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The impacts of postharvest storage innovations on food security and welfare in Ethiopia

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ABSTRACT

Postharvest loss exacerbates the food insecurity and welfare loss of farming households in developing countries. This paper analyzes the impact of improved storage technologies on food and nutrition security and welfare using nationally representative data from Ethiopia. Endogenous switching regression models are employed to control for unobserved heterogeneity. The study finds that the use of improved storage technologies increases dietary diversity and reduces child malnutrition and self-reported food insecurity. We also find that non-user households would have experienced these benefits had they used improved storage technologies. Overall, the study suggests that improved storage technologies can enhance food and nutrition security, and could play a key role in alleviating the challenges of feeding a growing population.

1. Introduction

Postharvest loss presents a significant challenge for food security and agricultural production efficiencies in developing countries. In developed economies, postharvest loss is characterized as a consumer behavior while in developing countries it is largely caused by financial, managerial and technical deficiencies (Conteh et al., 2015; FAO, 2011; Premanandh, 2011). Consequently, in developing countries, food loss is concentrated at stages 'close to the farm' such as production, handling, and storage (Lipinski et al., 2013; Parfitt et al., 2010; Premanandh, 2011). The problem is more acute in Sub-Saharan Africa (SSA) where a significant portion of the production is lost because of poor storage, lack of structured markets, limited processing capacity and weather related factors (Affognon et al., 2015; Shiferaw et al., 2011; Tefera, 2012; Tefera et al., 2011). While the global estimate shows that roughly one-third of the food produced for human consumption is lost or wasted (FAO, 2011), postharvest loss in SSA is estimated to be about 37% which is equivalent to an annual per capita food loss between 120 and 170 kgs (FAO, 2011; Sheahan & Barrett, 2017).[1] In Eastern and Southern Africa alone, food losses are valued at $1.6 billion per year, which is nearly 13.5% of the total value of grain production (Abass et al., 2014; World Bank et al., 2011). This evidence suggests that postharvest loss is a threat to the food and nutrition security and welfare of rural households.

Postharvest loss reduces the food available for consumption and, therefore, has direct impacts on food security, nutrition, and household welfare. Food loss also tightens food markets and increases food prices particularly in the lean season by cutting part of the food supply in the markets (Tefera et al., 2011) which in turn lowers farmers' income (Hodges & Stathers, 2013). For the rural poor who are net-buyers of food, an increase in food prices would significantly lower the purchasing power of their (disposable) income. Postharvest grain loss leads to grain quality deterioration which forces farmers to end up supplying their produce to lower value markets which are often informal (Hodges & Stathers, 2013). In the absence of well-functioning insurance and credit markets, the risk of crop storage loss coupled with financial pressure or liquidity constraints might compel farm households to sell most of their produce immediately after harvest (Tefera et al., 2011). Consequently, they will be forced to buy food during the lean season when prices are at their peak and they might lose the opportunity to

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[1] The postharvest loss estimates in SSA vary widely (e.g. Parfitt et al., 2010; Lipinski et al., 2013; Rosegrant et al., 2015; Affognon et al., 2015; Rutten, 2013) by region and crop type (Lipinski et al., 2013). The value of post-harvest cereal grain losses alone in Sub-Saharan Africa could total $4 billion a year (World Bank et al., 2011) and it could feed about 48 million people at 2500 kcal per person per day (Juma et al., 2013; Stathers et al., 2013; World Bank et al., 2011).

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benefit from inter-seasonal price variations. This would negatively affect their welfare (e.g. income) and access to food (Gabriel & Hundie, 2006). Besides its negative economic impacts, postharvest loss also has substantial environmental repercussions that are manifested through the unsustainable use of scarce natural resources (e.g. land, water), production inputs (fertilizer, pesticides) and energy to produce and process food that is lost (Lipinski et al., 2013; Kummu et al., 2012; World Bank et al., 2011). Producing extra food to compensate for losses also represents a waste of resources (Lipinski et al., 2013; Stathers et al., 2013). This would not only result in long-term food insecurity and diminished welfare but also jeopardizes future generations' food production capacity. In sum, postharvest loss entails opportunity costs and resource misallocation. Therefore, tackling the causes of postharvest loss along the entire food chain would significantly help in improving food security and welfare, and in reducing the environmental footprints of food systems (Hodges et al., 2011; Kummu et al., 2012; Parfitt et al., 2010; Sheahan & Barrett, 2017).

Improved storage technologies could be useful strategies for preventing post-harvest losses (World Bank et al., 2011), and improving food security and household welfare (Fuglie, 1995; Parmar et al., 2017).[2] In this paper, improved storage technologies refer to the use of metal silos, air tight drums, modern store or improved locally made structures for food crop storage (Kaminski & Christiaensen, 2014; Lipinski et al., 2013; Rosegrant et al., 2015).[3] These technologies could also help households cope with increasing food demand, improve the efficiency of the agricultural sector, and enhance agricultural productivity and sustainability (Basu & Wong, 2015; Lybbert & Sumner, 2012; Lipinski et al., 2013). However, for many years, significant resources have been devoted towards increasing agricultural production in developing countries, without an equal push for reducing postharvest losses (World Bank et al., 2011; Affognon et al., 2015). Accordingly, there has been bias towards production and pre-harvest research and policies. Due to the renewed interest in agriculture in the aftermath of the recent food, climate and financial crises (Dethier & Effenberger, 2012), postharvest loss mitigation interventions are now seen as important elements of reducing food insecurity in Sub-Saharan Africa (Hodges & Stathers, 2013; Sheahan & Barrett, 2017; World Bank et al., 2011). A number of improved storage technologies have been introduced to farmers in Sub-Saharan Africa (Hodges et al., 2011; Tefera et al., 2011). However, few studies assess farm households' decisions to use such technologies and their impact on household welfare. In general, the literature on the welfare impacts of agricultural innovations is highly skewed to pre-harvest or production techniques and the evidence base on the impacts of postharvest technologies is thin.

Recent reviews on postharvest loss mitigation interventions and their impact underscore the lack of rigorous studies which establish an empirical link between these interventions (e.g. postharvest storage innovations) and household welfare (Affognon et al., 2015; Sheahan & Barrett, 2017). Among the few exceptions is a study by Gitonga et al. (2013) that use propensity score matching and find that metal silos almost completely reduce postharvest storage losses, help farmers increase months of maize storage, reduce expenditure on storage chemicals, enable sale of surplus at higher prices and reduce the period of inadequate food provision in Kenya. However, their evaluation approach did not control for possible bias from unobserved endogeneity. Cunguara and Darnhofer (2011) use a doubly robust estimator, subclassification regression and matching methods, and find that improved granaries had no significant impact on household income in rural Mozambique. Mutenje et al. (2016) employ a multinomial endogenous switching regression model and report that the joint adoption of improved storage and improved maize varieties provides the highest maize yield in Malawi compared to other combinations of technologies. Using double hurdle and Tobit models, Bokusheva et al. (2012) find that the use of metal silos improves the food security and well-being of user households in four Central American Countries (El Salvador, Guatemala, Honduras, and Nicaragua). They also emphasize that a significant proportion of the metal silos are subsidized in most of the Central American countries and in some cases, the metal silos are donated to poor farmers.

This study focuses on Ethiopia, a sub-Saharan African country where climate change, postharvest loss, food insecurity, and undernutrition are ubiquitous. Food security and child undernutrition remain critical issues in the country particularly in rural areas where a significant portion of the population is poor and earn a bulk of their income in agriculture. The major sources of food in Ethiopia are food grains (cereals and pulses) followed by starchy roots and tubers such as potato, sweet potato and Ethiopian banana (enset) (Chauvin et al., 2012; Gabriel & Hundie, 2006). At the farm level, crop storage is mainly undertaken using traditional and poor quality methods such as bags in the house, sacks, and traditional granaries (Gabriel & Hundie, 2006; Mengistu & Gerrard, 2014). While recent information on food crop storage technologies and postharvest loss in Ethiopia is largely nonexistent, some estimates show that postharvest loss ranges from 5% to 26% of production due to poor storage and the inherent weakness in the postharvest system (Gabriel & Hundie, 2006). Since many households in Ethiopia suffer protracted periods of food shortage, such a loss is tremendous. Improved storage methods have been promoted in Ethiopia for at least two decades by different organizations (e.g. the Sasakawa Global 2000 and Ethiopian Ministry of Agriculture and Rural Development) through participatory action research and field demonstrations (Mengistu & Gerrard, 2014). However, we are not aware of any study that rigorously demonstrates the impact of improved storage techniques on food and nutrition security and welfare in the country. The overarching objective of this study is to estimate the food security and household welfare impacts of postharvest food storage technologies. We employ a diverse set of identification and estimation strategies that address selection and endogeneity problems.

The paper contributes to the bodies of literature on the impacts of agricultural innovations, postharvest research and storage economics in the following ways. First, unlike previous studies which used a single measure for food security, this study uses various objective and subjective measures to capture the different dimensions of food security. Second, in addition to contributing to the literature which links improved agricultural technologies (innovations) and household food security and welfare, this paper also extends the link to intrahousehold food (nutrition) security. Until recently, there has been no empirical evidence showing how improved crop storage techniques improve child nutrition (Chaboud & Daviron, 2017). To the best of our knowledge, there are few rigorous empirical studies that estimate the impacts of agricultural innovations on child nutrition. This paper fills this research gap by estimating the impact of improved food storage technologies on child nutritional status. Finally, the study employs endogenous switching regression treatment effects frameworks that are increasingly being used to evaluate impact in a cross-sectional setting due to their merit in controlling for unobserved endogeneity.

The rest of the paper is organized as follows. The next section describes the conceptual framework, empirical estimation strategies, data, and the variables. Section three discusses the empirical results. The last section highlights the key findings and policy implications of the study.

2. Methodology

2.1. Conceptual framework

Farm households are assumed to be heterogeneous agents and their decision to use improved storage technology is constrained by resources, information and the availability of the technology (Foster &

[2] See Stathers et al. (2013) for discussion of the possible channels through which postharvest management (e.g. food storage) affects food security and wellbeing.

[3] The main storage innovations discussed in the paper are airtight drums.