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The impact of high value markets on smallholder productivity in the Ecuadorean Sierra: A Stochastic Production Frontier approach correcting for selectivity bias ☆,☆☆

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ABSTRACT

This paper uses data from small-scale potato farmers in Ecuador to examine the impact of the program *Plataformas de Concertación* on productivity growth. Using propensity score matching combined with a Stochastic Production Frontier model that corrects for sample selection bias, we disaggregate the yield growth attributable to the program into technological change (TC) and technical efficiency (TE). While the results do not exhibit a clear indication of selection bias, the analysis does show that on average beneficiaries exhibit higher yields than control farmers given the same input levels, but lower TE with respect to their own frontiers. These results suggest that while the program raised the technology gap in favor of beneficiaries, it had a negative effect on TE in the short run. The latter finding is consistent with the notion that beneficiaries enjoyed a significant change in production techniques, but it is very likely that they were still in the "learning by doing" stages at the time the data was collected. In fact, the results suggest a fast recovery in TE levels on the part of beneficiaries as time with project increased.

Introduction

Agricultural projects often seek to improve productivity with the expectation that such improvements would lead to higher income and welfare among beneficiaries. Examples of interventions include the introduction of new seed varieties, the adoption of new farming techniques (such as integrated pest management or IPM), linking farmers to markets, better accounting practices, provision of extension services, farmer field schools (FFS), or a combination of various actions. The effective use of a newly adopted technology requires investing the time and effort to become acquainted with the new practices before the full benefits of adoption can be felt by the farmer. This may entail a process of trial and error during several agricultural cycles. While adopting new techniques or inputs can potentially lead to increases in production at the end of an agricultural cycle, this does not necessarily mean that the new procedures are being implemented in an efficient manner. This is particularly true for smallholders, who are typically characterized by having lower levels of education, living in isolated rural areas, and having limited access and exposure to information and markets. Thus, much of the innovative content and techniques can be quite foreign and may entail a challenging process for this type of farmers. Therefore, when evaluating the impact of an agricultural project, it is important to differentiate between indicators of technological change (TC) versus managerial performance (or technical efficiency, TE).

The economic impact evaluation literature has been growing in recent years, and this growth has been mainly focused on the social sectors where the indicators of impact tend to be more easily identifiable (Winters et al., 2011). Rigorous impact evaluations of agricultural projects have been relatively scarce and the evidence on the effectiveness of such projects in developing countries is mostly inconclusive (IDB, 2010; Del Carpio and Maredia, 2009). The relative scarcity of formal evaluations of agricultural projects is likely

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due to several reasons. First, agricultural projects are generally designed to increase output and therefore impact evaluations focus on production-based indicators, typically associated with TC. However, collecting this type of data can be challenging, beginning with the definition of the sample unit, since production is often linked to multiple plots but the decision-making process takes place at the household level. The challenge is greater when attempting to evaluate the impact of a project on different types of households, such as smallholders and large holders, who often have very distinct production systems (Winters et al., 2010).

Second, in analyzing agricultural production, the relationship between inputs and outputs or profitability is often examined through gross margins or total value product functions. Yet, presumably, agricultural projects have an impact not just on inputs and outputs, but also on how these inputs are used and combined. Whether these inputs are being used in an efficient manner to obtain the maximum possible levels of output needs to be considered in an evaluation (Winters et al., 2010). Yet, this is rarely done since, as noted, most project evaluations focus on TC indicators. While such focus allows the researcher to identify impact on different components of production, it does not provide any information on whether farmers made the right use of the available inputs and technology at their disposal, i.e., managerial performance is ignored.

Given these difficulties, combining Stochastic Production Frontier Analysis (SPFA) with impact evaluation methodologies provides a useful avenue for measuring the productivity impact of agricultural projects. SPFA is a widely used econometric technique that estimates the 'best practice' relationship between inputs and output of the farm households in the sample. In addition, SPFA can help identify the levels of efficiency (or inefficiency). Therefore, this approach makes it possible to quantify the potential to increase agricultural output without the need for additional inputs or new technology (Coelli et al., 2005).

Papa Andina, the focus of this paper, is a partnership that worked to address rural poverty in the Andean highlands by fostering innovation and market development for potatoes. The approach recognizes that while agricultural research is a main driver of TC and agricultural development in addressing rural poverty, this research needs to be linked to practical improvements in value chains that are important to smallholders (Horton et al., 2011). A key program within *Papa Andina* is the *Plataformas de Concertación*, hereafter *Plataformas*. This program offered a space for public and private sector partnerships where diverse actors—including farmers, potato processors, supermarkets, national research institutes, universities and non-governmental organizations—could work together to innovate and link small-scale potato producers to commercial interests. *Plataformas* offered a mechanism not just to support agricultural research in the field, through new varieties and different mechanisms to enhance production and marketing, but also served as an experiment in institutional innovation. The question is whether this approach is an effective mechanism to increase farmer production and efficiency and this constitutes the overall goal of this paper.

In implementing impact evaluations of development projects, several researchers have promoted the use of randomized experiments (Duflo et al., 2008). However, it is often the case that experimental designs are costly and difficult to implement; thus, one needs to rely on non-experimental methods (Barrett and Carter, 2010). One common non-experimental approach to assessing project impact is propensity score matching (PSM), which alleviates biases stemming from observable variables (World Bank, 2006). However, in projects where beneficiaries self-select, unobservable variables (e.g., managerial ability) can also be a source of bias. If panel data are available, fixed effects estimators along with PSM can be used to deal with the problem, provided that the unobservables are time invariant (Angrist and Pischke, 2009). Thus, the generation of a counterfactual along with the mitigation of biases from observables and unobservables can be addressed in non-experimental designs as long as one has data on treatment and control groups at both the baseline and the endline. Recent applications of this methodology to agricultural projects include the work of Bravo-Ureta et al. (2011) in Honduras and Cerdán-Infantes et al. (2008) in Argentina.

A challenge frequently encountered in the field is that analysts and/or policy makers might be interested in measures of impact even when baseline data is not available. In such a situation, which is the case for *Plataformas*, one needs to rely on cross-sectional data along with suitable matching procedures and other econometric techniques, such as instrumental variables, in order to obtain the desired impact measures (Cavatassi et al., 2011a). In this paper, we are particularly interested in separating the effect of TC and TE on farm productivity. To achieve our goals we make use of cross-sectional data collected after the project was underway. A number of steps were taken to ensure that the data on treatment and control groups would have been very similar at the baseline, but it is likely that selection issues still remain. Therefore, we address possible self-selection in a stochastic frontier context using the model recently introduced by Greene (2010) and adapted to the evaluation of development programs by Bravo-Ureta et al. (2012).

In sum, a key feature of this paper is bridging SPFA with impact evaluation methods. Development projects often have a major component intended to improve decision-making and managerial ability along with the transfer of technologies designed to increase output. Thus, for such projects, SPFA methodologies are ideally suited to decompose productivity growth into technological and managerial components; however, these methodologies have hardly been applied for this purpose. A major reason for the absence of such applications is likely to be the challenges posed by selectivity bias, which is a common feature in development projects. In this fashion, this paper adds to a very limited but emerging literature that combines SPFA modeling with impact evaluation techniques.

The remainder of the paper is structured as follows. Section 2 provides an explanation of *Plataformas*, and a description of the data is provided in Section 3. Section 4 presents the analytical framework for analyzing TC and TE and the closely related empirical strategy. Section 5 provides the results and Section 6 concludes.

Plataformas de Concertacion[1]

The *Plataformas* are multi-stakeholder alliances, which bring farmers together with a range of agricultural support service providers, including INIAP (*Instituto Nacional Autónomo de Investigaciones Agropecuarias*), local NGOs, researchers, universities, and local governments. The *Plataformas* pay special attention to expanding the direct participation of low-income farmers in high-value producer chains by providing them with new technologies, by promoting their organizational skills and social capital, and by involving them in a "value chain vision" of production and commercialization that directly links them to the final output markets, thus circumventing intermediaries (Cavatassi et al., 2009). As noted by Devaux et al. (2009, p. 36), "this facilitates knowledge sharing, social learning and capacity building, leading to improvements in small farmer productivity and the quality of potatoes supplied to market." The overall objective of the *Plataformas* is then to "reduce poverty and increase food security, through increasing

[1] More information on the different aspects and activities of *Plataformas* can be found in Cavatassi et al. (2009).