Food Policy 50 (2015) 92–105

Contents lists available at ScienceDirect

Food Policy

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

Does storage technology affect adoption of improved maize varieties in Africa? Insights from Malawi's input subsidy program

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A R T I C L E I N F O

Article history:
Received 2 December 2013
Received in revised form 29 September 2014
Accepted 29 October 2014

Keywords:
Food security
Storage
Improved maize seed adoption
Input subsidies
Malawi
Sub-Saharan Africa

A B S T R A C T

To date there is limited knowledge of how having access to post-harvest storage technology affects a smallholder African farmer's decision to adopt higher-yielding improved maize varieties. This is a key issue because higher yielding varieties are known to be more susceptible to storage pests than lower-yielding traditional varieties. We address this question using panel data from Malawi, and incorporating panel estimation techniques to deal with unobserved heterogeneity. Our results indicate that acquiring chemical storage protectants after the previous harvest is associated with a statistically significant and modest positive impact on the probability of adopting improved maize, total area planted to improved maize varieties, and share of area planted to improved maize varieties in the next planting season. We also find that the storage chemical subsidy is associated with significant crowding out of commercial storage chemical purchases, as farmers who acquire subsidized chemicals are more than 50 percentage points less likely to purchase commercial chemicals on average. These findings have implications for maize adoption and input subsidy policies, and they indicate that researchers, extension staff, and policy makers should consider post-harvest issue when promoting adoption of improved varieties.

Introduction

Increasing adoption of modern inputs such as improved seeds and chemical fertilizer is essential for boosting staple crop production and increasing smallholder food security in sub-Saharan Africa (SSA). Numerous studies in SSA find that adoption of improved maize varieties contributes to raising productivity which increases household income and food security (Smale, 1995; Katengeza et al., 2012; Mason and Smale, 2013; Bezu et al., 2014). However in addition to increasing productivity, it is essential to recognize that food security does not simply end at harvest because susceptibility to pests during storage can cause tremendous post-harvest dry weight (quantity) losses of up to 30% in six months of storage for grains (Boxall, 2002). In addition, previous work confirms common rural knowledge that higher yielding but softer dent hybrids, the most commonly promoted improved maize varieties in SSA, offer less natural protection against storage insects such as maize weevil and larger grain borer due to their softer husks, than do lower yielding but harder traditional flint varieties (Smale et al., 1995; Adda et al., 2002).[1] Therefore farmers face a rational trade-off at planting time between choosing an improved variety that may boost production but where the harvested maize is more susceptible to pests when stored vs. choosing a traditional variety that is lower yielding but less vulnerable to pests in storage. Nevertheless, issues related to post harvest loss are often overlooked in studies that model smallholder improved seed adoption behavior.

With these considerations in mind, the first objective of this article is to determine how use of storage technology in the form of chemical protectants affects a smallholder's decision to adopt improved varieties of maize seed in Malawi.[2,3] In doing so this study makes an empirical contribution to both the technology adoption lit-

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[1] Smallholder perceptions of greater storage pest damage in improved vs. local maize varieties has also been recently verified in Malawi (Lunduka et al., 2012; Jones, 2012).

[2] In this study improved maize seeds are defined as hybrid varieties and open pollinated varieties (OPV). Although smallholder farm households in Malawi report that more than 95% of the improved maize seed they acquire is hybrid, anecdotal evidence from Malawi indicates that most farmers refer to *any* improved seed as hybrid.

[3] Storage chemicals are currently the most widely used form of "modern" protection against post-harvest pests in Malawi, and Table 1 indicates that more than half of all farmers use them in either liquid or powder form. Chemicals are commonly applied even when bags of maize are stored in the kitchen, sleeping, or living area of the home as external storage facilities may not exist.

http://dx.doi.org/10.1016/j.foodpol.2014.10.015

erature and the input subsidy literature in SSA. Malawi has received wide-spread recognition for scaling up a large inorganic fertilizer subsidy program in 2005 and a subsidy for improved maize seeds in 2006 (Dugger, 2007). With the expansion of the seed subsidy program, by the 2008–2009 agricultural year almost 40% of smallholder households had received subsidized improved seed (Mason and Ricker-Gilbert, 2013).[4] However less attention has been paid to the fact that Malawi implemented a subsidy for maize storage chemicals beginning after the 2009 harvest and running through 2012 harvest as a compliment to the fertilizer and seed subsidy. The storage chemical component was added to the subsidy program based on a recognition that post-harvest pests may undermine increases in maize production that are achieved by farmers who adopt improved varieties through the subsidy program.

Therefore, the second objective of this study is to test whether or not, and to what extent the storage chemical subsidy may crowd out or crowd in the commercial market for storage chemicals. This is an important issue because for the storage chemical component of the subsidy program to be successful it must increase the amount of storage chemicals that households use. If acquiring subsidized storage chemicals makes people more likely to buy commercial storage chemicals then the subsidy program crowds in commercial storage chemical use, and adds to the total quantity of storage chemicals applied to farmers' maize. Conversely, if those who acquire subsidized storage chemicals use some or all of it in place of commercial purchases, then the effect of the subsidy on total chemical use will be reduced, causing crowding out of commercial chemicals, and undermining the effectiveness of the program.

The first wave of data from our study provide evidence on storage chemical use after the 2007/08 growing season, the year before the storage protectant subsidy was scaled up, but when the fertilizer and seed subsidy was in full swing. In the first wave all purchases of storage chemicals are from the commercial market. The second wave of data provide information on storage protectant use after the 2010 season when the storage chemical subsidy, the fertilizer subsidy, and the seed subsidy were all in full effect. During that season households could potentially purchase storage chemicals from either commercial or subsidized sources. As a result, this article should provide useful insights about acquisition to storage technology and how it potentially serves as a complimentary input to fertilizer and seed.

There is a growing literature measuring the impact of input subsidy programs on smallholder behavior and well-being in SSA. One related study in Malawi finds that households who acquire subsidized seed and fertilizer plant a significantly larger share of their land to maize and tobacco, the crops targeted by the country's input subsidy program, than do other households (Chibwana et al., 2012). Another study uses household-level panel data from Malawi and Zambia and finds that in both countries households who acquire subsidized improved maize seed varieties purchase significantly less improved seed varieties on the commercial market (Mason and Ricker-Gilbert, 2013). The present study adds to the literature on input subsidies by estimating the impact of storage chemicals on a farmer's improved seed adoption decision in the context of a large-scale input subsidy program.

To our knowledge, there is little research investigating the relationship between investment in storage technology and adoption of improved maize varieties. One previous study in Ghana (Gyasi et al., 2003) and one study in Zambia (Langyintuo and Mungoma, 2008) consider how a farmer's perception of hybrid maize storability affects his or her decision to adopt it. Both studies estimate hybrid maize adoption and include "storability" as a dummy variable equal to one when a farmer perceives that hybrid maize stores better than local varieties and 0 otherwise. However, these studies do not consider a farmer's ability to protect maize stocks in their model. One limitation of the previous approach is that there is likely limited variation in the storability dummy, as evidence from Malawi suggests that most farmers believe local varieties to store better than hybrid (Smale, 1995; Lunduka et al., 2012). Therefore, the present article builds upon past work by considering how accessing storage protectants affects a farmer's decision to adopt improved varieties of maize.

In this article we first set up a model of smallholder maize adoption decision making, where the farmer chooses whether or not to adopt improved maize varieties as a binary decision. Second we model the farmer's decision of how much absolute area to plant to improved maize varieties. Third we estimate the farmer's decision on the share of his or her area to plant to improved maize varieties. The key right hand side (RHS) variable of interest is whether or not the household used storage chemicals on their maize crop after the previous harvest. In doing so, we empirically test whether or not households who access storage chemicals are significantly more likely to adopt improved maize seed and also plant larger areas of land to improved maize varieties in the next growing season. Since the key RHS variable is whether or not the household uses storage chemicals after the previous harvest it is pre-determined when the household makes planting decisions the following season. This structure avoids possible concerns about reverse causality. In addition, we use several panel estimation techniques including first-differencing and the Mundlak–Chamberlain device to deal with potential correlation between covariates and unobservable factors that could potentially bias our coefficient estimates, particularly those variables that represent participation in the input subsidy program.

The rest of this article is organized as follows. In the next section we present a background of Malawian post-harvest challenges, improved maize adoption, and the input subsidy program. Then introduce the conceptual model, the empirical model, and the identification strategy. Subsequently, data, results, and conclusions are presented.

Background

Post-harvest losses in Malawi

Post-harvest storage losses in Southern Africa are predominately caused by molds, rodents, and insect pests (World Bank, 2011). The main harvest in Malawi is followed by a long dry season so mold damage to grain is not a significant storage problem for smallholders. Nevertheless, post-harvest grain damage due to insect pests is a major issue. While producers have always dealt with the maize weevil as a dominate pest, improving smallholder maize storage practices in Africa has become increasingly more important over the past thirty-five years since the larger grain borer (LGB) was accidentally introduced in Africa from Central America in the 1970s and 1980s (Golob, 2002). Lacking natural predators, LGB's nearly simultaneous initial infestation in Tanzania and Togo have since expanded throughout both Eastern and Western Africa. As a result farmers have had to abruptly and fundamentally shift storage practices in this time to avoid inevitable stock destruction as the threat from LGB has increased (Addo et al., 2002). LGB supposedly entered Malawi in 1991/92 through trade shipments from Tanzania through the northern district of Chitipa. LGB is now prevalent in almost every district of Malawi and poses an enormous constraint on smallholder maize storage (Singano et al., 2008).

In the past many farmers throughout the continent preferred to store husked maize on cob, but the husk provides LGB with a more

[4] Smallholders receiving (100%) subsidized improved seed acquired on average 5.7 kg and purchased an average of 0.9 kg. The 61% of smallholder farmers not receiving subsidized seed purchased an average of 5.5 kg of commercial seed (Mason and Ricker-Gilbert, 2013).