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Adoption of improved wheat varieties and impacts on household food security in Ethiopia

Bekele Shiferaw [a,*], Menale Kassie [b], Moti Jaleta [c], Chilot Yirga [d]

[a] Partnership for Economic Policy (formerly CIMMYT), Nairobi, Kenya
[b] International Maize and Wheat Improvement Center (CIMMYT), Nairobi, Kenya
[c] International Maize and Wheat Improvement Center (CIMMYT), Addis Ababa, Ethiopia
[d] Ethiopian Institute of Agricultural Research, Holeta, Ethiopia

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ABSTRACT

This article evaluates the impact of the adoption of improved wheat varieties on food security using a recent nationally-representative dataset of over 2000 farm households in Ethiopia. We adopted endogenous switching regression treatment effects complemented with a binary propensity score matching methodology to test robustness and reduced selection bias stemming from both observed and unobserved characteristics. We expand this further with the generalized propensity score (GPS) approach to evaluate the effects of continuous treatment on the response of the outcome variables. We find a consistent result across models indicating that adoption increases food security and farm households that did adopt would also have benefited significantly had they adopted new varieties. This study supports the need for vital investments in agricultural research for major food staples widely consumed by the poor, and efforts to improve access to modern varieties and services. Policies that enhance diffusion and adoption of modern wheat varieties should be central to food security strategies in Ethiopia.

Introduction

Wheat is among the most important staple food crops grown in Ethiopia. Given the low productivity of traditional varieties, Ethiopia imports significant quantities, especially in drought years when deficits are large. Some of the food import stems from food aid coming into the country under relief and recovery programs. One of the key strategies pursued by the government for ensuring food security in the country was to expand the availability of modern wheat varieties for farmers. In 2009/10 main season, the total area under wheat production was 1.68 million ha while the total production was about 3.07 million tons (CSA, 2011). Over the same time period, wheat accounted for about 16% of the total area of cereals in Ethiopia. There are about 4.6 million farm households (36% of cereal farm households) who are directly dependent on wheat farming in Ethiopia. The national average productivity of wheat is 1.83 tons/ha (CSA, 2011). Despite the low yields, demand for wheat has been growing fast in both rural and urban areas in the country. Changes in dietary patterns and a rapid growth in wheat consumption have been noted over the past few decades in several countries in sub-Saharan Africa (SSA) (Morris and Byerlee, 1993; Shiferaw et al., 2011). A recent analysis by Jayne et al. (2010) has also confirmed rapid growth in wheat consumption as a consequence of urbanization, rising incomes, and dietary diversification in Eastern and Southern Africa. While many countries in Africa are largely dependent on wheat imports to meet their growing demands, Ethiopia is one country where smallholder wheat production is prominent, allowing it to meet more than 70% of the demand from domestic production (Shiferaw et al., 2011). These statistics indicate the critical importance of improving the productivity and production of wheat through generation and development of improved wheat technologies in order to promote broad-based economic growth and poverty reduction in Ethiopia.

Both bread wheat and durum wheat are grown in Ethiopia and about 87% is grown during the main growing season (*meher*). While bread wheat is a recent introduction to Ethiopia, durum wheat is indigenous and mainly grown in the Central and Northern highlands. Durum wheat was the main wheat crop both in terms of area and production, but this has changed dramatically since the mid-1980s with the release and dissemination of semi-dwarf, high yielding and adaptable bread wheat varieties. In our sample, about 69% of sampled households have adopted bread wheat, while only 1% have adopted durum wheat varieties. Over the last several years, CIMMYT has been collaborating with the Ethiopian Institute of Agricultural Research (EIAR) in the development and dissemination of improved wheat varieties. Through this long-standing

* Corresponding author.
E-mail addresses: b.shiferaw@pep-net.org (B. Shiferaw), m.kassie@cgiar.org (M. Kassie), m.jaleta@cgiar.org (M. Jaleta), ctizale@yahoo.com (C. Yirga).

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partnership, about 44 improved bread wheat and 30 durum wheat varieties have been released, with associated agronomic and crop protection practices.

Despite considerable efforts to develop and disseminate several modern wheat varieties, the adoption and livelihood impacts of these technologies have not been analyzed systematically. Although the literature on the adoption and impact studies of crop technologies is large, most studies have looked at the impact of other crops (maize, groundnuts, pigeonpeas, rice) on agricultural productivity and household welfare (e.g. Mendola, 2007; Minten and Barrett, 2008; Alene et al., 2009; Shiferaw et al., 2008; Asfaw et al., 2012; Becerril and Abdulai, 2010; Kijima et al., 2011; Kassie et al., 2011; Amare et al., 2012). Much less is known about the welfare impact of wheat technology at farm household level.

A recent study on the impact of improved groundnut varieties in rural Uganda found that adoption can significantly increase crop income and reduce poverty (Kassie et al., 2011). Some studies in West Africa using the economic surplus approach show that adoption of improved maize varieties is associated with improved household welfare (Alene et al., 2009). Kijima et al. (2008) found that the introduction of a new rice variety for Africa decreased poverty significantly without worsening income distribution. Minten and Barrett (2008) show that communes in Madagascar with higher rates of adoption of improved agricultural technologies, and consequently higher crop yields, enjoyed lower food prices, higher real wages for unskilled workers, and greater food security and lower poverty. Asfaw et al. (2012) found that the adoption of improved pigeonpea varieties in Tanzania increased household welfare as measured by per capita consumption expenditure.

The paper adds value to existing literature on impact assessment of agricultural technologies. First, our analysis uses a comprehensive and nationally representative household- and plot-level survey data from all major wheat growing areas of Ethiopia. This has allowed us to include several policy-relevant variables that were not included in previous studies. Second, to the best of our knowledge, this is the first rigorous paper on the link between food security and wheat technology adoption in Africa in general and in Ethiopia in particular. Rigorous impact assessment is important for informed and evidence-based policy making, for instance, to develop and implement appropriate support policy measures for improving targeting, access and use of modern varieties. Third, in addition to standard per capita food consumption measures of food security, we also consider farm households' self-reported subjective food security status. This allows us to check for consistency of measured indicators with farmers' assessment of their own food security status during the whole year, after taking seasonal shocks into account. The use of subjective measures, including self-reported poverty (see e.g. Deaton, 2010, who argues for wider use of self-reported measures from international monitoring surveys) and people's subjective perceptions of their own economic welfare (see e.g. Ravallion and Lokshin, 2002, who used subjective economic welfare measures in Russia) is a growing field, and our paper represents one of the first applications to evaluate technology impacts on food insecurity.

The next section describes the data and summary statistics for the variables selected for the empirical model. Section three presents the wheat adoption decision model and food security function with endogenous adoption and switching behavior to assess determinants of adoption and the resulting effects on household food security. We describe an endogenous switching regression (ESR) treatment effects approach to evaluate the responses of food security to variety adoption. Section four discusses the empirical results. Finally, the concluding section highlights the key findings and implications for policy to enhance adoption and impacts on food security.

Data and description of variables

The data used for this study is based on a farm-household survey in Ethiopia conducted during 2011 by the International Maize and Wheat Improvement Center (CIMMYT) in collaboration with the Ethiopian Institute of Agricultural Research (EIAR). The data was collected with a purpose of wheat technology adoption analysis and its impacts on smallholder producers. The sampling frame covered eight major wheat-growing agro-ecological zones that account for over 85% of the national wheat area and production distributed in four major administrative regions of Ethiopia. A total of 2017 farm households in eight agro-ecological zones, in 26 zones (provinces), 61 districts and 122 *kebeles* (local councils) were interviewed. The sample distribution by agro-ecology and region is shown in Table 1.

A multi-stage stratified sampling procedure was employed to select villages from each agro-ecology, and households from each village. First, agro-ecological zones that account for at least 3% of the national wheat area each were selected from all the major wheat growing Regional States of Ethiopia: Amhara, Oromia. Tigray, and Southern Nations Nationalities and Peoples (SNNP). Second, based on proportionate random sampling, up to 21 villages in each agro-ecology, and 15–18 farm households in each village were randomly selected.

The data was collected using a pre-tested structured questionnaire by trained and experienced enumerators who have good knowledge of the farming systems and speak the local language. The enumerators were trained and supervised by CIMMYT scientists in collaboration with EIAR senior researchers.

The survey covered a wide range of variables that influence technology adoption and food security at household, plot and village levels. Key socioeconomic data collected at the household level, among other things, contained information on consumption expenditures (home-produced consumed food, consumption of purchased food and non-food), respondents' perception of their own household food security status, marketed surplus, access to credit, asset ownership (crop land and livestock), age, gender and education level of the household head and members, family size, kinships (number of relatives in and outside the village that a respondent can rely on for critical support in times of need), social networks (number of traders respondents know in their vicinity), adoption of varieties and other technologies, sources of variety information, and marketing of own crop and livestock production. The consumption expenditure data was collected for the preceding year covering a period of 12 months. This was collected using carefully calibrated frequency of buying that varied across purchased food items and the amount spent during each period and then aggregated to the annual level. In order to enhance accuracy, this was discussed and provided jointly by both the husband (head of household) and the women (wife) in the family.

Data was collected on standard per capita food consumption and subjective food security indicators. The standard per capita food consumption indicator of food security is based on food expenditure (household's own consumption of home produced food + purchased food + aid or gift food), adjusted by adult equivalent. However, since food consumption is based on a single-round survey; consumption data may under- or over-report the true status of household food security. To minimize this problem, we estimate the models for both objective and subjective food security indicators. A recent study, Mallick and Rafi (2010), adopted subjective food security measures to overcome the shortcoming of the food consumption method pointed above. We use the perception of the respondents' own food security status to generate subjective measures of household food security in addition to the objective measures. Based on all food sources (own production + food