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Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania

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ABSTRACT

Agricultural training is a potentially effective method to diffuse relevant new technologies to increase productivity and alleviate rural poverty in Sub-Saharan Africa (SSA). However, since it is prohibitively expensive to provide direct training to all the farmers in SSA, it is critically important to examine the extent to which technologies taught to a small number of farmers disseminate to non-trained farmers. This paper investigates the technology dissemination pathways among smallholder rice producers within a rural irrigation scheme in Tanzania. As an innovative feature, we compare the performance of three categories of farmers: key farmers, who receive intensive pre-season training at a local training center; intermediate farmers, who are trained by the key farmers; and other ordinary farmers. By collecting and analyzing a unique five-year household-level panel data set, we estimate difference-in-differences models to assess how the gap in performance evolve as the technologies spill over from the trained farmers to the ordinary farmers. To disentangle the technology spillover process, we also examine the extent to which social and geographical network with the key and intermediate farmers influences the adoption of technologies by the ordinary farmers, by incorporating social relationship variables into spatial econometric models. We found that the ordinary farmers who were a relative or residential neighbor of a key or intermediate farmer were more likely to adopt new technologies than those who were not. As a result, while the key farmers' technology adoption rates rose immediately after the training, those of the non-trained ordinary farmers caught up belatedly. As the technologies disseminated, the paddy yield of the key farmers increased from 3.1 to 5.3 tons per hectare, while the yield of the ordinary farmers increased from 2.6 to 3.7 tons per hectare. Our results suggest the effectiveness and practical potential of farmer-to-farmer extension programs for smallholders in SSA as a cost effective alternative to the conventional farmer training approach.

1. Introduction

Technological change is a necessary step in the development process. This is especially true for agricultural development in Sub-Saharan Africa (SSA), where agricultural productivity has been largely stagnant for many years. This is in sharp contrast to the experience of Asia, where the Green Revolution has significantly improved grain yields for the last several decades (Otsuka & Kalirajan, 2005; Otsuka & Yamano, 2005). Among major cereals, rice is considered to be one of the most promising crops to achieve the African Green Revolution (Otsuka & Kijima, 2010; Seck, Tollens, Wopereis, Diagne, & Bamba, 2010; Tsusaka & Otsuka, 2013). Fertilizer-responsive, high-yielding modern rice varieties developed in Asia have exhibited high yield potential and adaptability, especially in irrigated areas in SSA (Nakano, Bamba, Diagne, Otsuka, & Kajisa, 2013; Otsuka & Larson, 2013). Despite their significant high yield potential, however, modern varieties, chemical fertilizers, and improved agronomic practices have yet to be widely adopted in SSA (Nakano, Kajisa, & Otsuka, 2015). Since such high-potential technologies are already available, it is vitally important to investigate how these technologies diffuse among small-scale farmers for the improvement of rice productivity in SSA.

One potentially effective method to diffuse these new technologies is agricultural training (Anderson & Feder, 2007; Feder, Just, & Zilberman, 1985; Otsuka & Larson, 2015). However, since it would

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be prohibitively expensive to train all the farmers in SSA on new rice cultivating technologies, examining the extent to which technologies taught to a small number of farmers disseminate to non-trained farmers through social and neighborhood networks may lead to more practical alternatives. Recently there has been increasing empirical interest in social learning as a means of technology dissemination and some studies observe that social leaning or "learning from others" plays a significant role in agricultural technology adoption (Adegbola & Gardebroek, 2007; Bandiera & Rasul, 2006; Case, 1992; Conley & Udry, 2010; Foster & Rosenzweig, 1995; Maertens & Barrett, 2012; Moser & Barrett, 2006; Munshi, 2004). If social learning works effectively, new technologies taught to a small number of farmers should diffuse to other farmers through social networks. However, the existing empirical results on the diffusion of technologies from trained farmers to non-trained farmers are mixed. In some studies, technologies did not spread from trained farmers to non-trained farmers as effectively as expected (Feder, Murgai, & Quizon, 2004; Tripp, Wijeratne, & Piyadasa, 2005), while other studies document technology diffusion of the sort, though the extent of technology spillover is not fully assessed (see Davis et al., 2012 for the review).

This paper investigates the effectiveness of farmer-to-farmer training programs on rice cultivation technologies provided by the Japan International Cooperation Agency (JICA) and the Ministry of Agriculture Training Institute (MATI) of Tanzania in 2009. JICA and MATI sought to establish a farmer-to-farmer training scheme, called TANRICE training,[1] as a potentially cost-effective way of disseminating agricultural technologies. As a first step, 20 farmers (designated "key farmers") in a regional irrigation scheme were trained on new cultivation technologies at a nearby training institute for 12 days before the start of the main crop season of 2009. Once the season was underway, these key farmers, together with officers of MATI and the village extension officer, held training sessions at a demonstration plot. For these in-season training sessions, each key farmer was responsible for inviting five additional farmers. The invited farmers were referred to as "intermediate farmers" and were expected to later train other non-trained "ordinary farmers." This training structure provided a unique opportunity to examine whether technologies taught to a small number of selected farmers would effectively disseminate to non-trained farmers.

We formulated two hypotheses: (1) First, since the key farmers are the most intensively trained, they adopt the new technologies and achieve higher yield rapidly after training, which expands the yield gap between the key farmers and the others. Subsequently, the intermediate farmers follow the key farmers, which narrows the yield gap between the key and intermediate farmers and widens the yield gap between the intermediary and ordinary farmers. However, in the course of time, the ordinary farmers also catch up by learning technologies from the key and intermediate farmers, thereby closing the gaps in yield and technology adoption. (2) Our second hypothesis is that the ordinary farmers learn new technologies by communicating with the key and intermediate farmers through social and geographical networks.

In order to examine these hypotheses, a five-year panel data set was constructed to cover the period before and after TANRICE training by combining survey data collected in 2010, 2011, and 2012, and recall data for 2008 and 2009 collected in 2010. In examining our first hypothesis, we employ fixed effects difference-in-differences (FE-DID) and propensity score matching difference-in-differences (PSM-DID) models to estimate the changes in impact of TANRICE training on the adoption of technologies by the key, intermediary, and ordinary farmers, and assess its effect on their productivity. To address our second hypothesis, we utilize spatial econometric method to investigate the facilitating role of the key and intermediate farmers in the adoption of technologies by the ordinary farmers. In the spatial models, we also control for possible spillover effects among the ordinary farmers, since early adopters may also influence the behavior of other ordinary farmers.

We found that the technology adoption rates, productivity, and profitability of the key farmers rose immediately after training, which resulted in a wider gap between the key farmers and the other farmers in the initial stage of the program. In a remarkable finding, however, the gap decreased within a matter of a few years due to technology dissemination from the key and intermediate farmers to the ordinary farmers. Over the course of the study, the paddy yield of the key farmers increased from 3.1 tons per hectare in the year preceding the training to a high of 5.3 tons per hectare, while the yield of the ordinary farmers increased from 2.6 to 3.7 tons per hectare. These results suggest the effectiveness and potential of farmer-to-farmer agricultural training programs.

Our paper is organized as follows: Section 2 describes the study site and data collection method, followed by descriptive analyses in Section 3. Section 4 shows the FE-DID and PSM-DID analyses of the impact of TANRICE training on the adoption of technologies and the paddy yield for the three categories of farmers. Changes in income and profit over time, for each category of farmers, are also examined. In Section 5, spatial econometric analyses are performed to examine the influential role of the key and intermediate farmers in the technology adoption by the ordinary farmers through social and geographical networks. Section 6 concludes the paper.

2. Study site and data

2.1. Study site

The panel surveys were conducted among rice farming households in the Ilonga irrigation scheme in the Kilosa district, Morogoro region, of Tanzania. The irrigation scheme is located nearly 15 km from the nearest town of Kilosa. The main crop season in this area runs from November to May, during which farmers produce rice on irrigated plots, while other crops such as maize, beans, and vegetables are grown on rainfed upland plots. During the short crop season from July to September, some farmers produce vegetables on the irrigated plots.

For farmers in the irrigated area, JICA provided the TANRICE training on rice production technologies before and during the main crop season from November 2008 to May 2009. (Hereinafter this particular crop season will be referred to as the 2009 crop season; likewise, prior and subsequent crop seasons will be referenced by the year in which they end.) The program covered several technologies: the use of modern varieties of rice, the application of chemical fertilizer, improved bund construction, plot leveling, and transplanting in rows. Improved bund construction entails piling soil solidly around the plots, while plot leveling involves flattening the ground for better storage and equal distribution of water on paddy fields. Transplanting seedlings in rows allows rice growers to control plant density precisely and remove weeds easily.

As noted earlier, intensive training was offered to 20 farmers, called key farmers, at the nearby training institute (MATI Ilonga) over a period of 12 days in November 2008 prior to the 2009 crop season. Subsequently, during the 2009 main crop season, each key farmer invited five intermediate farmers to training sessions held at a demonstration plot within the irrigation scheme. The key farmers and MATI jointly provided three-day training sessions to the intermediate farmers at three different stages of farming—nursery preparation, transplanting, and harvesting. Following

[1] The formal name for the TANRICE training program is Technical Cooperation in Supporting Service Delivery Systems of Irrigated Agriculture (TC-SDIA).

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