

# The Efficiency of Small Farmers in Goiânia/Brazil for Food Security: an analysis by the DEA method

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**Abstract.** The aim of this article is to analyze the efficiency of the provision of healthier foods for public school students whose offer was made by family farmers. The importance of this work stems from the need to change the eating habits of children and young people, based on the assumptions of Food Security. In addition, proving the efficiency of small farmers is important to encourage Solidarity Economy projects in order to raise the incomes of the poorest workers. We use Data Envelopment Analysis (DEA) as a research method, through the Variable Returns of Scale (VRS) model oriented to the output. The choice of this model is justified because it takes into account the scale of production and the need to increase the number of schools served by small farmers. Our results show that small producers are efficient especially in agricultural products (Vegetables, Tuberos vegetables and Fruits). On the other hand, more elaborate products (Canned food, Flour and semolina, Dairy products) did not reach the efficiency. This result shows that schools can be supplied with fresh and healthy food from the region itself, benefiting the health of children and young people and the economy of small local farmers.

**Keywords:** Small Farmers in Brazil, Solidary Economy, Data Envelopment Analysis (DEA).

## 1 Introduction

In developing countries, the importance of alternative ways to exchange goods has grown. In this aspect, we have sought more inclusive forms for the generation of wealth, leaving aside the traditional models of capitalism [1, 2, 3].

A new form of production organization is the Solidarity Economy [2]. This form seeks the generation of work and income for people excluded in the formal labor market, where they find in the collectives (associations or cooperatives) opportunities to improve the quality of life for their family. It should be noted that Solidarity Economy is present both in urban spaces and in rural areas. In the case of rural areas, there is the

presence of the Solidarity Economy in Family Agriculture, which seeks in the collectives to reach markets, especially the government procurement programs, which would be inaccessible if they acted individually [2, 3].

In Brazil, several family farmers have become suppliers of products for school meals. However, there are few studies that analyze the efficiency of this process for the Food Security of public school children. Thus, the aim of this article is to analyze the efficiency of the provision of healthier foods for public school students whose offer was made by family farmers.

Brazil has overcome the hunger problems and poverty by utilizing public policies, which distribute income in a fair way. The relation between poverty and food insecurity has been analyzed by models that estimate the consumption of certain type of food. These findings report that the income is one of the most important factor to favoring a much healthier diet. Any kind of food insecurity tends to drop after the third strata household income per capita (R\$ 40), even though some kind of less nutritious food rises among the wealthier social classes [1, 4, 5, 6, 7, 8, 9].

At this scenario, the hunger and malnutrition are no longer the major challenge. Studies and public policies have been concerned with analyzing the type of food is eaten by low classes and education deficit. It is known that industrialized goods with low cost and low nutritional value are preferred rather than healthier ones, for instance, fruit, legumes and the greens [10, 11, 12].

This is a relevant topic, since it deals with two important social aspects for the development of Brazil. Firstly, it analyzes if the products offered by Family Agriculture are efficient with respect to the average price and the quantity offered. On the other hand, it seeks to integrate the offer of these products with the pressures of Food Security, so that safer foods are offered to the children, which contributes to the change of eating habits in the future.

This article is divided into four sections in addition to this introduction. The second section discusses the concepts of Solidarity Economy and Food Security. The third section presents the method used in this work. The fourth section discusses the findings and the fifth section concludes.

## **2 Solidary Economy, Small Farmers and Food Security**

Solidarity economy is a society project that seeks a new form of economic organization as a strategy to cope with unemployment and social exclusion. The solidarity economy breaks with capitalist production relations, introducing popular experiences based on foundations of economic cooperation and self-management [10].

Economic cooperation is fundamental to this type of economy, which has as its principle collective property and the right to individual freedom [2]. Self-management, however, corresponds to the way in which these ventures are administered. Democratic management is necessary to guarantee self-management. Thus, self-management requires a greater effort from workers who, in addition to the usual tasks, must deal with the general problems of the organization, and for this it is necessary that all partners have knowledge of what happens and possible alternatives for making decisions.

This new economic form projects with the foundations of collectivity and solidarity that are important for the scenario of great social inequalities, however, they have challenges to be faced in order to continue and grow this movement. The main challenges are: maintenance of ideological consistency, technical-scientific contribution, structuring of commercialization and organization of public policies [3].

Regarding the structuring of commercialization and the organization of public policies, there is the opportunity to strengthen the Solidarity Economy in Family Agriculture through the government procurement program called the National School Feeding Program (PNAE), also known as the Merenda Campaign School. This program is governed by law No. 11,947 of June 2009, which governs the guidelines of school feeding, one of which is a preference for the acquisition of food produced by family farming. In addition, the law determines that at least 30% of the financial resources passed on to the National Education Development Fund (FNDE) by the National Education Development Fund (FNDE) should be allocated to the rural family farmer or the family farmer.

The family farmers need to decide whether they will participate of the program, through feasibility analysis, as well as produce quality food with nutritional and sanitary standards of food production.

Small farmers need to be prepared for changes in eating habits because the standard of food consumption in Brazil has been changed over the years. These changes come from a number of social and economic factors, which influence the preference of the consumers such as the urbanization, age group and woman entrance in the labor market. All of these compose an important role in the composition of family food basket [4].

It is important to observe the aspects of food habits in Brazil. In the end of last decade, the country was about to reach some of the world Millennium Development Goal target set by the United Nations (UN), particularly in reducing the extreme poverty and malnutrition. More than that, the nutritional transition started to show that the bigger part of Brazilian population is out of the problems related to the hunger, however, new challenges come out. Among them, the fight against the overweight and obesity is highlighted, making the scene much more complex, and ensuring the need to analyze the consumption of food in the less privileged Brazilian classes [5].

After the global nutrition crisis in 2007/2008, the food security has been made a part of the political agenda of many countries. This issue of great political relevance has been attracted interest in researching, but there is a lack of sense in the present studies about the link between small farmers and food security [12].

The first step towards achieving food security is the access to food, although to the best of our knowledge, hunger is not caused by the inexistence of enough food, but because people do not have the right to access it. Food security exists when the residents in a house own the regular and permanent accessibility to sufficient food.

Food security is a multidimensional concept that widely features the availability of food (physical access to food), food accessibility (economic access to food), the use of food (absorption of the nutrients into the body) and the vulnerability [12].

To enable this transition possible, "Fome Zero", a government program is the answer to reduce the hunger, malnutrition and the extreme poverty. The social programs

like as cash transfers (Bolsa Familia), Benefício da Prestação Continuada, rural pensions and the valorization of the minimum wage were very important factors in reducing poverty and food insecurity of the poor families, particularly since 2001 [1, 6, 7]. Bolsa Familia has contributed to the rise of the nutritional and food security, due to 76% of the cash transfers are spent on food ensuring a better diet for the families in the lower classes.

The importance of the income increase for food security can be better understood as it verifies that the income elasticity on dieting expenses goes up with the household income per capita (RPC), despite the elasticity is always smaller than 1. The money spent on food is 60.2% in the first class of income (RPC up to R\$ 100), then it drops to 36.6% in the second class (from R\$ 100 to R\$ 200) and keeps systematically decreasing to only 5.2% in the RPC class that is above R\$4 thousand Reais [8]. According to the authors, rice and beans have negative elasticity which means that a proportional income increase of all Brazilians will not make a rise in the demand for these products.

Although the household income is the main constraint on the food insecurity measured by Escala Brasileira de Insegurança Alimentar (EBIA) (9), Hoffmann [1,6,9] has studied the determiners of the probability of the families in consuming some types of food and in having food insecurity in their homes. The Pesquisa Nacional por Amostra de Domicílios (PNAD) data in 2004 shows that 34.9% of residences still remained with some level of food insecurity [6]. In 2009, despite the number of residences analyzed increased to 12.6%, the number of those ones at the moderate insecurity was reduced to 40.2% and the number of the severe insecurity dropped to 12.4% [9].

When it comes to terms of the type of food consumption, there is a bigger probability in the consuming of pork meat in the South, whereas, in the North and Northern, it is the consuming of basic food (rice, beans, manioc flour, powder milk and margarine). In the Southeast, the consumption is based on french rolls and in the Central-west rice and liquid milk, in contrast to that, the annual per capita consumption of manioc flour in São Paulo State does not reach one kilo, while in the Northern, it is over fifteen kilos and in the North 33.827 kg [8].

The average rate of consuming manioc flour can be explained by the location, whether the residence is rural or urban. The consumption of this good is four times bigger in the rural areas than in the cities [8].

It is estimated that there is a bigger probability of happening food insecurity in the residential places after controlling the income effect [6]. However, the remote rural areas tend to have poorer residences. The unfavorable evolution of the food security in the rural homes from 2009 to 2013 might have occurred due to the “rural” in 2013 be one of the more restricted areas whose residences are, in general, relatively poor [1].

When the probability of occurring food insecurity is analyzed by the occupation sector by a reference family member, there is bigger probability for the workers of the agriculture sector [6]. The proportion of homes with extreme food insecurity is almost three times bigger among those, in which the reference person is black or brown (10%), than among those whose reference person is white (3,55%) [6]. Notice that black and brown people have the bigger probability of acquiring sugar, rice, second class bovine

meat, and manioc flour. Also, there is a negative probability of consuming first class bovine meat, banana, potatoes, tomato, cheese and fluid milk [4].

This result might be associated to the income elasticity of some high quality products or relatively expensive, which are, that way respectively bought in bigger quantity by the relatively rich and white people. The flexibility of income in consuming first class bovine meat is bigger than the second class bovine meat. Thus, Hoffmann [1, 6, 8, 9] findings report that people in poorer income bracket now have more probability of consuming powder milk, a type of food known by its bigger income elasticity. At least, in some aspects, the consumption of powder milk by the poor could be justified by the lack of fridges in the houses. Because of that, the presence of fridges increases the probable acquisition of fluid milk [4].

Education background of the reference person is also a change responsible for the food security occurrence. An additional year of schooling lessens the severe food insecurity (-8%) and the light, moderate or severe aggregate insecurity (-4.3%) [7]. According to the author, the level of education and the income distribution brings transformation in choosing more nutritious food. When the family's chief is uneducated, the probability of consuming sugar, rice, beans, manioc flour and second class bovine meat is higher, furthermore, the increase in education, beyond the income, rises the probability of consuming organic and light/diet products [11].

As far as family members are concerned, the probability of food insecurity in the residences with one or two people is bigger [6]. This matches to the international survey data, in which the great number of the family members helps to dilute the fixed costs for living [12]. However, other work demonstrates how the extreme food insecurity in the residences with more than seven people is possible [6].

PNAD data (2013) appears to show that the average residents per private home was 3.09 as general, and 2.96 in the homes with food security, 3.57 in the homes with light insecurity, 3.46 in the homes with moderate insecurity and 3.43 in the private homes with extreme food insecurity [1]. It is clear that the average number dropped from 4.14 in 2004 to 3.43 in 2013 in the homes with moderate or extreme food insecurity.

### 3 Method

The efficiency of a system can be measured from the division between the current value of an indicator of system performance and the maximum value that this indicator reaches [13].

The method used to determine system efficiency is called Data Envelopment Analysis (DEA). The DEA is a nonparametric method, by the empirical construction of a linear frontier by pairs, to measure the productive efficiency of a set of Decision Making Units (DMU) [14, 15].

From the efficiency of each DMU, a ranking of relative efficiency is generated. Efficient frontier expresses maximum number of outputs that can be produced per unit of inputs, representing the production limit determined by the technology. Efficient DMUs represent a best practice frontier, serving from analysis for the least efficient [16].

Several studies analyze the efficiency of production systems in different aspects, such as the banking sector [17], airports [18], the industrial sector [19], cities and countries [20, 21, 22] and rural producers [23].

For this work, social efficiency studies can be used as a theoretical basis [24]. It is worth mentioning that many authors have used the DEA to construct indicators of human development and social well-being [24, 25, 26].

Our work differs from others because it uses food groups such as DMUs to measure the efficiency of food security for students in public schools being attended by small farmers in the region of Goiânia (Goiás / Brazil).

There are different models that can be used to implement DEA. These models differ according to their assumptions. The type of returns of scale designates the two main DEA models: CRS (Constant Returns to Scale) and VRS (Variable Returns to Scale). The hypothesis of the VRS model considers that the variation of outputs is not necessarily equiproportional to inputs, being that in the frontier there will be three regions: increasing, in which the outputs grow proportionally more than the inputs; Proportionality; and decreasing, where outputs grow proportionately less than inputs [13, 16].

Table 1 illustrates the mathematical formulation of the major DEA models.

**Table 1.** Main DEA radial models.

CCR	$MAX \sum_{i=1}^m u_i \cdot y_{i0}$ <p>Subject to:</p> $\sum_{j=1}^n v_j \cdot x_{j0} = 1$ $\sum_{i=1}^m u_i \cdot y_{ik} - \sum_{j=1}^n v_j \cdot x_{jk} \leq 0 \text{ for } k = 1, 2, \dots, h$	$MIN \sum_{i=1}^n v_j \cdot x_{j0}$ <p>Subject to:</p> $\sum_{j=1}^m u_i \cdot y_{i0} = 1$ $\sum_{i=1}^m u_i \cdot y_{ik} - \sum_{j=1}^n v_j \cdot x_{jk} \leq 0 \text{ for } k = 1, 2, \dots, h$
BCC	$MAX \sum_{i=1}^m u_i \cdot y_{i0} + w$ <p>Subject to:</p> $\sum_{j=1}^n v_j \cdot x_{j0} = 1$ $\sum_{i=1}^m u_i \cdot y_{ik} - \sum_{j=1}^n v_j \cdot x_{jk} + w \leq 0 \text{ for } k = 1, 2, \dots, h$ <p><i>w without signal restriction</i></p>	$MIN \sum_{i=1}^n v_j \cdot x_{j0} - w$ <p>Subject to:</p> $\sum_{j=1}^m u_i \cdot y_{i0} = 1$ $\sum_{i=1}^m u_i \cdot y_{ik} - \sum_{j=1}^n v_j \cdot x_{jk} + w \leq 0 \text{ for } k = 1, 2, \dots, h$ <p><i>w without signal restriction</i></p>

Source: Mariano and Rebelatto (2014, p. 5).

The data used in this research are primary data, collected by the researchers with the support of a project funded by the British Council and the Goiás State Research Foundation (FAPEG). We used 90 types of food that were categorized according to the Table of Nutritional Composition of Food Consumption in Brazil from Pesquisa de Orçamentos Familiares (POF), which is the largest family budget survey in Brazil, published by the Instituto Brasileiro de Geografia e Estatística (IBGE).

The categories of food analyzed are: Cereals and pulses, Dairy, Sugars and sugar confectionery, Baked goods, Processed meats, Oils and fats, Poultry and eggs, Sugars and products confectionery, miscellaneous.

The variables chosen were: total amount of food offered (input), average price of food offered (input), total price of food supplied (input). We choose the output-oriented DEA-BCC model. We decided to take the orientation to output, considering that one wants to maximize outputs (number of schools attended) without reducing input (price and quantity). The software used for this analysis was MATLAB.

To validate our variables, we used a Pearson correlation matrix with statistical significance. The software used for this analysis was STATA 13.0.

## 4 Findings

Our Pearson correlation matrix showed that the inputs and the output have statistical significance. For example, the correlation between the schools served and the quantity of products offered was 0.6931 with a significance level of 1%. The price of the products and the schools served presented the coefficient expected by the economic literature (-0.7452), considering that when the price increases the quantity demanded decreases. This correlation also showed a level of significance of 1%.

The output-oriented DEA-BCC model evaluated the efficiency of the process for offering food to public schools from the local family farm. The model showed that the only effective foods were fruits and vegetables. Cereals and pulses, Dairy products, Flour and sugar products, Flour, starch and pasta, Bakery products, Processed meats, Oils and fats, Poultry and eggs and others were not efficient.

This result shows that among the foods offered for school meals, the most efficient are those considered healthy and, therefore, offer greater food security for the children. This shows that the partnership between family farmers and public schools is important for the development of the local economy, but also for the nutrition of children and young people.

**Tabel 2.** Efficiency estimation

Products	Type	Efficiency
Cabbage/Couve	Vegetables and other	1.00
Jiló	Vegetables and other	1.00
Almeirão	Vegetables and other	1.00
Beet	Tuberous vegetables	1.00
Saffron	Tuberous vegetables	1.00

Sweet potato	Tuberous vegetables	1.00
Green pepper	Vegetables and other	1.00
Mint	Vegetables and other	1.00
Yam	Vegetables and other	1.00
Basil	Vegetables and other	1.00
Salsinha	Vegetables and other	1.00
Tomate	Fruits	1.00
Watermelon	Fruits	1.00
Green Smell	Vegetables and other	0.97
Cabbage/Repolho	Vegetables and other	0.94
Green corn	Canned food	0.90
Lettuce	Vegetables and other	0.88
Chuchu	Vegetables and other	0.88
Cassava flour	Flour and semolina	0.85
Onion	Vegetables and other	0.84
Green cabbage/Repolho	Vegetables and other	0.84
Garlic	Vegetables and other	0.83
Cress	Vegetables and other	0.82
English potato	Tuberous vegetables	0.78
Peeled cassava	Tuberous vegetables	0.77
Carrot	Vegetables and other	0.77
Coriander	Vegetables and other	0.76
Pod	Vegetables and other	0.70
Chard	Vegetables and other	0.69
Cará	Vegetables and other	0.67
Orange	Fruits	0.66
Orange Pear	Fruits	0.63
Broccoli	Vegetables and other	0.63
Pineapple	Fruits	0.59
Lemon	Fruits	0.58
Mango	Fruits	0.58
Cauliflower	Vegetables and other	0.53
Bean	Cereals and legumes	0.52
Cheese	Dairy Products	0.52
Soy	Cereals and legumes	0.51
Fruit pulp	Sugar and confectionery products	0.50
Soy flour	Flour and semolina	0.49
Pumpkin	Vegetables and other	0.48
Avocado	Fruits	0.47
Canjica Corn	Cereals and legumes	0.46
Grated cheese	Dairy Products	0.44
Corn	Cereals and legumes	0.43
Papaya	Fruits	0.43
Assorted Sweets	Sugar and confectionery products	0.41
Banana	Fruits	0.40

Pasteurized Milk Type C	Dairy Products	0.39
Arugula	Vegetables and other	0.39
Chive	Vegetables and other	0.38
Cashew pulp	Sugar and confectionery products	0.37
Passion fruit pulp	Sugar and confectionery products	0.37
Strawberry Pulp	Sugar and confectionery products	0.36
Tamarind Squash	Sugar and confectionery products	0.36
Okra	Vegetables and other	0.35
Cheese bread	Bread	0.32
Swine Sausage	Processed meats	0.30
Pineapple Pulp	Sugar and confectionery products	0.30
Cucumber	Vegetables and other	0.26
Chicken sausage	Processed meats	0.26
Tangerine	Fruits	0.25
Soy oil	Oil and fat	0.25
Eggs	Poultry and eggs	0.25
Rice	Cereals and legumes	0.24
Tangerine type 2	Fruits	0.24
Cakes	Sugar and confectionery products	0.24
Soy protein	Flour and semolina	0.24
Candy "Rosca"	Bread	0.22
Mexerica Ponkan	Fruits	0.21
Melon	Fruits	0.20
Mozzarella cheese	Dairy Products	0.19
Cajá Pulp	Sugar and confectionery products	0.18
Acerola Pulp	Sugar and confectionery products	0.18
Yogurt	Dairy Products	0.18
Corn pasta	Flour and semolina	0.18
Candy "Rapadura"	Sugar and confectionery products	0.17
Bread "Pão Caseiro"	Bread	0.13
Juice	Miscellaneous	0.12
Apple	Fruits	0.12
Dairy beverage	Dairy Products	0.09
Sweet Milk In Pasta	Sugar and confectionery products	0.03
Radish	Tuberous vegetables	0.02
Sour Sprinkles	Bread	0.02
Type 2 Sweet Sprinkles	Bread	0.02
Cheese Grated Type 2	Dairy Products	0.02
Sour passion fruit	Fruits	0.02
Milk Butter	Dairy Products	0.01

However, industrialized or semi-processed products presented low efficiency, which may demonstrate a disadvantage of this business model. Future studies need to analyze which agents are most effective in offering the different types of food to public schools, which may differentiate the business models to be adopted.

## 5 Conclusion

This article measured the efficiency of food offerings by small farmers to public schools in order to verify the food security of Brazilian children and young people. The results showed that healthy foods are the most efficient in the partnership between small farmers and public schools (Solidary Economy), which demonstrates the importance of this business model for Food Security.

Processed foods were not efficient, which shows that the purchase of these products needs to be done with other suppliers (industries or traders). Future studies can map which products are suitable for each type of supplier, taking into account logistics and business strategy.

Finally, our results have shown that Solidarity Economy and Food Security are important in two respects. First, because the partnership between small farmers and public schools develops the local economy, benefiting mainly family farming, usually characterized by lower income workers. Second, the provision of locally produced healthy and fresh food benefits children and young people in public schools through a balanced diet and can change eating habits in the future.

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