking farmers whether they asked or answered questions during the training. Next, we generated an effort indicator to the value of 1 if the farmer asked or answered a question during the training, and 0 otherwise; LOC_i is an indicator for farmer *i*'s locus of control. To measure the LOC, we adopted the survey instrument developed by Bernard, Taffesse and Dercon (2008), where farmers answer the following question: 'Which one of the following statements do you agree the most?' The responses were either, (1) 'To be successful, above all, one needs to work very hard', or (2) 'To be successful, above all, one needs to be lucky'. We then recoded these responses such that LOC equals 1 (internally controlled) if farmer *i* chooses the first response, or 0 otherwise; $X1_i$ are other control variables, including age, sex, family size, land size, farm experience, education, TV ownership, mobile phone ownership, credit access, position held, locus of control, satisfaction in the training, effort during the training, trust attitude, self-assessed agricultural knowledge, trust in the expertise of the EAs and MFs, as well as trust in the extension system; μi is the stochastic error term.

Since the test questions used to measure the farmers' knowledge acquisition were in multiple-choice format, it was likely that some farmers might answer some questions correctly, just out of luck. To mitigate this, and as a robustness check, we also estimated the impact of the trainer type on the probability of scoring more than half in the knowledge acquisition test. To do this, we converted the outcome variable into a dummy variable named $Pass_i$ in equation 2, where it took the value 1 if a farmer's score was greater than five, or 0, otherwise, and estimated the following probit model.

$$Prob(Passi=1 \mid Z_1) = \Phi(\alpha_0 + \alpha_1\, Treatment_i + \alpha_2 Trust_i + \alpha_3 Effort_i + \alpha_4 LOC_i + \sum_{(i=1)}^{14} \alpha_i X1_i) \qquad (2)$$

where, α_0 is the constant; $\alpha_1 - \alpha_4$ are the parameters of interest; Φ is the cumulative normal distribution function; Z_1 is the set of all righthand-side variables.

Determinants of trust, effort and locus of control

We also aimed to understand the determinants of trust, effort and locus of control. These were dummy variables (i.e. taking the values 1 and 0), hence we estimated the following probit model to uncover the determinants as follows:

$$Prob(Y_i=1 \mid X2_i) = \Phi(\delta_0 + \sum_{(i=1)}^{14} \delta_i X2_i) \qquad (3)$$

where, Y_i represents the outcome of interest variables–trust in extension service, effort and locus of control; δ_i are the parameters of interest, and $X2_i$ are the vectors of explanatory variables; Φ is the cumulative normal distribution function.

Empirical Results and Discussion

In this section, we present the statistical and econometric results. We start by showing the descriptive statistics along with balancing properties and move to present the main result, which is identifying the most effective knowledge transmission channel. Next, we investigate the role of trust and effort independently, and later we use an interaction term to test whether effort is the mechanism that leads to higher knowledge acquisition. Afterwards, we discuss the effect of locus of control on knowledge acquisition. Lastly, we conclude by showing the determinants of trust, effort and locus of control.

Effective knowledge transmission channel

We hypothesised that farmers would learn more from model farmers who might be better equipped to deliver information in such a way that would be easily accessible to their fellow farmers. Previous studies also suggest the importance of relatability of information sources in the uptake of the information (for example, BenYishay and Mobarak 2019). Moreover, as we discussed in the introduction, if the extension agents were doubling as political agents, farmers might trust them less and learn less from them. Contrarily, farmers might learn more from extension agents if they perceived them to be more knowledgeable because they had better education. Additionally, it could be the case that the extension agents were better equipped to convey the message because they may have had the pedagogical training on how to deliver agricultural knowledge to less-educated farmers in an accessible manner.

Before discussing the econometric results, we present the results of the balancing test and descriptive statistics. The balancing test indicates that we have successful randomisation with regards to most of the demographic and socioeconomic control variables. Note that 'internal control', 'extension agent know same' and 'model farmer know same' are unbalanced. We control for these effects and other variables in our regressions to test the robustness of the treatment effect estimate (we return to this discussion in the coming paragraph). As can be seen from Table 2, on average, farmers trained by extension agents scored higher than those trained by model farmers. What is interesting, however, is that farmers trained by both on average scored more than half, which could imply that both methods serve well in transmitting knowledge. Figure 4 shows the distribution of test scores by trainer type. The test score of farmers trained by model farmers more or less follows a normal distribution, whereas for farmers trained by extension agents, the distribution is skewed to the right, with more farmers scoring more than the median.

The descriptive statistics presented in Table 2 show that the average age of the participant farmers is forty-two and forty-four for the control and treatment groups, respectively. The average landholding is 0.715 hectares and 0.784 hectares; most of the farmers have either no education or basic education that enables them to read and write; 88 per cent and 87 per cent of farmers own mobile phones; 63 per cent and 67 per cent of farmers have or have held some type of position in their communities; and 44 per cent and 40 per cent own a television (these statistics are presented such that the first values are for the control group and the second values for the treatment group, respectively). Note that the proportion of females is very low, constituting about 1 per cent of the participants in both groups. This is mainly due to the fact that very few women were household heads in the study area, and our training targeted household heads since they are in charge of making farming-related decisions.

Figure 4: Distribution of test scores by trainer type

Interestingly, more farmers reported satisfaction with the training in our control group (trained by model farmers) than in the treatment group (trained by extension agents), with about 72 per cent of farmers expressing 'very satisfied' to the following survey question: 'How satisfied are you with the training you just received?', whereas the percentage for those trained by the extension agents was 65 per cent.[5] Similarly, trust in the extension service was higher in the control group compared to the treatment, at 65 per cent and 59 per cent, respectively. Following the World Values Survey, we also measured generalised trust among the respondents by asking the following question: 'Generally speaking, would you say that most people can be trusted or that you cannot be too careful in dealing with people?' The response options given were: 1) 'Most people can be trusted', or 2) 'You cannot be too careful in dealing with people'. According to the survey results, 40 per cent of the respondents in the control group and 35 per cent of the respondents in the treatment group appeared to be trusting.

Table 2: balance table between control and treatment groups

Variables	Control	Treatment	Difference
Scores	5.621	6.484	0.863***
	(2.045)	(2.004)	(0.234)
Effort	0.462	0.529	0.067
	(0.500)	(0.501)	(0.058)
Farm size	5.076	5.084	0.008
	(1.603)	(1.769)	(0.195)
Age	42.855	44.116	1.261
	(12.444)	(12.626)	(1.449)
Sex	0.938	0.955	0.017
	(0.242)	(0.208)	(0.026)
Land size	0.715	0.784	0.069
	(0.539)	(0.755)	(0.076)
Farm experience	24.766	26.658	1.893
	(12.707)	(13.596)	(1.522)
No education	0.559	0.535	-0.023
	(0.498)	(0.500)	(0.058)
Read and write	0.366	0.394	0.028
	(0.483)	(0.490)	(0.056)
Own TV	0.441	0.400	-0.041
	(0.498)	(0.491)	(0.057)
Position	0.634	0.671	0.036
	(0.483)	(0.471)	(0.055)
Internally controlled	0.883	0.948	0.066**
	(0.323)	(0.222)	(0.032)
Training satisfied	0.717	0.652	-0.066
	(0.452)	(0.478)	(0.054)
Trusting	0.400	0.348	-0.052
	(0.492)	(0.478)	(0.056)
Know more	0.331	0.310	-0.021
	(0.472)	(0.464)	(0.054)
Know same	0.510	0.600	0.090
	(0.502)	(0.491)	(0.057)
Extension agents know more	0.655	0.581	-0.075
	(0.477)	(0.495)	(0.056)

Extension agents know same	0.214	0.335	0.122**
	(0.411)	(0.474)	(0.051)
Model farmers know more	0.531	0.452	-0.079
	(0.501)	(0.499)	(0.058)
Model farmers know same	0.331	0.471	0.140**
	(0.472)	(0.501)	(0.056)
Trust extension	0.648	0.587	-0.061
	(0.479)	(0.494)	(0.056)
Observations	145	155	300

Notes: The variables 'Extension agents know more' and 'Extension agents know same' were generated from the following survey question. 'Compared to most farmers in your village how knowledgeable are the extension agents about agriculture?' and the responses were (1) 'They know more'; (2) 'They know the same'; or, (3) 'They know less', where the base category is (3), 'They know less'. Similarly, 'Model farmers know more' and 'Model farmers know same' are generated by asking farmers the following: 'Compared to most farmers in your village how knowledgeable are the Model farmers about agriculture?' and the responses were :(1) 'They know more'; (2) 'They know the same'; or, (3) 'They know less', where, the base category was (3) 'They know less'. Similarly, education was a three-category variable where farmers were categorised as having (1) 'No education', (2) 'Read and write', and (3) 'Have some formal education'. The base category is (3), 'Have some formal education'. Standard errors are in parentheses.

Significance: * $p<0.05$, ** $p<0.01$, ***$p<0.001$.

Table 3 presents the regression results of the OLS model and the marginal effects of the probit model. The results show that farmers trained by the EAs gained more knowledge compared to those trained by MFs. On average, a farmer trained by EAs obtained a knowledge score that was higher by 0.86 points compared to that of farmers trained by the MFs. This difference is statistically significant even at a 1 per cent level and is robust to the inclusion of a number of demographic, social, economic, behavioural and perception factors. The probit model also yields qualitatively similar results, but the effect size is slightly bigger than the one from the OLS model. Figure 5 graphically illustrates the OLS estimates.

As we discuss in the introduction, previous studies of the diffusion of knowledge through different sources have showed mixed results. For example, BenYishay and Mobarak (2019) found a higher knowledge flow from farmers to fellow farmers than from experts to farmers in Malawi. Contrarily, Kondylis et al. (2017) could show no higher diffusion of knowledge from trained model farmers (contact farmers, as they call them) to other farmers compared to the diffusion of knowledge from extension agents to farmers in Mozambique. The reason for the difference in the results could be the fact that, in the BenYishay and Mobarak (2019) study, they carefully selected contact farmers who were representative of the farmers in Malawi, whereas in Kondylis et al. (2017) they used the existing contact farmers (also known as model farmers). This could be an indication that the difference between the model farmers and other farmers may constrain learning and information flow, despite the policy intention that aims to use model farmers (farmers who are more productive and have a higher propensity to adopt technologies and experiment) to entice other farmers to learn and adopt technologies. Indeed, our FGDs informed us that it was those with better land quality and better resources who were often selected to be model farmers and not necessarily because of their 'better agricultural knowledge'. This perception could lead farmers to be less interested in learning from the model farmers. Based on our key informant interviews, we also found that the model farmers felt that fellow farmers 'look down on them' and that the farmers were uninterested in taking advice from them.

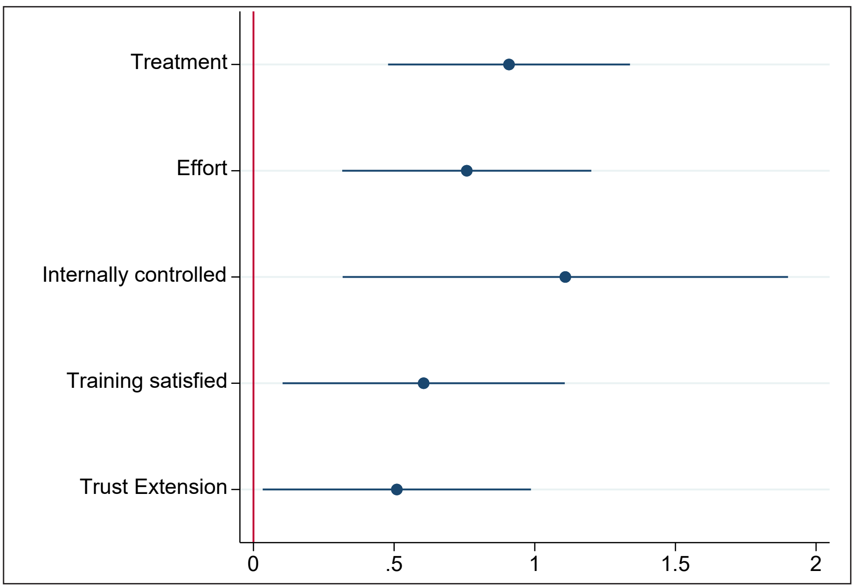

Figure 5: Coefficients of selected variables from the OLS regression estimation

Trust and learning

Trust plays a vital role in society, and the lack thereof could undermine the performance of an economy in several ways. Empirical evidence has shown that trust affects education, service uptake and trade, among other inputs, thereby impacting economic growth and development (Knack and Keefer 1997; Sako 2006; Bjørnskov 2012; Belissa et al. 2019).

In this section, we focus on the role of trust of the extension service in learning outcomes. We measured trust in the extension system by asking farmers how much they trusted the extension system on a scale of three: 'so much trust', 'not much trust', and 'no trust at all'. We then re-coded this into a dummy variable, taking 1 if the farmers selected 'so much trust', and 0 if the farmer selected 'not much trust' and 'no trust at all'. According to the widely accepted definition of trust by Mayer, Davis and Schoorman (1995), trust is 'the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other part.' According to this definition, trustors are vulnerable, meaning that 'there is something of importance to be lost', which is the case with farmers because they have to follow the advice given by the extension agents to make livelihood-determining decisions. Trust in the extension service, as we show in Table 3, is positively and significantly correlated with learning from the extension agents. Keeping all else constant, a farmer who trusts the extension service obtains about 0.50 points higher in the knowledge score. These results contradict the study by Buck and Alwang (2011), where they found no correlation between trust and learning outcomes among Ecuadorian farmers.

In fact, this finding is not surprising in the study area. During the focus group discussion, it became apparent that farmers in the area were convinced that the extension agents had increasingly taken the role of input suppliers rather than sources of knowledge and information. The farmers underscored that the EAs' main job had become distributing inputs such as chemicals at times of 'werershign' ('epidemic of diseases and weeds'), and fertiliser. Farmers also appeared to be frustrated by the inadequacy of input distribution due to limited supply and alleged corruption. They appealed for the government to work towards availing inputs in the market at a reasonable price instead of trying to provide it for free because the free supply did not benefit anyone. One discussant said:

> Once, a disease hit our farm, and the EAs brought chemicals for us to spray. However, the amount we got was too small even to cover a row, let alone

> an entire plot. When asked why they are giving us such a small amount of chemicals, the EAs told us that the only have a small supply and that they have to make sure that every farmer gets some. But we knew that was not the case. We knew where the were taking the chemicals. In the end, none of us were able to control the disease, and we faced a devastating loss of production.

Some discussants during the FGD also stated that the EAs know little about agriculture. They indicated that some EAs would not even know the types of crops by looking at the plants. One farmer said:

> I grow turmeric, but I am pretty sure that the EAs would not know what the plant is if you ask them. How could they help me improve my production if they do not know what plant I am growing?

When asked about the importance of farmer training centres and demonstration plots, in one of the villages one discussant said:

> Some years ago, the agriculture office used to have demonstration plots; these days, they have none. These days, we meet at the FTC once a month to discuss random issues, such as, '*yager guday lay lemeweyayet*', ('to discuss national issues').

In another village, farmers informed us that there was a demonstration plot often covered with various crops planted in rows. One discussant stated with amusement, 'They (the EAs) even plant the mung bean in rows. However, I planted it by broadcasting, and it looked much better than theirs; mine had longer and bigger seedpods'.

On the other hand, some of the discussants expressed that sometimes they received very useful advice from the EAs. In one of the FGDs, one discussant gave the following example:

> We were once baffled because when we spray a pesticide, our crop was dying. Then, the EAs taught us the need to thoroughly wash our sprayer in between chemical applications, as some chemicals, when mixed with another, could have an adverse effect on the plants. This piece of advice saved us from killing our plants with pesticide contaminated with other kinds of chemicals.

From the focus group discussions, it seemed the farmers were losing confidence in the extension system, including the expertise of EAs. But it is also important to note that some farmers had benefited from the advice received from EAs.

Effort and learning

The results, also reported in Table 3, show that effort is associated with higher knowledge acquisition. Farmers who exerted more effort scored about 0.76 points more than those who exerted less effort. Note that this result shows the correlation between effort and test scores. Since it could also be the case that participants who are highly motivated to learn in the first place would be the ones who are more likely to exert effort (that is, ask or answer questions during the training), we refrained from interpreting these results as a causal relationship.

Additionally, to test whether effort is the mechanism that leads to a higher learning outcome from extension agents, we included an interaction term between effort and treatment status. This was because, for example, farmers assigned to be trained by the extension agents would be more likely to exert more effort to learn because they would expect the agents to be more knowledgeable and would want to extract as much knowledge from them as possible. The results of the interaction term, presented in Table 4, however, show no statistically significant difference in effort level between the two groups. This means that farmers in the extension agent treatment arm were no more likely to exert more effort than those in the model farmer treatment. Hence, the observed higher score in the extension trainer treatment arm could be due to better delivery of the content by extension agents. However, as it is difficult to measure the delivery technique, we were unable to provide evidence for this, and it could be an interesting area for future research.

Locus of control and learning

Another interesting result we uncovered was the role of a farmer's locus of control in knowledge acquisition. Locus of control (LOC) is an individual's sense of control over her or his life (Rotter 1990). According to Rotter (1990), individuals who believe they control what happens in their life are categorised as individuals with internal control, whereas individuals who believe that an external force determines what happens in their life are categorised as individuals with external control. Studies have shown a strong association between LOC and various outcomes. For example, Abay et al. (2017) found that farmers with internal LOC have a higher tendency to adopt new technologies compared to their counterparts with external LOC. Another study in Taiwan found that individuals with internal control tend to have less stress and higher job performance (Chen and Silverthorne 2008).

As can be seen in Table 3, keeping all other factors constant, farmers with an internal locus of control score about 1.05 points higher in the knowledge scale compared to those with an external locus of control (this result is statistically significant at 5 per cent). This appears to be consistent with a study by Piatek and Pinger (2010) that looks at the association between

LOC and wages in Germany, and shows that individuals with internal LOC earn a higher income than those with external LOC. In addition, the study finds that the mechanism through which the effect of LOC is transmitted to wage is the level of education.

Table 3: regression results from ols and probit models

Variables	**Score**	**Score**	**Pass**	**Pass**
Treatment	0.863***	0.906***	0.589***	0.797***
	(3.69)	(4.15)	(3.91)	(4.44)
Effort		0.764***		0.501**
		(3.44)		(2.89)
Farm size		0.0506		0.0555
		(0.73)		(0.97)
Age		-0.0338		-0.0237
		(-1.72)		(-1.54)
Sex		0.464		0.453
		(0.96)		(1.18)
Land size		-0.259		-0.118
		(-1.45)		(-0.81)
Farm experience		0.0207		0.0136
		(1.05)		(0.87)
No education		-0.0238		-0.201
		(-0.06)		(-0.58)
Read and write		-0.139		-0.186
		(-0.32)		(-0.53)
Own a TV		-0.372		-0.126
		(-1.68)		(-0.71)
Position		0.241		0.243
		(0.99)		(1.28)
Internally controlled		1.046**		0.671*

		(2.61)		(2.16)
Training satisfied		0.614*		0.425*
		(2.47)		(2.20)
Trusting		0.225		0.177
		(1.00)		(0.98)
Know more		0.323		0.0906
		(0.86)		(0.31)
Know same		-0.0166		-0.0103
		(-0.05)		(-0.04)
Extension agents know more		0.752		0.280
		(1.88)		(0.91)
Extension agents know same		0.152		0.0360
		(0.37)		(0.11)
Model farmers know more		0.149		0.143
		(0.38)		(0.49)
Model farmers know same		-0.214		-0.194
		(-0.55)		(-0.66)
Trust Extension		0.495*		0.490**
		(2.05)		(2.61)
Constant	5.621***	3.365***	0.0605	-1.560*
	(33.44)	(3.42)	(0.58)	(-2.02)
Observations	300	300	300	300

Notes: The reference categories for farmers' self-assessed knowledgeability, perceived knowledgeability of extension agents, perceived knowledgeability of model farmers, and farmers' education are, 'Model farmers know less', 'Extension agents know less', 'Model farmers know less', and 'Formal education', respectively. Standard errors are in parentheses. Significance: * p<0.05, ** p<0.01, ***p<0.001.

Table 4: Ols regression results with interaction terms

	(1)	(2)	(3)	(4)
	Score	Score	Score	Score
1.Treatment	0.376		1.049**	0.601
	(1.19)		(3.01)	(1.94)
1.effort	0.705*	1.338***		0.561
	(2.18)	(3.57)		(1.28)
1.Treatment X 1.effort	0.831			0.596
	(1.85)			(1.38)
1.trust_Extension		0.980**		0.574
		(3.08)		(1.77)
1.trust_Extension X 1.effort		-0.456		-0.162
		(-0.96)		(-0.36)
1.no education			0.104	
			(0.31)	
1.Treatment X 1.no education			-0.342	
			(-0.73)	
Cons	5.295***	4.958***	5.562***	3.514***
	(24.13)	(21.42)	(21.93)	(3.49)
Other control variables	No	No	No	Yes
N	300	300	300	300

Notes: Standard errors are in parentheses.

Significance: * p<0.05, ** p<0.01, *** p<0.001

Determinants of trust, effort and locus of control

We display the results from the probit model in Table 5. Interestingly, none of our demographic and socioeconomic variables correlate significantly with trust in the extension system, with the exception of gender.[6] Moreover, the measure of generalised trust does not correlate with trust in the extension system, ruling out the possible explanation that, generally, more trusting farmerss would tend to show more trust in the extension service. Interestingly, however, the perception of higher knowledgeability of the extension agents strongly and positively correlated with trust in the extension service.

Farmers who believed the extension agents were knowledgeable compared to fellow farmers in the village showed about 92 per cent more trust in the extension service (this result is significant at 1 per cent). Contrarily, farmers who believed they were more knowledgeable compared to fellow farmers in their village showed less trust in the extension service. A farmer who perceived himself as more knowledgeable was about 89 per cent less likely to trust the extension service; this relationship is significant at 5 per cent. The only variable that significantly correlates with effort is 'position', which is whether the farmer has held any position in the community, such as community leadership, community elder, etc. The results show that farmers with positions seemed to exert about 38 per cent more effort compared to farmers who had never held community positions (significant at 10 per cent). On the other hand, we found that none of the variables included in our estimation appeared to affect farmers' LOC.

Table 5: Determinants of trust, effort and locus

Variables	**Trust Extension**	**Effort**	**Internally controlled**
Farm size	-0.0764	0.0906	-0.0955
	(-1.48)	(1.81)	(-1.24)
Age	-0.00461	-0.0146	0.00662
	(-0.32)	(-1.05)	(0.30)
Sex	0.702*	0.108	-0.337
	(1.99)	(0.30)	(-0.58)
Land size	-0.104	-0.264	0.0358
	(-0.80)	(-1.81)	(0.19)
Farm experience	0.0156	0.00280	-0.0114
	(1.06)	(0.20)	(-0.52)
No education	-0.0986	-0.532	-0.965
	(-0.30)	(-1.75)	(-1.12)
Read and write	0.108	-0.130	-1.014
	(0.32)	(-0.42)	(-1.18)
Own a TV	0.0780	-0.00794	0.421
	(0.48)	(-0.05)	(1.71)
Position	0.0379	0.381*	0.0579
	(0.21)	(2.21)	(0.22)

Internally controlled	0.489	0.311	
	(1.70)	(1.09)	
Trusting	-0.102	0.101	-0.405
	(-0.61)	(0.63)	(-1.67)
Know more	-0.888**	0.110	-0.353
	(-3.12)	(0.42)	(-0.67)
Know same	-0.244	0.208	-0.900
	(-0.92)	(0.85)	(-1.81)
Extension agents know more	0.915***	0.337	0.372
	(3.36)	(1.23)	(1.00)
Extension agents know same	0.0266	0.309	0.543
	(0.09)	(1.06)	(1.30)
Constant	-0.670	-0.491	3.442**
	(-0.94)	(-0.71)	(2.63)
Observations	300	300	300

Notes: The reference categories for farmers' self-assessed knowledgeability, perceived knowledgeability of extension agents, perceived knowledgeability of model farmers, and farmers' education are: 'farmers know less', 'extension agents know less' 'model farmers know less', and 'formal education', respectively.

Standarderrors are in parentheses. Significance: * p<0.05, ** p<0.01, ***p<0.001.

Conclusion and Policy Implications

Connecting farmers to scientific knowledge and relevant information is crucial to fostering their productivity and economic growth at large. Cognisant of this, the Ethiopian government has established one of the largest agricultural extension services in the world. However, due to data limitations, its effectiveness as an information and knowledge transmission channel remains unclear. Additionally, as discussed in the introduction, studies argue that the unprecedented level of investment in the extension service by the government is politically motivated, and thus it is used as a tool by the government to control farmers – the majority of the population in Ethiopia. If this is the case, farmers may be sceptical of the motives of the extension agents and may discount information and knowledge that comes from the extension system.

Against this backdrop, to understand whether the extension service is an effective knowledge and information communication channel compared with advice from fellow farmers, we designed and implemented a randomised training experiment in two districts in Ethiopia. We provided training on a new farm technology known as 'push-pull', to randomly selected farmers, using extension agents and model farmers. Next, we administered a mutiple-choice test, which was drawn from the training, to the trained farmers, in order to identify which type of trainers led to higher knowledge acquisition.

Our results showed that farmers trained by both extension agents and model farmers, on average, scored more than 50 per cent, but learning from extension agents led to a higher knowledge acquisition than learning from model farmers. We also found that those who exerted more effort obtained a higher knowledge score. Similarly, farmers who had more trust in the extension system, and farmers with an internal locus of control, acquired more knowledge. Moreover, we tested if effort was the mechanism that leads to higher knowledge in the extension treatment. However, we found no evidence that the high-learning outcome observed among farmers trained by the extension agents was driven by a greater level of effort exerted by farmers while learning from the extension agents. Thus, our finding might be because the extension agents are better at conveying information.

Based on the results of this study, we draw the following policy recommendations. Firstly, we recommend that the government should keep using both extension agents and model farmers as complementary sources of agricultural knowledge, rather than substituting one for the other. By using the two channels as complements, rather than for example using only EAs, the government could reduce its personnel expenses. Secondly, we recommend that the government should pay due attention to increasing the trustworthiness of the extension service by limiting the responsibilities of the extension agents to agriculture-related work only, and considers separating input distribution from knowledge distribution channels.

Now we discuss some of the important limitations of our study. Firstly, we acknowledge that this study focuses only on identifying an effective knowledge communication channel and understanding the learning process. This means that many other aspects of the knowledge acquisition process are left unexamined. For example, our study does not investigate the wider political and social factors that affect knowledge acquisition in agriculture. Another important limitation of our study is the measurement of locus of control and trust. Given that these concepts are complex and abstract, trying to capture them by using a single survey instrument may be inadequate. Therefore, future research should investigate the broader spectrum of the knowledge acquisition processes and use a more detailed survey and/or experimental approach to obtain more reliable data on trust and locus of control.

Acknowledgements

We gratefully acknowledge the financial support from CODESRIA's Meaning Making Research Initiative, grant number MRI/CTR 9/2018-2019. We also would like to thank the participant farmers; the extension agent and model farmer trainers; the Debre Birhan Agricultural Research Institute; the district administration offices; and, the enumerators for all the support. We also thank Dr Chanyalew Seyoum for his feedback on our qualitative research design. Lastly, we would like to thank the four anonymous internal reviewers and the two anonymous external reviewers for the comments and suggestions that have improved the manuscript immensely. Any remaining errors are our own.

Notes

1. In our context, agricultural technologies refer to new and improved techniques and inputs that can enhance agricultural productivity. However, the concept covers a wider concept. For example, Norton (2014) defines it as follows: 'Agricultural technology classically embraces research and extension, and for the most part research in developing countries has meant the development of new crop varieties and improved methods of crop management in the field.'
2. The study was conducted in Iowa, in the US, where farmers were typically wealthy. Also, the authors do not find resource as a constraint for non-adoption.
3. The history of AES dates back to the out-of-classroom education programmes of Cambridge and Oxford universities around the mid-nineteenth century. Later, the programme was developed by the land grant universities of the US to reach out to farmers and equip them with scientific knowledge for optimal farm operation (Maunder et al. 1972; True 1969). Subsequently, many other countries have adopted the AES.
4. Gots are the lowest administrative units in Ethiopia.
5. This could be due to lower initial expectation of farmers assigned to the model farmer training arm; as we show in the results of the FGD, farmers are sceptical about the knowledgeability of model farmers.
6. We observed that, compared to male farmers, women farmers showed higher trust, keeping other factors constant, significant at 10 per cent. But we view this result with caution since our observation of women was only about 1 per cent of the sample).

References

Abay, K.A., Blalock, G. and Berhane, G., 2017, Locus Of Control And Technology Adoption In Developing Country Agriculture: Evidence From Ethiopia, *Journal of Economic Behavior & Organisation*, Vol. 143, pp. 98–115.

Anderson, J. R. and Feder, G., 2004, Agricultural Extension: Good Intentions And Hard Realities, *The World Bank Research Observer*, Vol. 19, No. 1, pp. 41–60.

Asfaw, A. and Admassie, A., 2004, The Role Of Education On The Adoption Of Chemical Fertiliser Under Different Socioeconomic Environments In Ethiopia, *Agricultural Economics*, Vol. 30, No. 3, pp. 215–228.

Asfaw, S., Shiferaw, B., Simtowe, F. and Haile, M., 2011, Agricultural Technology Adoption, Seed Access Constraints And Commercialisation In Ethiopia, *Journal of Development and Agricultural Economics*, Vol. 3, No. 9, pp. 436–477.

Awokuse, T. O., 2009, Does agriculture really matter for economic growth in developing countries? Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Milwaukee, WI, 28 July 2009. Available online at https://core.ac.uk/download/pdf/7130483.pdf.

Belissa, T., Bulte, E., Cecchi, F., Gangopadhyay, S. and Lensink, R., 2019, Liquidity Constraints, Informal Institutions, And The Adoption Of Weather Insurance: A Randomised Controlled Trial in Ethiopia, *Journal of Development Economics*, Vol. 140, pp. 269–278.

BenYishay, A. and Mobarak, A. M., 2019, Social Learning And Incentives For Experimentation And Communication, *The Review of Economic Studies*, Vol. 86, No. 3, pp. 976–1009.

Berhanu, K. and Poulton, C., 2014, The Political Economy Of Agricultural Extension Policy In Ethiopia: Economic Growth And Political Control, *Development Policy Review*, Vol. 32, No. 2, pp. s197–s213.

Bernard, T., Taffesse, A. S. and Dercon, S., 2008, Aspirations Failure And Well-Being Outcomes, Paper presented at In Ethiopia: Towards An Empirical Exploration, in Improving Institutions for Growth workshop, Oxford, UK, March (Vol. 21).

Birkhaeuser, D., Evenson, R. E. and Feder, G., 1991, The Economic Impact Of Agricultural Extension: A Review, *Economic Development And Cultural Change*, Vol. 39, No. 3, pp. 607–650.

Bjørnskov, C., 2012, How Does Social Trust Affect Economic Growth?, *Southern Economic Journal*, Vol. 78, Vol. 4, pp. 1346–1368.

Buck, S. and Alwang, J., 2011, Agricultural Extension, Trust, And Learning: Results From Economic Experiments In Ecuador, *Agricultural Economics*, Vol. 42, No. 6, pp. 685–699.

Central Intelligence Agency (CIA), 2020, The World Factbook, Washington DC: CIA. Available online at https://www.cia.gov/the-world-factbook/.

Chen, J. C. and Silverthorne, C., 2008, The Impact Of Locus Of Control On Job Stress, Job Performance And Job Satisfaction In Taiwan, *Leadership & Organization Development Journal*, Vol. 29, No. 7, pp. 572–582.

Christiaensen, L., Demery, L. and Kuhl, J., 2006, *The Role Of Agriculture In Poverty Reduction An Empirical Perspective*, Washington DC: The World Bank.

Cole, S. and Fernando, A. N., 2012, The Value Of Advice: Evidence From Mobile Phone-Based Agricultural Extension, Harvard Business School Working Paper No. 13-047. Available online at https://dash.harvard.edu/bitstream/handle/1/10007889/13-047.pdf?sequence=1.

Conley, T. G. and Udry, C. R., 2010, Learning About A New Technology: Pineapple in Ghana, *American Economic Review*, Vol. 100, No. 1, pp. 35–69.

Croppenstedt, A., Demeke, M. and Meschi, M. M., 2003, Technology Adoption In The Presence Of Constraints: The Case Of Fertiliser Demand In Ethiopia, *Review of Development Economics*, Vol. 7, No. 1, pp. 58–70.

Dercon, S., Gilligan, D. O., Hoddinott, J. and Woldehanna, T., 2009, The impact Of Agricultural Extension And Roads On Poverty And Consumption Growth In Fifteen Ethiopian Villages, *American Journal of Agricultural Economics*, Vol. 91, No. 4, pp. 1007–1021.

Duflo, E., Kremer, M. and Robinson, J., 2008, How High Are Rates Of Return To Fertiliser? Evidence From Field Experiments In Kenya, *American Economic Review*, Vol. 98, No. 2, pp. 482–88.

Duflo, E., Kremer, M. and Robinson, J., 2011, Nudging Farmers To Use Fertiliser: Theory And Experimental Evidence From Kenya, *American Economic Review*, Vol. 101, No. 6, pp. 2350–90.

Feder, G. and Slade, R., 1986, The Impact Of Agricultural Extension: The Training And Visit System In India, *The World Bank Research Observer*, Vol. 1, No. 2, pp. 139–161.

Fuglie, K., Gautam, M., Goyal, A. and Maloney, W. F., 2019, *Harvesting Prosperity: Technology and Productivity Growth In Agriculture*, Washington DC: The World Bank.

Gebremedhin, B., Hoekstra, D. and Tegegne, A., 2006, Commercialization of Ethiopian agriculture: Extension service from input supplier to knowledge broker and facilitator, IPMS (Improving Productivity and Market Success) of Ethiopian farmers project, Nairobi: International Livestock Research Institute (ILRI). Available online at https://cgspace.cgiar.org/bitstream/handle/10568/564/CommerciaIPMSWorkingPaper_1.pdf?sequence=1&isAllowed=y.

Godtland, E.M., Sadoulet, E., Janvry, A. D., Murgai, R. and Ortiz, O., 2004, The impact of farmer field schools on knowledge and productivity: A study of potato farmers in the Peruvian Andes, *Economic Development and Cultural Change*, Vol. 53, No. 1, pp. 63–92.

Hailemichael, S. and Haug, R., 2020, The Use And Abuse Of The 'Model Farmer'approach In Agricultural Extension In Ethiopia, *The Journal of Agricultural Education and Extension*, Vol. 25, No. 5, pp. 1–20.

Khan, Z.R., Pickett, J. A., Berg, J. V. D., Wadhams, L. J. and Woodcock, C. M., 2000, Exploiting Chemical Ecology And Species Diversity: Stem Borer And Striga Control For Maize And Sorghum In Africa, *Pest Management Science: Formerly Pesticide Science*, Vol. 56, No. 11, pp. 957–962.

Knack, S. and Keefer, P., 1997, Does Social Capital Have An Economic Payoff? A Cross-Country Investigation, *The Quarterly Journal Of Economics*, Vol. 112, No. 4, pp. 1251–1288.

Kondylis, F., Mueller, V. and Zhu, J., 2017, Seeing is believing? Evidence From An Extension Network Experiment, *Journal of Development Economics*, Vol. 125, pp. 1–20.

Krishnan, P. and Patnam, M., 2013, Neighbours And Extension Agents In Ethiopia: Who Matters More For Technology Adoption? *American Journal of Agricultural Economics*, Vol. 96, No. 1, pp. 308–327.

Liu, E.M., 2013, Time To Change What To Sow: Risk Preferences And Technology Adoption Decisions Of Cotton Farmers In China, *Review of Economics and Statistics*, Vol. 95, No. 4, pp. 1386–1403.

Maunder, A., 1972, *Agricultural Extension. A Reference Manual*, Geneva: Food and Agriculture Organisation (FAO).

Mayer, R. C., Davis, J. H. and Schoorman, F. D., 1995, An Integrative Model Of Organisational Trust, *Academy of Management Review*, Vol. 20, No. 3, pp. 709–734.

Owens, T., Hoddinott, J. and Kinsey, B., 2003, The Impact Of Agricultural Extension On Farm Production In Resettlement Areas Of Zimbabwe, *Economic Development and Cultural Change*, Vol. 51, No. 2, pp. 337–357.

Pan, Y., Smith, S. C. and Sulaiman, M., 2018, Agricultural Extension And Technology Adoption For Food Security: Evidence from Uganda, *American Journal of Agricultural Economics*, Vol. 100, No. 4, pp. 1012–1031.

Piatek, R. and Pinger, P., 2010, Maintaining (Locus Of) Control? Assessing The Impact Of Locus Of Control On Education Decisions And Wages, ZEW and IZA Discussion Paper, No. 5289, Bonn: IZA. Available online at http://ftp.iza.org/dp5289.pdf.

Pingali, P. L., 2012, Green revolution: Impacts, Limits, And The Path Ahead, *Proceedings of the National Academy of Sciences*, Vol. 109, No. 31, pp. 12302–12308.

Ragasa, C., 2019, Modeling the effectiveness of the lead farmer approach in agricultural extension service provision: Nationally representative panel data analysis in Malawi, IFPRI Discussion Paper 1848, Washington DC: International Food Policy Research Institute (IFPRI).

Rashid, S., Tefera, N., Minot, N. and Ayele, G., 2013, Fertilizer in Ethiopia: An Assessment Of Policies, Value Chain, And Profitability, IFPRI Discussion Paper 1304, Washington DC: International Food Policy Research Institute (IFPRI).

Rogers, E. M. and Shoemaker, F. F., 1971, Communication of Innovations; A Cross-Cultural Approach, New York: Free Press.

Rotter, J. B., 1990, Internal versus external control of reinforcement: A case history of a variable, *American Psychologist*, Vol. 45, No. 4, p.489.

Ryan, B. and Gross, N., 1950, Acceptance And Diffusion Of Hybrid Corn Seed In Two Iowa Communities, *Iowa Agriculture and Home Economics Experiment Station Research Bulletin*, Vol. 29, No. 372, Art. 1.

Sako, M., 2006. Does trust improve business performance, in Kramer, M., ed., 2007, *Organisational Trust: A Reader*, Oxford: Oxford University Press, pp. 267–294.

Savastano, S. and Feder, G., 2006, *The Role Of Opinion Leaders In The Diffusion Of New Knowledge: The Case Of Integrated Pest Management*, Washington DC: The World Bank.

Smucker, G. R., White, T. A. and Bannister, M., 2000, *Land Tenure And The Adoption Of Agricultural Technology In Haiti*, CAPRi Working Paper No. 6, Washington DC: International Food Policy Research Institute (IFPRI). Available online at https://www.capri.cgiar.org/files/pdf/capriwp06.pdf.

Tessema, Y. M., Asafu-Adjaye, J., Kassie, M. and Mallawaarachchi, T., 2016, Do Neighbours Matter In Technology Adoption? The Case Of Conservation Tillage In Northwest Ethiopia, *African Journal of Agricultural and Resource Economics*, Vol. 11, No. 3, pp. 211-225.

True, A.C., 1928, *A History Of Agricultural Extension Work In The United States, 1785–1923*, No. 15, Washington DC: US Government Printing Office.

Weber, J. G., 2012, Social Learning And Technology Adoption: The Case Of Coffee Pruning in Peru, *Agricultural Economics*, Vol. 43, pp.73–84.

Young, H. P., 2009, Innovation diffusion In Heterogeneous Populations: Contagion, social Influence, And Social Learning, *American Economic Review*, Vol. 99, No. 5, pp.1899–1924.