Food Policy 36 (2011) 378–390

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

Assessing the impact of improved agricultural technologies on household income in rural Mozambique

Benedito Cunguara [a,b,*], Ika Darnhofer [a]

[a] Institute of Agricultural and Forestry Economics, University of Natural Resources and Life Sciences, Feistmantelstrasse 4, 1180 Vienna, Austria
[b] Centre for Development Research, University of Natural Resources and Life Sciences, Gregor Mendel Strasse 33, 1180 Vienna, Austria

ARTICLE INFO

Article history:
Received 9 February 2009
Received in revised form 3 December 2010
Accepted 1 March 2011
Available online 15 April 2011

Keywords:
Causal inference
Poverty
Impact assessment
Southern Africa

ABSTRACT

In many areas of Africa, rural livelihoods depend heavily on subsistence farming. Using improved agricultural technologies can increase productivity in smallholder agriculture and thus raise household income and reduce poverty. Data from a nationally representative rural household survey from 2005 is used to assess the impact of four technologies – improved maize seeds, improved granaries, tractor mechanization, and animal traction – on household income in Mozambique. To ensure the robustness of the results, three econometric approaches were used: the doubly-robust estimator, sub-classification and regression, and matching and regression. The results show that, overall, using an improved technology did not have a statistically significant impact on household income. This may be associated with a widespread drought that occurred in 2005. Despite drought, distinguishing between households based on propensity score quintiles revealed that using improved technologies, especially improved maize seeds and tractors, significantly increased the income of those households who had better market access. Thus, to allow households to benefit from the use of improved technologies, policy makers need to reduce structural impediments to market participation by ensuring adequate road infrastructure and enabling access to markets.

Introduction

Agricultural productivity in Sub-Saharan Africa is among the lowest in the world (Savadogo et al., 1998; Fulginiti et al., 2004). For example, in Mozambique the yield of the most important staple crop, maize, is estimated at 1.4 tons ha^{-1}, which is far below the potential yield of 5–6.5 tons ha^{-1} (Howard et al., 2003). The low productivity can be linked to poor farmer health during the late dry season and the beginning of the cropping season (Abellana et al., 2008); the failure of agricultural commodity and credit markets (Mather, 2009); and the very limited use of improved agricultural technologies (Mather et al., 2008). To increase agricultural productivity, both the Government of Mozambique and Non-Governmental Organizations (NGO) are promoting the use of improved agricultural technologies in crop production (e.g. drought tolerant seeds, animal traction) as well as promoting the use of adequate storage facility for the harvested grain e.g., through improved granaries (Government of Mozambique, 2006).

The goal of promoting these improved technologies is to increase productivity so as to reduce food insecurity as well as produce a marketable surplus which contributes to household income. This approach has been summarized as the agricultural productivity pathway out of poverty and subsistence agriculture (Barrett, 2008). The first hurdle to be overcome is the adoption of the improved technology, which has been the subject of numerous studies (for a review see Feder et al., 1985; Sunding and Zilberman, 2001; Doss, 2006). Much less attention has been given to assess whether once a technology has been adopted, it has indeed fulfilled its promise of increasing household incomes.

Indeed, many studies focus on assessing the profitability of a technology. Some studies have used the net present value (see for example, Oehmke and Crawford, 1996; Howard et al., 2003). This approach implicitly assumes that users and non-users had the same productivity levels before the adoption took place, which may not be the case and may affect the validity of the results. Also, to assess the profitability for a wider population, baseline data on probable adopters would be needed before the adoption takes place. This may be possible in research trials or on a small scale, but is not feasible at the regional or national scale. Other studies estimate an Ordinary Least Squares (OLS) model and obtain the impact of the adoption by including a dummy variable indicating whether the farmer cultivated a certain crop (Walker et al., 2004)

* Corresponding author at: Institute of Agricultural and Forestry Economics, University of Natural Resources and Life Sciences, Feistmantelstrasse 4, 1180 Vienna, Austria. Tel.: +43 1 47654 3785; fax: +43 1 47654 3592.
E-mail address: benedito.cunguara@boku.ac.at (B. Cunguara).

0306-9192/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodpol.2011.03.002

or used an improved technology. Here too it is implicitly assumed that the decision to adopt the improved technology is uncorrelated with other factors affecting productivity (Doss, 2006; Imbens and Woolridge, 2009).

Many of these approaches to assess the economic impact of an improved technology do not allow taking the selection bias into account. Indeed, farmers are not randomly assigned to the two groups (users and non-users of a technology) but make the adoption choices themselves. Alternatively, farmers or villages may be systematically selected by development agencies, based on some criteria or rule, leading to an endogenous program placement effect. Therefore, users and non-users may be systematically different, and these differences may manifest in differences in household incomes that could be mistakenly attributed to the use of a technology. This means that an ex-post assessment of the impact of using an improved technology on household incomes is difficult, given a possible selection bias due to observed or unobserved household characteristics. Failure to account for this potential bias could lead to unreliable estimates of the impact of the technology.

There have been a few empirical studies in Sub-Saharan Africa that assessed the impact of improved technologies, while addressing the issues of selection bias and endogenous program placement (e.g., Mendola, 2007; Kassie et al., 2008). However, there is still very little empirical evidence about the impact of improved technologies on the income of households with similar observed characteristics.

In this study, to estimate the average effect of using an improved technology, the outcome variable (total household income) is compared between farmers using a given improved agricultural technology (called "users") and their counterparts with similar observable covariates who do not use the technology (called "non-users"). To ensure the robustness of the estimated average effect, Imbens and Woolridge (2009) recommend using mixed methods that combine regression analysis with either the propensity score or matching methods. Specifically, they suggest using the following three approaches: the doubly robust estimator; sub-classification and regression; and matching and regression. Using these three methods has several advantages. First, they do not require baseline data on potential users before adoption takes place (Imbens and Woolridge, 2009). Second, they ensure that the comparison of the outcome variable is undertaken between households with similar (i.e. overlapping) characteristics (Dehejia and Wahba, 2002). Third, when comparing sub-populations of households with similar characteristics, covariates are independent of the use of improved technologies, and thus a causal interpretation of the results is reasonable (Imbens and Woolridge, 2009).

The remainder of the paper is structured as follows. First the conceptual model is presented, describing how the four selected agricultural technologies (i.e. improved maize seeds, animal traction, tractor mechanization, and improved granaries) can contribute to increasing household income. The methods section details how the three econometric approaches were implemented, and how the overlap and the unconfoundedness assumptions were tested. This section also defines the independent variables included in the models. The result section describes the effect of each of the four technologies on the household income, showing how the results of the three approaches complement each other and strengthen the analysis. The conclusion discusses the results and provides some implications for agricultural policy.

Data source and conceptual framework

This paper uses data from the National Agricultural Survey of 2005 (Trabalho de Inquérito Agrícola or TIA05). This nationally representative survey included 6149 households and was implemented by the Ministry of Agriculture. The data was collected between September and November 2005 and cover the agricultural season from September 2004 to August 2005. This agricultural season was characterized by a widespread drought. Data from the national agricultural surveys show that 2005 had the lowest staple food production for the period 1996–2008 (Cunguara and Hanlon, 2010). Analysis of data from the year 2005 can thus be seen as indicative of the potential of improved agricultural technologies to increase household incomes in a drought year. As the occurrence of droughts and/or dry spells is becoming increasingly frequent, especially in the southern provinces (Joubert and Tyson, 1996; Usman and Reason, 2004), the ability of improved technologies to contribute to household income even in years of droughts can affect their adoption rate.

The outcome variable is the total household income in the 2004/2005 agricultural season. Total household income was chosen, as the use of improved technologies may affect household resource allocation, and hence affect total household income and not just crop income. Moreover, crop income is the most important source of income, making up 63% of total household income in 2005 (Mather et al., 2008).

Total household income was calculated as the value of own production and off-farm earnings, less any paid-out costs. This approach was also used in other studies on Mozambique (Walker et al., 2004; Boughton et al., 2006; Mather et al., 2008; Mather, 2009), thus allowing for a comparison of results. TIA05 collected the following income sources: net crop income, livestock sales, off-farm self-employment such as income from natural resource-extraction or from a small-business, off-farm wage income, and remittances. The total household income was included in the models after logarithmic transformation to ensure that the dependent variable is normally distributed. The estimated coefficients can thus be interpreted as elasticities.

The technologies evaluated were selected based on the expected impact on household income and on data availability. Besides the four technologies included in this analysis, the TIA05 also included e.g. the use of chemical fertilizers and pesticides. However, since the survey did not collect data on the type or amount of agro-chemical used, nor on the crops on which they were applied, the data were not meaningful enough to be included.

The first agricultural technology modeled is the use improved maize seeds. The Sasakawa-Global program has been promoting the use of improved maize seeds in Mozambique since 1995 (Howard et al., 2003). Improved maize refers to the use of certified seeds of maize, which may or may not be hybrid. Most farmers using improved maize seeds obtain it through purchase (approx. 78% among those who used improved maize seeds, according to the TIA05 data). Others obtain it through government or NGO distribution, mainly during emergencies such as following a drought or flood (Remington et al., 2002). A study has estimated that the use of improved seeds can increase total factor productivity by 10%, and increase farmer's incomes by almost 8% (de Janvry and Sadoulet, 2002). Other studies are less optimistic. For example, Howard et al. (2003) found that the income of farmers using improved maize seeds (after paying the input loans obtained through the Sasakawa-Global program in Mozambique) is not statistically different from the income of farmers using traditional seeds. Insufficient or erratic rainfall is likely to limit the ability of improved maize seeds to increase household income as it may not achieve higher yields than traditional seeds.

The second technology assessed in this paper is animal traction. This refers to the use of draught power in agriculture, mainly for plowing. Animal traction is practically not found in the northern provinces of Mozambique, mostly due to the occurrence of animal trypanosomiasis. Although some NGOs have encouraged the use of