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The heterogeneous effect of shocks on agricultural innovations adoption: Microeconometric evidence from rural Ethiopia

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ABSTRACT

Theoretically, the relationship between shocks and agricultural innovation adoption could be ambiguous. While shocks could lower the competence and capacity of households to adopt new agricultural innovations, households can also take-up agricultural innovations as a coping mechanism against the different shocks they face. Using a nationally representative household data from Ethiopia of the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) of the World Bank, this paper analyzes the effect of idiosyncratic and covariate shocks on adoption of different agricultural innovations, assuming interdependence among the innovations. We find shocks to have heterogeneous effects on the adoption of agricultural innovations. Specifically, production and health shocks have negative effects on the adoption of high-cost innovations such as improved seeds, chemical fertilizer, and irrigation. However, production shocks are positively associated with low-cost innovations such as organic fertilizer. To enhance farmers' adoption of agricultural innovations, especially high-cost innovations, there is a greater need towards the design of policies and interventions that would reduce household's exposure to production and health shocks.

1. Introduction

Smallholder agriculture plays a vital role in enhancing food security, poverty reduction and sustainable development in developing countries, particularly in Sub-Saharan Africa (SSA). Despite its momentous role, the performance of the sector has not lived up to expectations. While Africa is expected to catch-up with the rest of the world, agricultural productivity remains low mainly due to poor land management practices and production methods (Bulte et al., 2014). African agriculture is also characterized by a pervasive yield gap and volatility in production and marketed volume that could greatly be attributed to extreme weather events, human health and market-related shocks (Tittonell and Giller, 2013). Consequently, the risks of food insecurity and poverty are becoming policy and development challenges in SSA (FAO et al., 2015). Given Africa's challenge of having to feed its rapidly growing population, increasing agricultural productivity and narrowing yield gaps is inevitable for improving food security and boosting economic growth under covariate constraints such as climate change (Dzanku et al., 2015). Technical change in agriculture is one of the feasible options to close yield gaps in low production potential regions where high pressure on land, low soil fertility and low productivity are ubiquitous (Dzanku et al., 2015).

Technical change through increased adoption of agricultural innovations is an essential criterion to increase agricultural productivity, enhance food security, ensure inclusive growth and reduce poverty (Teklewold et al., 2013b; Ndiritu et al., 2014; Sheahan and Barrett, 2017). Despite their widely cited benefits and excessive efforts exerted to encourage farmers to invest in agricultural innovations (Teklewold et al., 2013b), the adoption rates are still low in rural areas of developing countries (Somda et al., 2002; Jansen et al., 2006; Kassie et al., 2009; Wollni et al., 2010; Khonje et al., 2015). This is particularly true for Ethiopia where adoption of many agricultural innovations is still low and food insecurity and poverty continue to be major constraints to productivity growth and sustainable human development (Teklewold et al., 2013a,b). The low adoption rate could be attributed to various factors including individual farmers' characteristics, poor infrastructure, market imperfection, weak institutional support and price risks (Sadoulet and Janvry, 1995; Kassie et al., 2013; Shiferaw et al., 2014).

The adoption of agricultural innovations and their determinants is well established in the literature. However, most of the previous studies focus on adoption of single agricultural technology (e.g. Baidu-Forson,

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1999; Shiferaw and Holden, 1998; Bekele and Drake, 2003; Chirwa, 2005; Beegle et al., 2006; Amsalu and de Graaff, 2007; Kassie et al., 2009; Abdulai and Huffman, 2014; Shiferaw et al., 2014; Kathage et al., 2015; Khonje et al., 2015). However, farmers often face many alternative agricultural innovations that need to be adopted as complements or substitutes to address overlapping constraints and objectives such as weeds, pests, disease infestations and low soil fertility (Dorfman, 1996; Khanna, 2001; Moyo and Veeman, 2004; Bandiera and Rasul, 2006; Teklewold et al., 2013b; Ndiritu et al., 2014; Wainaina et al., 2016). Ignoring such relationship may underestimate or overestimate the influence of various factors on farmer's adoption of agricultural innovations.[1] Other studies which tried to consider multiple agricultural innovations assume mutually exclusiveness and independence among the considered innovations and hence use multinomial logit or probit model to analyze the determinants of adoption of agricultural innovations (Nhemachena and Rashid, 2008; Deressa et al., 2009).

There are few studies that relax the assumption of mutual exclusiveness of adoption of agricultural innovations and analyze the determinants of multiple innovations adoption by a household. For example, Wainaina et al. (2016) analyze the adoption of high input innovations and natural resource management practices in Kenya. Kassie et al. (2015) explore smallholder farmers' adoption decisions of multiple sustainable intensification practices in four eastern and southern Africa countries. Ndiritu et al. (2014) investigate the effects of gender differences in adopting agricultural innovations in Kenya. Kassie et al. (2013) demonstrate how different types of agricultural innovations are adopted in Tanzania. Teklewold et al. (2013b) also look into the adoption of multiple sustainable agricultural innovations in Ethiopia.

Nonetheless, the focus of most of the previous studies is on the economic and physical constraints of adoption of agricultural innovations. The effects of different types of unanticipated shocks that households experience and how such shocks may limit or trigger adoption of certain agricultural innovation(s) have been given less emphasis. The notable exceptions are the studies by Teklewold et al. (2013b) and Kassie et al. (2013) that find covariate shock (rainfall shock) to have a negative and mixed effect on the adoption of agricultural innovations. While this finding seems to be a plausible result, it does not provide a comprehensive relationship between adoption of agricultural innovations and unanticipated shocks as their study focus mainly on a single shock indicator, which might mask the reality that farmers face various shocks at a time. The focus of this paper is, therefore, to examine how different idiosyncratic and covariate shocks affect adoption of agricultural innovation(s) in addition to the other control variables.

Rural households face market, production and health risks which emanate mainly from frequently occurring shocks such as an increase in the price of agricultural inputs, crop failure due to drought, crop diseases and pest infestations, and illness of household members (Dercon et al., 2005). These shocks may have a negative effect on food production, income, and the asset base of households. They can also alter households' planning horizons, individual discount rates and hence the adoption of agricultural innovations. Furthermore, adopting agricultural innovations can be both an *ex-ante* shock management strategy and an *ex-post* response to shocks. Although it is difficult to isolate these strategies in rehearsal, we attempt to test whether agricultural innovations adoption responds to the idiosyncratic and covariate shocks that the household faces.

The conventional thought about the effect of shock on households' welfare is that, when it happens, it lowers farm households' propensity to adopt productivity enhancing but risky technologies and activities. When households face uninsured risk, instead of moving up the risk-return ladder, they opt to engage in low risk-low return economic activities which subsequently push them into risk-induced poverty traps (Dercon and Christiaensen, 2011). In developing countries, households adopt different coping mechanisms to reinstate the income forgone due to shocks. Different studies indicate various coping strategies at the time of shocks including the use of own savings in the form of cash, grain, livestock or farm implements (e.g. Paxson, 1992; Udry, 1995), insurance and borrowing from informal credit sources (Udry, 1994; Besley, 1995; Heltberg and Lund, 2009), reallocation of household member(s) to wage labor (Kochar, 1999; Rose, 2001; Beegle et al., 2006; Heltberg and Lund, 2009), dependence on environmental resources (Pattanayak and Sills, 2001; McSweeney, 2003; Takasaki et al., 2004; Fisher et al., 2010; Völker and Waibel, 2010; Khundi et al., 2011; Debela et al., 2012), and remittances from family members or relatives residing elsewhere (Rosenzweig, 1988). More specifically in the Ethiopian context, there are strong informal social networks such as "*equb*" (informal credit institution) and "*idir*" (funeral insurance) that provide financial support at the time of shocks such as the death of a household member and serious property loss. Therefore, in the short run, the loss that can happen by due to an unanticipated shock can easily be supplanted, which even can stimulate adoption of different agricultural innovations and farm practices. A recent study from Ethiopia shows that agricultural shocks reduce farm income, however, income from non-farm earnings offsets the agricultural income lost due to the shocks (Porter, 2012). This could prove that shocks may have heterogeneous effects on the adoption of multiple agricultural innovations. Therefore, unanticipated shocks may have a positive or negative impact on the adoption of innovations, especially for those agricultural innovations that need financial liquidity (e.g. improved seed and chemical fertilizer). This makes it important to understand the effect of shocks under a multi- agricultural innovations adoption framework as the effect could vary across different agricultural innovations.

This paper hypothesizes that various shocks have differential effects on adoption of agricultural innovations. Furthermore, we hypothesize that a particular shock may have a heterogeneous effect on adoption of different agricultural innovations. We further argue that shocks can have either synergetic or antagonistic effect on agricultural technology adoption. It is clear that different kinds of shocks reduce the ability of rural households and impose a burden on the household who faces the shock. In this case, shocks and agricultural innovations would compete for limited resources a household has and might reduce the ability to acquire agricultural innovations. On the other hand, households might reallocate their resources to acquire agricultural innovations as a coping strategy against the shocks they face. This prediction departs from the conventional belief that shocks, in general, have negative effects on innovations adoption.

The paper contributes to the growing economic literature on multiple agricultural innovations adoption (e.g. Kassie et al., 2013, 2015; Teklewold et al., 2013b; Ndiritu et al., 2014; Asfaw et al., 2016; Wainaina et al., 2016) in the following ways. First, it is based on a rich and large household dataset from the main regions of Ethiopia which make the results nationally representative. Second, it provides a more comprehensive and rigorous analysis of the interdependent adoption of improved agricultural innovations and the heterogeneous effect of idiosyncratic and covariate shocks on farmers' choice of these innovations.

The rest of the paper is organized as follows. The next section presents the empirical model used along with the theoretical framework which supported the study. Section three presents and discusses the data used for the analyses and the descriptive statistics for the key variables. Section four discusses the main findings of the study. The final section concludes the study and presents some policy recommendations.

2. Conceptual framework and empirical model

We explore the negative and/or positive effects of different shocks

[1] See Wu and Babcock (1998) for further discussion.