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# Sources of small family farm production inefficiency, recôncavo region, Bahia, Brazil

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**ABSTRACT**

The main objective of this study was to identify and analyze the sources of inefficiency in family operated small agricultural properties in the Brazilian state of Bahia's Recôncavo region from a sample of 44 producers. A non-parametric approach, in the context of cost minimizing behavior under constant returns to scale, was used to estimate the indices of technical, scale, allocative, and total (economic or cost) efficiency. Results indicated that the largest source small family farm inefficiency in the Recôncavo region is allocative inefficiency, that is to say, the non-observance of price relationships when making production decisions. On the average, 79.1% of these farms' total inefficiency is due to allocative inefficiency, 9.3% to technical inefficiency, and 11.7% to scale inefficiency.

**Keywords:** peasant household, economic efficiency, non-parametric model.

## 1. Introduction

The central focus of this work is the structure of small family farm agricultural production in the Recôncavo region of the state of Bahia, Brazil. More specifically, the inefficiency of farmers cultivating relatively small areas in a sub-area of the Recôncavo known as the Região Fumageira de Mata Fina is evaluated. Farms occupying less than 10 hectares numerically predominate in this sub-area, which is composed by eight municipal districts: Cabaceiras of Paraguaçu, Conceição do Almeida, Cruz das Almas, Dom Macedo Costa, Governador Mangabeira, Muritiba, São Felipe, and Sapeaçu.

According the Brazilian Agricultural Census of 1995/96 (IBGE, 1998), these small properties make up 89% of the region's farms and cultivate 28% of the region's total agricultural area. In spite of the tiny portion of the total agricultural area used by these small farms, they produce, approximately, 61% of the value of the region's vegetable production and 31% of the value of its animal production. Uncultivated productive land represents around 3.7% of the region's total acreage, indicating the impossibility of significantly increasing production by increasing the area under cultivation. The region's main agricultural activities are the cultivation of annual and perennial crops, which together represent more than 80% of the region's principal agricultural products. Of these products, 90% of the peanut, tobacco in leaf, yam, orange, and lemon production, approximately 45% of the bean production, and 53% of the cassava production is brought to market, indicating the producers' strong market orientation. Work on small family farms occupies 87% of the region's agriculture labor force, and 95% of the small family farm's labor force is made up of family members (responsible and non paid family members, as defined by IBGE, 1998).

Although a precise definition has not been established for "small producers," all definitions attribute at least two common characteristics to them: small size in terms of resource endowment and a low level of income.

Dillon and Hardaker (1980) say that, from an economic standpoint, the most significant characteristic of the small producer is the small resource base from which they operate. Generally they control a small area of land, suffer chronic debt, have almost no access to credit or institutional assistance (technical attendance, research, education, and health services, etc), and have an extremely low level of available human capital in the form of education, knowledge, and health. Concomitantly, they are confronted with unstable market demand and pricing, receive inadequate support from extension services, have a tiny portion of the control and operation of rural institutions, and lack socioeconomic power.

Dias (1979) found that rural poverty in Brazil is concentrated in small properties due to the used factors’ low productivity. In his "poor but efficient" hypothesis Schultz (1964) argues that traditional farmers (those who, over a long period of time, have learned their production process) will identify the optimal sets of inputs and outputs for cultivation of their respective crops. He suggests then that agricultural development policies should adopt an approach that expands the smallholder’s production frontiers through technological change, as this would be the most cost-effective means to increase these low income farmers’ welfare. This vision helped to guide the "Green Revolution" and the development of crop production technologies for implementation in developing countries.

Countless studies have rejected the Schultz hypothesis after finding widespread technical inefficiency among smallholder producers. These studies consequently recommended that policy makers reallocate scarce resources toward redressing apparent obstacles to technical efficiency by improving farmer extension and educational services while initiating land tenure reform programs (Sherlund et al, 1998). In this context, identification of the sources of inefficiency and the most efficient uses of available technology becomes fundamental to the development of public policies and private initiatives to improve the living conditions of small family farm households and integrate them into the market as competitive members.

Over the last two decades, there has been increasing interest in the analyses of productive activities’ technical, scale, and allocative efficiency, much of which is focused on the agricultural sector.

Generally, traditional efficiency analysis is based on partial indices of productivity of the factors that transform resources into final products. The main limitation to the use of the partial indexes of productivity in efficiency analysis is that, for a firm as a whole, variations in the efficiency index cannot be interpreted as variations in the efficiency of a specific resource, but as changes in the use of all the factors per unit of output.

The objective of this paper is to evaluate small family farm production efficiency in the Recôncavo region of the State of Bahia, Brazil, and to identify and measure the sources of that inefficiency using a non-parametric approach.

## 2. Methodology

The application of economic models to evaluate the global efficiency of production is based in the works of Debreu (1951), Koopmans (1951), and Farrell (1957). These authors used the concepts of isoquant frontiers and production functions to define relative technical efficiency as the firm’s (any unit of observation) "distance" from a production frontier built with observed data from input-output combinations.

### 2.1 The concepts of technical and allocative efficiency

Figure 1 aids in the understanding of the concept of technical efficiency established by Debreu, Koopmans, and Farrell.

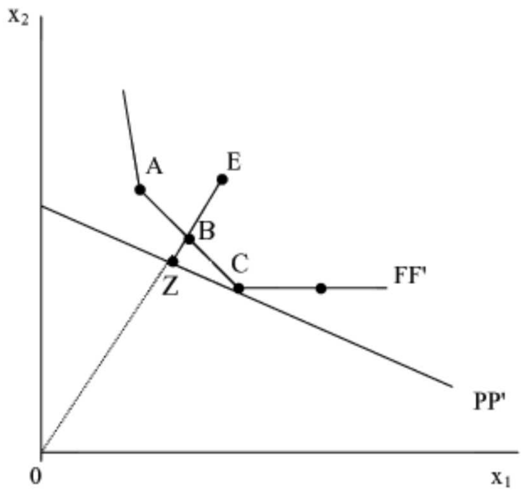


Figure 1: The concept of technical and allocative efficiency

Defining $x_1$ and $x_2$ as the inputs employed in production, the frontier isoquant is represented by the segment FF' that in relative terms can be characterized as a unitary isoquant, that is to say, $f(x_1, x_2) = 1$. According to Debreu and Farrell, observations A, B, C, and D, located along the frontier isoquant, are efficient since any equi-proportional reduction in the use of the inputs $x_1$ and $x_2$ would not be possible without a reduction in the output level; the observation (firm) at E is considered inefficient because a radial reduction (equi-proportional) of inputs $x_1$ and $x_2$ to point B would be possible while maintaining the output level. According to Koopmans’, observation unit D is also inefficient since the same output could be obtained by reducing input $x_1$ to the level used in C. The technical efficiency of a firm operating at point E using $x_{1E}$, $x_{2E}$ of inputs is given by the relationship 0B/0E, that is to say, the ratio of the inputs needed to produce $y_E$ in relation to the inputs actually used to obtain the same output. Consequently, the technical inefficiency of a firm operating at E is given by 1-(0B/0E) and represents the possible reduction in the level of the inputs while maintaining the same level of output.

In Figure 1, line PP' expresses the price relationship between inputs $x_1$ and $x_2$. Point C is on the frontier isoquant and, therefore, technically efficient. Since line PP’ is tangent to the FF’ isoquant at point C, this point is also allocatively efficient. Point B, although technically efficient, is allocatively inefficient since production cos is greater than Z = C, the maximum allocatively efficient point. Therefore, the ratio 0Z/0B measures the allocative efficiency and 0Z/0E measures the total efficiency (economic efficiency).

**2.2 Technical efficiency and returns to scale**

Fare et al. (1994) proposed the construction of a reference technology to measure technical efficiency under several return-to-scale assumptions. This model is illustrated in Figure 2 using the production frontier for one output (y), one input (x) and four firms (A, B, C and D).

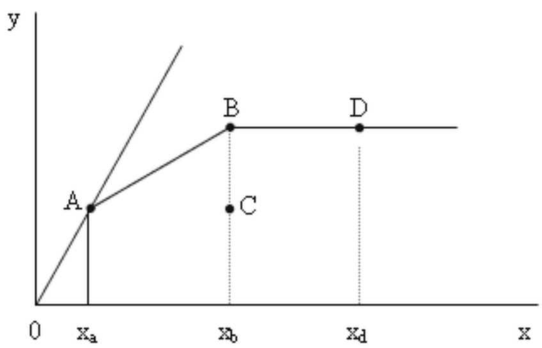


Figure 2: Reference technology and return to scale

Under constant returns to scale, the technology is limited by ray 0A. Assuming non-increasing returns, the convex combination of the production of y across firms cannot be larger than the largest amount of y produced by a single firm, leading to a production frontier given by 0ABD. Under variable returns to scale, the use of input by firm "j" cannot be smaller than the smallest amount of input used by any other firm. This leads to the possibility of increasing returns to scale so that the frontier doesn't lie closer to the y-axis than at point A ($x_a$ABD). Under variable returns the scale, the distance functions for input and output for the firm at point C are given by the ratio 0xb/0xa and XbC/XbB respectively.

Through a non-parametric approach, the above concepts are used in this study to evaluate the sources of inefficiency associated with small family farm production in the Recôncavo region of the State of Bahia. The technology employed on these farms is represented by the following set of inputs requirements:

$$T = \{(y, x): y \leq \sum_{j \in I} \lambda_j y_j,\ x \geq \sum_{j \in I} \lambda_j x_j,\ \sum_{j \in I} \lambda_j = 1,\ \forall j\}, \quad (1)$$

where x = vector of the inputs, y = vector of the outputs, ë= radial expansion (reduction) factor of outputs (inputs).

The T set is closed, convex, and negative monotonic.

Given the characteristics of the technology, the index of technical efficiency based on inputs is obtained from the solution of the following linear programming problem:

$$Min\, \theta_i \quad (2)$$

subject to:

$$y_i \leq \sum_{j \in I} \lambda_j y_j \quad (2a)$$

$$\theta_i x_i \leq \sum_{j \in I} \lambda_j x_j \quad (2b)$$

$$\sum_{j \in I} \lambda_j = 1 \quad (2c)$$

$$\lambda_j \geq 1, \forall j \quad (2d)$$

where $q_i$ is the index of technical efficiency of firm I, and the values of $l_j$ express the efficient units that are the reference for the unit analyzed, that is to say, these values express the factors of multiplication of the inputs and outputs so that the firm under analysis has the same efficiency as the units of reference. The variable returns to scale condition is given by restriction (2c); under constant returns to scale this restriction becomes $\lambda_j \in \Re^+$, and under non-increasing returns to scale it becomes $\sum \lambda_j \leq 1$.

The process described above is known as Data Envelopment Analysis (DEA) and it consists of obtaining the maximum possible radial (equi-proportional) reduction of all inputs by the analyzed firm (i) in relation to the other n-1 firms (j).

For $q_i$ equal to 1, the firm is on the production frontier; therefore no equi-proportional reduction is possible. For $q_i$ smaller than 1, the set of inputs can be reduced in the proportion 1 - $q_i$.

Considering that analysis under variable returns to scale is a more flexible method for determining efficiency indices than analysis under constant returns to scale (more flexible because it admits constant, increasing, and decreasing returns to scale), the efficiency indexes calculated under this condition are larger than those obtained under constant returns to scale. The relation between constant and variable returns to scale is used to obtain a measure of scale efficiency (Sharma et al., 1999) and is given by the following expression:

$$y_i = q_i^{rce}/q_i^{rve} \quad (3)$$

where $y_i$ is the index of scale efficiency, $q_i^{rce}$ and $q_i^{rve}$ are the indexes of technical efficiency under constant and variable returns to scale respectively. A firm is scale efficient if $y_i=1$, that is to say that technical efficiency calculated under constant returns to scale is equal to that calculated under variable returns to scale. Values of $y$ < 1 indicate the presence of increasing or decreasing returns to scale that can be identified from the solution of the index of technical efficiency under non increasing returns to scale ($q_i^{rnce}$): if $q_i^{rnce} = q_i^{rce}$, there are increasing returns to scale; if $q_i^{rnce} > q_i^{rce}$,there are decreasing returns to scale.

From equation (3), the index of technical efficiency under constant returns to scale can be expressed through decomposition into two components: index of scale efficiency ($y_i$) and index of pure technical efficiency ($q_i^{rve}$):

$$q_i^{rce} = y_i \, q_i^{rve} \quad (4)$$

The allocative efficiency index is related to the decision making process of the firm in that it refers to the choice of a combination of inputs that minimizes the costs.

Considering C(w, y, T) as the minimum cost and $q_i$ the index of technical efficiency, the allocative efficiency (or price efficiency) is obtained through the following expression:

$$f_i = C(w, y, T)/(w' q_i x) \quad (5)$$

Under constant returns to scale, the minimum cost, C(w, y, T), is obtained by the solution of the following linear programming problem.

$$\text{Min } w'x = C(w, y, T) \quad (6)$$

subject to:

$$y_i \leq \sum_{j \in I} \lambda_j y_j$$

$$x_i \leq \sum_{j \in I} \lambda_j x_j$$

$$\lambda_j \geq 1, \forall j$$

The index of economic efficiency (total efficiency or cost efficiency) is obtained through the following expression:

$$w_i = q_i^{rve} y_i f_i^{rce} \quad (7)$$

For a firm operating at optimum scale ($f_i = 1$) the total efficiency index then becomes,

$$w_i = q_i^{rve} f_i^{rce} \qquad (8)$$

The amount of cost inefficiency (or economic inefficiency) is given by $w'x(1-w_i) = w'x - w'x^*$ where w'x is the observed cost and $w'x^*$ it is the minimum cost under constant returns to scale. Cost inefficiency can be decomposed into its technical, allocative, and scale components in the following way:

$$w'x(1-w) = w'x[(1-q^{rve}) + q^{rce}(1-f_i^{rce}) + (q^{rve} - q^{rce})] \qquad (9)$$

where the terms within brackets are, respectively, the components of technical, allocative, and scale inefficiency.

### 2.3 Data

The data used to estimate economic inefficiency were compiled from completed questionnaires collected between January and March 1996 from 44 family operated small agricultural properties located in eight municipal districts within the Brazilian state of Bahia's Recôncavo region.

To calculate the efficiency measures, prices (in 1996 Brazilian *Reais*) and quantities of the following products and factors were used for each observation: Products—peanut ( 50 kg), cassava flour ( 60 kg), bean ( 60 kg), leaf tobacco (15 kg), yam (kg), orange (hundreds), lemon (hundreds), cassava root (tons); Factors—cattle manure (tons), ant pesticide (kg), tractor (hours), insecticide (liter), family labor (man/day), chemical fertilizers (50 kg), castor manure ( 50 kg).

## 3. Results and Discussion

Table 1 summarizes the efficiency indices obtained for the sample of small family farms according to the classification proposed by Ray and Bhadra (1993).

Table 1: Degree of technical, scale, allocative, and total efficiency of the 44 studied small family farms, Recôncavo region of the state of Bahia, 1996

| Efficiency degree | % Of observations | | | |
|---|---|---|---|---|
| | Pure technical efficiency | Scale efficiency | Allocative Efficiency | Total efficiency |
| Efficient (IE-1) | 84.0 | 79.5 | 25.0 | 25.0 |
| Weak inefficiency (0,9(IE < 1) | 2.3 | 4.6 | 2.3 | 2.3 |
| Moderate inefficiency (0,7(IE < 0,9) | 2.3 | 2.3 | 18.2 | 11.4 |
| Strong inefficiency (IE < 0,7) | 11.4 | 13.6 | 54.5 | 61.3 |
| Average efficiency | 0.95 | 0.90 | 0.58 | 0.53 |
| Minimum efficiency | 0.53 | 0.07 | 0.03 | 0.01 |
| Maximum efficiency | 1.00 | 1.00 | 1.00 | 1.00 |

Source of data: Research.

The results above show that the majority of studied small family farms are technically efficient (84%), scale efficient (79.5%), and allocatively inefficient (75%). Among the technically efficient farms, 68.5% are price inefficient, indicating that gains in total efficiency (efficiency of cost) can be obtained if resource allocation decisions take better account of the relationship among factor prices.

Thirty-three of the 44 observations show inefficiency, and nine of these inefficient observations show scale inefficiency (20.5% of the sample). Eight of these nine firms are operating under increasing returns to scale while one is operating under decreasing returns to scale. These results indicate that the firms operating under increasing returns to scale can gain technical efficiency if they increase production. In the case of the firm operating under decreasing returns, gains of efficiency would occur if they reduce production. The results show that, on average, insufficient operation scale is the largest source of technical inefficiency.

The relationship between technical efficiency and the use of land helps to understand the high number of properties on the production frontier. For the technically efficient observations (84% of the sample), the proportion of cultivated area in relation to the total area of the property ($q_i^{rve}=1$) is 91.59%. This proportion for technically inefficient observations ($q_i^{rve} < 1$) is only 65.86%. These data suggest that, due to the impossibility of increasing production through expansion of area under cultivation, most of the region's producers seek gains through more intensive use of inputs.

Total inefficiency was decomposed into pure technical, scale, and allocative effects through use of the efficiency indexes and expression (9). In Table 2, the calculated percentages of total, pure technical, scale, and allocative inefficiencies of the inefficient observations are ordered by decreasing percentage of pure technical inefficiency. The results show that in approximately 73% of the properties showing inefficiency, all inefficiency is associated to the price effect (allocative inefficiency). Only 6% of the inefficient observations show inefficiency to be associated with a combination of only scale and allocative effects; the rest of the sample of inefficient observations (21%) present a combination of pure technical, scale, and allocative inefficiency.

Table 2. Composition of the economic inefficiency of the sample, Recôncavo region, state of Bahia, 1996.

| Observations | Total inefficiency (in Real. 1996) | Technical inefficiency (%) | Scale inefficiency(%) | Allocative Inefficiency (%) |
|---|---|---|---|---|
| 2 | 755.10 | 0.0 | 0.0 | 100.0 |
| 9 | 248.08 | 0.0 | 0.0 | 100.0 |
| 10 | 1200.55 | 0.0 | 0.0 | 100.0 |
| 12 | 1856.99 | 0.0 | 0.0 | 100.0 |
| 13 | 2952.49 | 0.0 | 0.0 | 100.0 |
| 14 | 1843.37 | 0.0 | 0.0 | 100.0 |
| 16 | 1726.68 | 0.0 | 0.0 | 100.0 |
| 17 | 1487.47 | 0.0 | 0.0 | 100.0 |
| 19 | 1271.04 | 0.0 | 0.0 | 100.0 |
| 20 | 1494.18 | 0.0 | 0.0 | 100.0 |
| 22 | 873.83 | 0.0 | 0.0 | 100.0 |
| 23 | 16.90 | 0.0 | 0.0 | 100.0 |
| 24 | 2364.71 | 0.0 | 0.0 | 100.0 |
| 27 | 644.68 | 0.0 | 0.0 | 100.0 |
| 28 | 507.62 | 0.0 | 0.0 | 100.0 |
| 29 | 6600.29 | 0.0 | 0.0 | 100.0 |
| 30 | 1588.23 | 0.0 | 0.0 | 100.0 |
| 31 | 2816.99 | 0.0 | 0.0 | 100.0 |
| 32 | 2555.66 | 0.0 | 0.0 | 100.0 |
| 34 | 377.46 | 0.0 | 0.0 | 100.0 |
| 37 | 584.56 | 0.0 | 0.0 | 100.0 |
| 38 | 418.57 | 0.0 | 0.0 | 100.0 |
| 40 | 173.62 | 0.0 | 0.0 | 100.0 |
| 43 | 2008.55 | 0.0 | 0.0 | 100.0 |
| 4 | 1408.64 | 0.0 | 77.6 | 22.4 |
| 15 | 2770.51 | 0.0 | 88.1 | 11.9 |
| 11 | 1068.65 | 8.1 | 86.1 | 5.9 |
| 8 | 1227.56 | 33.1 | 20.7 | 46.2 |
| 36 | 2996.30 | 35.6 | 0.5 | 63.9 |
| 3 | 2073.23 | 46.1 | 30.8 | 23.1 |
| 21 | 1235.12 | 48.3 | 46.3 | 5.3 |
| 42 | 1583.24 | 57.9 | 34.3 | 7.8 |
| 39 | 834.90 | 76.9 | 0.3 | 22.8 |
| Average | 1562.60 | 9.3 | 11.7 | 79.1 |
| Minimum | 16.90 | 0.0 | 0.0 | 5.3 |
| Maximum | 6600.29 | 76.9 | 88.1 | 100.0 |

Source of data: Research.

## 4. Conclusions

This study applies a non-parametric model of economic efficiency to a sample of 44 family operated small agricultural properties in the Brazilian state of Bahia’s Recôncavo region. A cost minimization approach was adopted to obtain measures of the producers’ technical, scale, and allocative efficiency.

The sample’s average pure technical efficiency was 94.6%, with 84.0% of the observations located on the production frontier, having reached maximum technical efficiency. The average efficiency of scale was of the order of 90% for the total sample, with only 9 observations (20.5% of the total) presenting a scale efficiency index smaller then 1. The main source small producer economic inefficiency is associated to allocative inefficiency, with 75% of the observations presenting allocative efficiency indexes smaller than 1. Considering the sample as a whole, the results indicate that 78.4% of the total inefficiency (economic, or of costs) is due to allocative inefficiency, 12.6% to scale inefficiency, and 9.0% to technical inefficiency.

Based in the obtained results, it can be stated that the studied region’s small farmers are technically efficient and are at, or closely approach, the production frontier given the technology employed. Thus, a gain of margina productivity through technical means would only be possible through technological change.

The results also indicate the possibility of increasing the studied properties profitability through the rationalization of their production costs. Operating at full economic efficiency, the sample properties’ costs would be reduced on the order of 63%, with a reduction of labor costs contributing the most to cost minimization. However, small family farm households present characteristics that make them different from other capitalist firms in their understanding of economic rationality.

The studied producers tend to maximize the use of family labor, as suggested by this study’s results. This limits or even excludes the possibility of cost rationalization that implies the creation and release of surplus labor. Thi limitation would be obviated if producers expanded production by increasing the area under cultivation, thereby absorbing surplus labor. However, in the present case, expansion is almost impossible since the small producers of Bahia’s Recôncavo region lack unused agricultural land on which to expand.

It is inferred that policies designed to generate employment in other regional economic sectors could be used to reduce any future labor surplus arising from labor cost rationalization on the studied small family farms. Such policy, complemented with the development of agricultural technologies more appropriate to the structure of th small family farm production unit, would make efficiency gains possible and, consequently, improve this farmer segment’s level of income and social welfare.

Considering that the main source of our sample’s inefficiency is allocative, programs geared to support family operated small agricultural units (technical attendance and rural extension services) should seek to guide these producers towards the observance of price relationships when making production decisions.

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