Technical efficiency of citrus properties in the State of Sao Paulo

Felippe Clemente, Graduate student on Applied Economics, Federal University of Viçosa, Brazil, email: felippe.clemente@ufv.br.

Marília Fernandes Maciel Gomes, Associate Professor. Agricultural Economics Department. Federal University of Viçosa, Brazil, email: mfmgomes@ufv.br.

Viviani Silva Lírio, Associate Professor. Agricultural Economics Department. Federal University of Viçosa, Brazil, email: vslirio@ufv.br.

Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

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ABSTRACT: The orange crop is widespread in Brazil and is cultivated in almost all states. Meanwhile, Orange is a focused culture, with the State of Sao Paulo accounts for about 78% of production. But there is a discrepancy between the number of producers and the quantity produced orange. This mismatch between variables can signal a lack of efficiency in the citrus sector. In this context, the study aimed to examine the technical efficiency of citrus properties in the State of Sao Paulo in the period between the years 2009 and 2010. To achieve our goals, we applied the non-parametric approach of data envelopment analysis to calculate the levels of technical efficiency and Tobit econometric model to understand the determinants of technical efficiency. The results showed that most properties citrus works inefficiently and the variables that most contribute to increased efficiency are "schooling" and "time as a farmer".

Keywords: Technical efficiency, the citrus sector, DEA

RESUMO: A cultura da laranja é amplamente difundida no Brasil, sendo cultivada em praticamente todos os estados. Ao mesmo tempo, a laranja é uma cultura concentrada, sendo o Estado de São Paulo responsável por cerca de 78% da produção. Porém, justifica-se que há discrepância entre o número de produtores e a quantidade produzida de laranja. Esse descompasso pode sinalizar a ausência de eficiência no setor citrícola. Nesse contexto, o trabalho teve por objetivo analisar a eficiência técnica das propriedades citrícolas do Estado de São Paulo, no período compreendido entre os anos de 2009 e 2010. Para alcançar os objetivos, aplicou-se a abordagem não-paramétrica de análise envoltória de dados para calcular os níveis de eficiência técnica e o modelo econométrico Tobit, para conhecer os determinantes da eficiência técnica. Os resultados mostraram que grande parte das propriedades citrícolas atua de forma ineficiente e as variáveis que mais contribuem para aumento da eficiência são "escolaridade" e "tempo como produtor rural".

Palavras-Chave: Eficiência técnica, setor citrícola, DEA

JEL: Q12, C25

1. Introduction

The orange crop is widespread in Brazil and is cultivated in almost all states. At the same time, the orange is a spatially concentrated activity in the country, since 96% of production comes from only six states, especially São Paulo, responsible for about 78% of production (AGRIANUAL, 2010).

According to Neves (2005), the citrus sector is of fundamental importance for the economy because it involves more than 24 000 farms and employing approximately 11.2% of the agricultural labor force in the State of Sao Paulo and 2.2 % in Brazil. In 2010, Brazil was considered a major producer of orange, with 31% of world production, followed by the United States and European Union, with 16% and 11% respectively and also the main exporter of frozen concentrated orange juice (SLCC), with about 80% of the market. The exports of orange juice remains, since 1994, between 1.1 and 1.4 million tons, generating over a billion dollars of foreign exchange. (Neves, 2005).

Regarding the orange production in Sao Paulo state, there is a discrepancy between the number of producers and the quantity produced. According to Clemente (2010), the structure of the orange production in São Paulo state is characterized "by many who produce very little" and "produce very few." The producers of up to 100 hectares corresponding to 48% of the total number of producers, but account for only 17.5% of production. At the other extreme, producers with more than 300 hectares account for only 17% of the total number of producers, but respond with 43.3% of production in São Paulo. From this arises the question: Is it possible that there is inefficiency in the production of citrus in São Paulo orange?

As a hypothesis, it hás been found that this mismatch may signal in a first analysis, the lack of efficiency in the citrus sector.

In fact, the concept of efficiency is relative and differs from efficiency and productivity. The effectiveness is linked only to what is produced, without taking into account the resources used for production. Productivity is called by the ratio of what was produced and what was spent to produce. Since the effectiveness compares what has been produced, given the resources available, what could have been produced with the same resources. If the production unit of this parameter is far away, it can be considered inefficient. There are two forms of an inefficient unit become efficient. The first is to reduce inputs, holding constant the production, the second is increasing the production, keeping constant the inputs (Mello et al., 2005).

In applied terms, the analysis of efficiency of production units is important both for strategic purposes (comparison between production units), and for planning (evaluation of the results of using different combinations of factors) and decision making (how to improve current performance, by analyzing the distance between the output current and potential).

In this context, the study aims to analyze the technical efficiency of citrus properties in the State of Sao Paulo. The analyzed period covers the years 2009 and 2010, during which the interviews were conducted with citrus for information about orange production of each property.

To achieve the goal, the article is structured into four sections besides this introduction. The second section presents the theoretical work and in the third section the analytical framework. In the fourth and last section shows the main results and conclusions of the study, respectively.

2. Theoretical Reference

According to Carvalho (1984), usually in microeconomic analysis, we represent the production function as follows: $y = f(X_1, X_2, \dots, X_n)$, where y is the quantity produced and $X_1, X_2, \dots, X_n$ the quantities used and identify the various factors, respecting the production process more efficient choice. The production function is always defined in time and levels of non-negative factors and the product, ie, (i = 1,2 ,..., n).

The aggregate of these production functions and the subsequent econometric estimation to generate a macro production function, without taking into account the differences in productive efficiency, generate biased results (SATO, 1975). These, findings, to be used by the agents responsible for the production process could undermine the efficient allocation of resources, which are, in most cases, scarce and expensive.

Comparing different production units, one incurs errors based only on the estimation of the average production function. This happens because there are differences in the use of production factors, which generate different levels of technical efficiency of production. Thus, to correctly estimate the aggregate production function of the state, have to eliminate the inefficiencies in each production unit.

In this sense, it becomes necessary to estimate a frontier production function that characterizes the best technology (best practice), from which one can make comparisons between production units in terms of productive efficiency and structure of production technology.

Figure 1 illustrates the difference between an average production function estimated by ordinary least squares and a production function frontier. It is noticed that the average function, by minimizing the squared deviations, there are points above and below the function. In the boundary function, all points lie on it, or below. The points that lie on top of the border refer to the unit's efficiency. Equivalently, the points below the border have some kind of inefficiency (Fare et al., 1994).

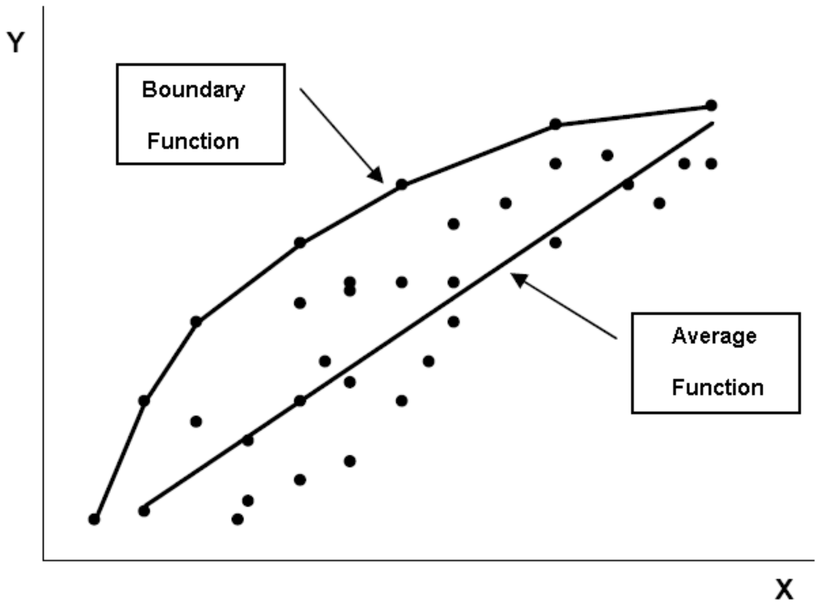

Figure 1 – Representation of the production function
Source: GOMES; BAPTISTA (2009).

The existence of inefficiency precludes correct estimation of the function, since it contradicts all the principles of microeconomic maximizing profit. Therefore, it is necessary to eliminate thein efficiencies in order to project the inefficient units to the efficient frontier. That done, we can estimate the production function, which best express the relationships between inputs and outputs, as devoid of inefficiency.

3. Methodology

3.1 Data Envelopment Analysis

The production of oranges, as well as other agricultural activities, involves production systems, according to the considered set of variables (inputs and outputs), is more complex resource allocation. The maximum quantities that can be obtained given then puts used to determine the production frontier (LINS; MEZA, 2000).

The data envelopment analysis (DEA) is a non-parametric technique based on mathematical programming to analyze the relative efficiency of production units. In the literature related to DEA, a production unit is treated as a DMU (decision making unit), since these models comes from a measure to assess the relative efficiency of decision makers units (GOMES, 2009).

According to Charnes et al. (1994), to estimate and analyze the relative efficiency of DMU's, the DEA uses the definition of Pareto optimality, under which any product may have increased their production without their inputs are increased or decreased production of another product. The efficiency is analyzed in relation between the units.

To incorporate the nature of multi-product and multi-input production, Charnes et al. (1994) proposes the DEA technique for the analysis of different units, and the relative efficiency.

The distance function is used to incorporate the nature of multi-product and multi-input in the analysis of productivity and efficiency, without the need to specify behavioral objectives of decision makers.

According to Färe et al. (1994), the convenient way to describe the characteristic multi product production technology is defined by the set S:

$$S = \{(x, y): x\ can\ produce\ y\}, \quad (1)$$

which is defined by the set of all vectors of inputs and outputs (x, y) such that x can produce y, where x is a vector (k x 1) non-negative inputs y, a vector (m x 1) does not negative product.

The set of production technologies can equivalently be defined by the set of production possibilities P (x), which represents the set of all vectors y of products that can be produced by the input vector x, ie,

$$Px = \{y\colon x\ can\ produce\ y\}. \qquad (2)$$

The distance function-oriented product, according to Shephard (1970), can be defined by the set of products P (x) as

$$d_0(x,y) = \min\{\emptyset : \left(\frac{y}{\emptyset}\right) \in P(x) \qquad (3)$$

$$d_0(x,y) = (\text{máx } \{\emptyset : (\emptyset y) \in P(x)\})^{-1} \qquad (4)$$

where $\emptyset$, in the expression (3), is a minimal factor by which the product can be contracted and still be in the range of production possibilities.

The distance function $d_0(x,y)$ may have values less than or equal to 1 if the output vector y is an element of the production possibility set P (x); if the output vector = 1, (x, y) is on the technological frontier in this sense, the production is technically efficient.

The DEA oriented product and assumption of non-constant returns to scale seeks to maximize the proportional increase in levels of output, holding fixed the amount of inputs. According to Charnes et al. (1994), can be represented algebraically by:

$$[d_0(x,y)]^{-1} = MAX_{\theta,\lambda,S^+,S^-}\ \phi,$$

sujeito a:

$$\begin{aligned} &\phi y_i - Y\lambda + S^+ = 0 \\ &-x_i + X\lambda + S^- = 0 \\ &N1'\lambda \le 1 \\ &\lambda \ge 0 \\ &S^+ \ge 0 \\ &S^- \ge 0 \end{aligned} \qquad (5)$$

where Yi is a vector (m x 1) quantities of product i-th DMU, xi is a vector (k x 1) input quantities of the i-th DMU, Y is a matrix (n x m) product of the n DMUs , X is a matrix (n x k) inputs of the n DMUs, λ is a vector (n x 1) weight; N1 is a vector (n x 1) of numbers 1, S^+ is a vector of slack on the products, S^- is a vector of slack relative to inputs, and ϕ is a scalar vector is equal to or greater than 1 and indicates the efficiency score of DMUs, ie, a value of 1 indicates technical efficiency of the i-th DMU in relation to others, while a value greater than 1 show the presence of technical inefficiency relative. The problem presented in (5) s solved n times - once for each DMU, and, as a result, shows the values ϕ of λ and ϕ is the efficiency score of DMU provides analysis and λ peers (efficient DMUs serve as a benchmark for the i-th DMU inefficient).

3.2 Tobit Model

To determine which variables are associated with efficiency and inefficiency of citrus properties in the State of Sao Paulo, we use the Tobit econometric model.

According to Greene (1993), when it intends to incorporate the error again in the equation to compute the stochastic part, will in some cases, the need to work with models censored variables, or as more commonly known, named Tobit model James Tobin is due to his Creator.

Thus, the Tobit model is estimated as follows:

$$Y_i^* = \beta X_i' + u_i \tag{6}$$

where u_i é iid≈N(0, σ^2)

The observed values Y_i are called Y^*, ie, are conditional on:

$$Y_i = Y^* \; se \; Y_i^* \geq Y_0 \tag{7}$$

$$Y_i = Y_0 \; se \; Y_i^* \leq Y_0 \tag{8}$$

Usually Y_0 is left to be zero. The problem is that for cases like this, the method of OLS leads to biased and inconsistent estimators (Amemiya, 1984).

This problem is solved by estimating the regression by the method of maximum likelihood (ML), which find an unbiased estimator and asymptotically efficient.

As stated by Amemiya (1984), the ML function for the Tobit model is:

$$L = \prod_0 [1 - \emptyset(X^{'}\alpha)] \prod_1 \sigma^{-1} \emptyset \left[(\frac{Y_i}{\sigma} - X_i^{'}\alpha) \right] \quad (9)$$

In equation (9), the first member represents the probability that the event be less than zero and the second term represents the density of the event to be observed. In two terms $\alpha = \frac{\beta}{\sigma}\cdot$, it is a convenient way to scale the equation for convergence.

At this point, we try to focus on information regarding the characteristics of properties (size and number of employees) and feature producer (age, education and time as a producer). It is expected that these variables impact positively on the fact that properties be efficient. Thus the following equation was estimated, based on primary data obtained from a sample of orange growers of the State of São Paulo:

$$Y_i = \beta_1 + \beta_2 I_i + \beta_3 E_i + \beta_4 Te_i + \beta_5 T_i + \beta_6 Nf_i + \varepsilon_i \quad (10)$$

where:

Y_i = efficiency scores obtained through data envelopment analysis. Therefore, each DMU has a positive coefficient of efficiency, limited to the range 0 to 1

I_i = age of the producer (in years);

E_i= education of the producer (in years);

Te_i = time as a farmer (in years);

T_i = farm size (in hectares);

Nf_i = number of employees in the properties;

ε_i = error term.

The estimation of equation (10) allows inferences to the entire population without loss of quality.

3.4 Source of data

The average cost of capital of the properties in the state of Sao Paulo and the average price sold to the orange industry were collected in the Institute of Agricultural Economics (IEA).

In order to investigate the characteristics of farmers and properties, we conducted an exploratory study with 67 orange producers in eleven cities of São Paulo in 2010.

4. Results and Discussion

4.1 Characteristics of the sample

For the research, questionnaires were applied to the structured type 67 orange growers of the State of Sao Paulo. In them, we tried to investigate the characteristics of citrus, as well as gather information about the property, such as the size and number of employees.

Among the main characteristics, it was observed that, in total, 34% of respondents were aged between 23 and 50 and 66% are aged over 50 years, which indicates the predominance of older producers with the production of oranges . Moreover, it was found that 33% of respondents have up to five years of study and 51% have more than 10 years of study. With regard to time as a farmer, the results show that 26% of respondents have up to 20 years in activity, 24% of farmers have between 20 and 30 years and 50% produce more than 30 years, showing the predominance of citrus with a large experience in the production of orange.

From the analysis of the property size of citrus (Figure 2) high lights the presence of "small" and "average" properties (up to 100 hectares), with 48%. For 81% of producers, the main source of income is agriculture and 55% get an annual gross income with orange over $ 100,000 (Figure 3).

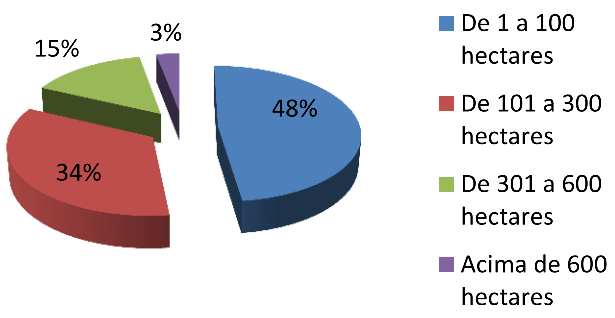

Figure 2 – Size farm
Source: Data of the search.

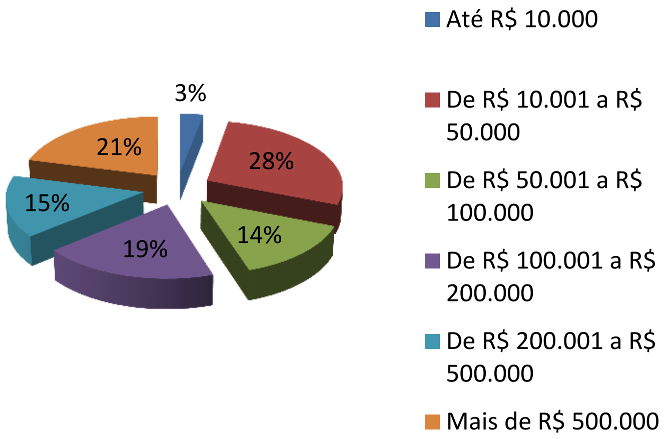

Figure 3 – Annual gross income with orange
Source: Data of the search.

The profile of manpower, it is observed that 84% of properties have manpower contractor and 16% have manpower exclusive family. Although the use of manpower is a familiar feature of small properties, there is the presence in this type of property and labor, and paid permanent work.

With the number of permanent employees, it appears that the average workers hired by property is approximately 6. However, the inequality of manpower between the farms is very large because there are properties with up to 75 employees and with no properties. This is also evidenced by high standard deviation (11.75).

In summary, the results indicate differences in productive characteristics of citrus properties of São Paulo, with emphasis on education, the gross income and the time as a farmer. These differences can lead to some inefficiency in the production of oranges in the region.

4.2 Analysis of Technical Efficiency

Technical efficiency compares what has been produced, given the resources available, what could have been produced with the same resources. Thus, to verify the efficiency properties of orange production was used data envelopment analysis.

Table 1 presents the summary statistics of the calculation of technical efficiency of the units that make up the sample. By averaging the scores of technical efficiency, you can see the efficiency of the properties. It notes allow individual scores more specific to each production unit, indicating inefficiency in resources, as well as pointing DMUs will serve as a model. This check is important to consider in what situation are each property to the detriment of the whole performance.

Table 1 – Scores of technical efficiency properties of citrus

Variable	Efficients units	Average	Standard deviation	Max	Min
Technical efficiency	13,43 %	0.79	0.21	1.00	0.25

Source: Data of the search.

The results show that the properties of citrus in São Paulo showed a significant degree of technical inefficiency.

The average technical efficiency was 0.79, suggesting the possibility of increased production, considering the same proportion of inputs currently used, with reference to the orientation of the product model. By analyzing the producing regions of São Paulo, shows that 67% of properties are effective in the North and Northeast State. This is due to the fact that these regions are the oldest in the country's orange production, allowing producers to greater knowledge about the best combination of inputs. Regarding the most inefficient properties, 71.4% are located in the south and southeast of the state.

To compare the degree of inefficiency of the plant building on the average score of technical efficiency, the indicator set was built by Ferrier and Porter (1991), as follows:

$$\left(\frac{1}{score} - 1\right) x100 \qquad (14)$$

Thus, one can say that the average difference in the properties of technical efficiency requires orange resource utilization 26.6% higher than the properties that are operating on the production curve.

In order to ascertain the determinants of the efficiency properties of citrus in the State of Sao Paulo, we used the Tobit econometric model. The model results are shown in Table 3.

Table 3 – Factors associated with technical efficiency citrus properties inthe State of São Paulo

Variable	Coeficient	St error	Value-p
Size farm (ha)	0,00021	0,00012	0,096
Number of employees	-0,0057	0,00292	0,054
Age of producer (in years)	0,0017	0,00183	0,365
Education of the producer (in years)	0,0283	0,00336	0,000
Time as a farmer (in years)	0,0039	0,00168	0,020
Constant	0,2866	0,09289	0,003
χ^2 = 55.48			

Source: Data of the search.

The coefficients estimated by the model showed satisfactory fit, indicating that the built-in variables have considerable power to explain the phenomenon under study, as verified by the level of significance of the χ^2 test, which was significant at 1% probability.

Among the factors that had an influence on technical efficiency, it emphasizes the variable "education of the producer," the most impact on the efficiency properties of citrus. This shows that training is the primary means for technical efficiency in production of oranges.

The variable "time as a farmer" also directly influences the efficiency properties, indicating that the experience with the production is an important variable to determine the efficiency of citrus.

A similar result was found by Ferreira (2005), in a study of efficiency analysis in the dairy industry in Brazil, showing that the professional management through specialized consultants is directly related to efficiency gains in the organization. Thus, productive units that have the support of professionals specialized in the production of marketing dairy products perform better than organizations that do not enjoy such support. In addition, the author points out that experience in the dairy industry are associated with an increase in the efficiency of the plant.

The variable "age", while important, was not significant. This may have occurred due to this strong relationship with the variable "time as a farmer." The variable "number of permanent employees" was significant with opposite sign than expected. Since the variable "size of the property" was significant and positive, but with very little impact in determining the efficiency of citrus.

With this, you can check that for the orange-producing properties of São Paulo, as well as experience as a farmer, highlights the importance of training courses and management for agricultural citrus. These capabilities could be carried out by the National Citrus Growers Association (Associtrus) in partnership with public institutions such as ESALQ and Citrus Experiment Station (CES) in order to improve the techniques of producers, thereby promoting increased efficiency in the production of fruit.

5. Conclusion

This study aimed to analyze the efficiency properties of citrus in the State of São Paulo in the period 2009 to 2010. With this, we applied the non-parametric approach to data envelopment analysis to calculate the levels of technical efficiency. To understand the determinants of technical efficiency of citrus, we used the Tobit econometric.

Based on the results, confirms the hypothesis that the properties citrus operate inefficiently, or not optimally allocate their resources for production. To increase efficiency in production, it is necessary to promote training courses for producers and agricultural fairs in the regions. These events could be run in partnership with entities representing the citrus (Associtrus) and state and local public institutions (municipalities, Experimental Center of Citrus, ESALQ).

Thus, we conclude that it is important that those involved with the productive sector of the orange aware of the existence of inefficiencies. In many cases, reducing these inefficiencies could improve the allocation of resources across the industry, ie, the inputs used in excess in some properties can be relocated, thereby increasing he total volume of production.

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