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Farm Management Information Systems (FMIS) and technical efficiency: An analysis of citrus farms in Brazil

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ABSTRACT

This study aims to investigate the impacts of personal aspects and aspects of the decision-making process (Rougoor et al., 1998) on the technical efficiencies of citrus farms in Brazil. A variable that measures the adoption of Farm Management Information Systems (FMIS) was created, which is an innovative aspect of this paper. Primary data for the crop year of 2013/14 (cross sectional data) were collected from a sample of 98 farms located in the State of São Paulo, one of the largest citrus regions in the world. The single stage model developed by Battese and Coelli (1995) was used to estimate the stochastic production frontier translog and the determinants of the efficiency of farms. The results showed that the technical efficiency scores across citrus farms range from 28% to 97%, with a mean of 75%. The expectation formation (personal aspect), the use of long-term contracts and the adoption of Farm Management Information Systems (aspects of decision-making processes) were significant determinants of technical efficiency. This result confirms the hypotheses built around these variables.

1. Introduction

In his pioneering study, Leibenstein (1966) noted that a set of management factors, such as internal incentives, use of appropriate contracts, better monitoring of production processes and the adoption of management tools, can differentiate efficient and inefficient firms. The author classified these factors as "X-efficiency." By means of several examples in industries and firms of different countries, Leibenstein (1966) showed that changes in firms' internal incentives and their production organization structures (changes in the layout of plants, production flows, increased employee training, etc.) were the main factors responsible for the efficiency differentials and productivity gains over time. Thus, productivity differentials between firms would in large part be explained by the factors of "X-efficiency" and not by differences in the use of traditional factors of production (labor and capital) as most authors believed.

Rougoor et al. (1998) developed a theoretical model relating personal aspects and aspects of the decision-making process to efficiency in agriculture. Following the study of Rougoor et al. (1998), some empirical studies have adopted econometric methods and tested this relationship with regard to several farming activities (Wilson et al., 1998, 2001; Trip et al., 2002; Nuthall, 2004; Cabrera et al., 2010; Chang and Mishra, 2011). Most of them showed a significant and positive effect of the adoption of management tools on the efficiency of farms.

This paper adopts the concept of "X-efficiency" (Leibenstein, 1966) and the approach of Rougoor et al. (1998) to test hypotheses regarding the effects of personal aspects (e.g., abilities and expectation) and aspects of the decision-making process (e.g., adoption of Farm Management Information Systems, FMIS) on the technical efficiency[1] of citrus farms in the State of São Paulo, Brazil.

The paper has two complementary aims: (i) to estimate a production frontier based on data from citrus farms in Brazil, thus making it possible to understand the characteristics of the production technology and calculate the efficiency scores of the farms; and (ii) to identify the effect of farmers' personal aspects as well as aspects of the decision-making process on the technical efficiency of the farms. To achieve these aims, primary data were collected from a representative random sample of 98 citrus farms in the State

[1] The Debreu-Farrell measure of technical efficiency oriented to output was adopted: Technical Efficiency = 1 – the maximum possible proportional increase in output, given the available technology and endowment of factors/inputs. Technically efficient firms assume the value 1, as they cannot increase output, given the available technology and their endowment of factors/inputs. Technically inefficient firms, in turn, could increase output, given the available technology and their endowment of factors/inputs.

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of São Paulo, Brazil. The data were collected in the context of a research project financed by the São Paulo Research Foundation and refer to the crop year 2013/14 (cross-sectional data). A stochastic frontier model with a single estimation stage (Battese and Coelli, 1995) was adopted to estimate a production translog frontier and the effects of management variables on the technical efficiency of the farms.

The study is innovative in that it tests the relationship between personal factors and aspects of the decision-making process in citrus farming, an activity of extreme importance for Brazilian agriculture. Additionally, a variable that measures the different aspects of the adoption of Farm Management Information Systems (FMIS)[2] was created, which is another innovative aspect of this paper. Kuhlmann and Brodersen (2001) discussed the main causes for the low diffusion of these technologies in agriculture. In the context of Brazilian agriculture, Mendes et al. (2014) showed that the adoption of FMIS remains incipient.[3] Verstegen et al. (1995), Nuthall (2004) and Fountas et al. (2015) argued that the key points in FMIS development and adoption are the productivity and profitability indicators associated with these technologies. Thus, an empirical analysis of the effect of FMIS on the technical efficiency of farms can be important to fostering the diffusion of these systems.

The next section presents a literature review of the impact of the adoption of management tools on farm efficiency. The third section presents a description of the sample, the variables, and the econometric model used for empirical analysis. The fourth section presents and discusses the main aspects of production technology, the technical efficiency scores and the factors determining the efficiency differentials. Lastly, section five presents some concluding remarks.

2. Management and efficiency in agricultural production

The theoretical model developed by Rougoor et al. (1998) shows that the adoption of technology applied to making management decisions, the way in which decisions are made and farmers' human capital are of fundamental importance in the determination of the technical and economic efficiencies of farms. The model assumes that aspects of the decision-making process (e.g., the adoption of FMIS to production planning and control) and farmers' personal aspects (e.g., motivations, management aims, and abilities of the farmer) directly affect the process of decision-making, thus influencing the technical and economic performance of farms. The author also found through a literature review that few empirical studies have tested the effects of personal factors and aspects of the decision-making process on the performance of farms. In this context, some more recent empirical studies have tested the influence of management factors on the technical and economic efficiencies of rural properties (Wilson et al., 1998, 2001; Trip et al., 2002; Nuthall, 2004; Cabrera et al., 2010; Chang and Mishra, 2011).

Wilson et al. (1998) employed the practice of product stocking as a proxy to measure the level of production planning of potato farmers in the United Kingdom (UK). The authors found a positive and statistically significant relationship between this variable and the technical efficiency of farms, thus confirming the hypothesis that management planning positively affects the efficiency of the production process. Wilson et al. (2001) adopted the theoretical model of Rougoor et al. (1998) and tested the effect of personal aspect (experience, schooling and management aims) and aspects of the decision-making process (number of sources of information) on the technical efficiency of wheat farms in England. The authors showed that the objectives of maximizing annual profits and protecting the environment are positively related to the technical efficiency of farms. Moreover, farmers who seek information and have more years of managerial experience are also associated with higher levels of technical efficiency.

Following the theoretical model of Rougoor et al. (1998), Trip et al. (2002) created four management variables related to: (i) the quality of establishing aims (goals and policy), (ii) the quality of production planning (planning), (iii) the quality of the collecting and monitoring of operational results (data recording and monitoring), and (iv) the quality of the evolution of the firm's performance (evaluation). Based on data from flower producers in the Netherlands, the authors showed that producers who display higher quality in collecting and monitoring data and in the evolution of the operational performance of their farms operate with higher levels of technical efficiency. The authors concluded that decision-making variables are of fundamental importance in explaining the differences in the efficiencies of farms.

In an analysis of the effects of computers on farming profits, Nuthall (2004) used a sample of 23 New Zealand farms and compared their profits pre- and post-adoption of computers for making managerial decisions. The author found that, on average, farm profits tended to increase after the adoption of computers. Over the few years, however, the profits of farms with computers (compared with the profits of farms without computers) showed a decreasing trend. This result shows that this relationship is more complex than it appears and is dependent on other factors, such as the farmer's training in the organization and processing of farm information using computers and software functionality.

Cabrera et al. (2010) showed that the intensification of dairy production (feed/cow) and the adoption of automated systems for production control have a positive effect on the technical efficiency scores of dairy farms in the American state of Wisconsin. Chang and Mishra (2011) found that US dairy farmers who adopted automated milking systems, kept production records and made use of regularly scheduled veterinary services achieved higher levels of technical efficiency.

The literature supposes that FMIS have great potential to help farmers in their decision-making processes. These systems, by providing potentially valuable information when making management decisions, can reduce informational problems and improve the planning and control of the production process and, consequently, the performance of farms (Rougoor et al., 1998; Kuhlmann and Brodersen, 2001; Osaki and Batalha, 2014; Fountas et al., 2015). For example, when farmers follow the market via the Internet, they obtain real-time information on the prices of production factors, products and available technologies at a low cost. Perfect knowledge of prices and production technologies and their changes over time are important to production planning and the selection of the optimal demand factors and production levels, in accordance with the assumptions of microeconomic theory. In turn, managerial systems of cost and productivity control are also fundamental for farmers to monitor and optimize the use and allocation of their production resources, resulting in higher technical efficiency.

Furthermore, the adoption of FMIS allows for better coordination and monitoring of productive processes, reducing internal transaction costs and increasing factor productivity.[4] Such systems are also important to increase coordination, reduce the asymmetry of information, and consequently, the transaction costs between firms in the same agro-food production chain (Kuhlmann and

[2] Sørensen et al. (2010) defined FMIS as planned systems for collecting, processing, storing, and disseminating data in the form needed to carry out a farm's operations and functions. In this paper, we adopt the definition of Sørensen et al. (2010).

[3] Data from the last Brazilian Agricultural Census (2006) showed that only 4.54% of Brazilian farms had computers and 1.87% of the total of Brazilian farmers had Internet access on their farms.

[4] The costs of internal coordination, obtaining information and monitoring the production activities of a firm are examples of transaction costs within the firm.