# Efficiency in Argentine agricultural sector

Rinaldo Antonio Colomé, Carlos Ceballos Ferroglio,
Jorge Darío Freitag, Federico Priotti

Ponencia presentada en la XLIX Reunión Anual de la Asociación Argentina de Economía Política realizado en 2014 en la Universidad Nacional de Misiones. Misiones, Argentina

ASOCIACION ARGENTINA
DE ECONOMIA POLITICA

ANALES | ASOCIACION ARGENTINA DE ECONOMIA POLITICA

XLIX Reunión Anual

Noviembre de 2014

ISSN 1852-0022
ISBN 978-987-28590-2-2

# EFFICIENCY IN ARGENTINE AGRICULTURAL SECTOR

**Colomé, Rinaldo**
**Ceballos, Ferroglio Carlos**
**Freitag, Jorge**
**Priotti, Federico**

# "Efficiency in Argentine Agricultural Sector"

**Colomé, Rinaldo Antonio[♦] (Director)**
**Carlos Ceballos Ferroglio[⊕]**
**Jorge Darío Freitag[♣]**
**Federico Priotti[•]**

**Abstract**

The principal purpose of this paper is to analyze the agricultural productive efficiency in the Pampean Region of Argentina. To achieve this goal, the Data Envelopment Analysis (DEA) technique is used. The "core area" composed by North of Buenos Aires, South of Santa Fe and South East Córdoba is the highest productive efficient zone, becoming the "border" to which other areas should aim. We found different levels of efficiency among crops within areas, which could be a key element to discuss the amount payable for land renting.

**Keywords: Pampean Region of Argentina, productive efficiency, Data Envelopment Analysis (DEA), efficiency frontiers**

**Resumen**

El propósito principal de este trabajo es analizar la eficiencia productiva agrícola en la Región Pampeana de Argentina. Para alcanzarlo se utiliza la técnica del Análisis Envolvente de Datos (Data Envelopment Analysis, DEA). La "zona núcleo" compuesta por Norte de Buenos Aires, Sur de Santa Fe y Sudeste de Córdoba es la de más alta eficiencia productiva, convirtiéndose en la "frontera" que las otras áreas deben tener como objetivo. Se encontraron diferentes niveles de eficiencia entre los cultivos dentro de las áreas, lo que podría ser un elemento clave para discutir el monto de los arrendamientos.

**Palabras clave: Región Pampeana de Argentina, eficiencia productiva; Análisis Envolvente de Datos (DEA), fronteras de eficiencia**

**JEL CLASIFICATION: Q18, N50**.

---

[♦] Escuela de Graduados and Instituto de Economía y Finanzas, Facultad de Ciencias Económicas, Universidad Nacional de Córdoba, and Academia Nacional de Ciencias Económicas; racolome@eco.unc.edu.ar racolome@hotmail.com ; Victorino Rodriguez 1432, 5009 Córdoba, Argentina. Phone: +54 351-4813007. Cel phone: +54 351-6606072. Fax: +54 351-4334436.

[⊕] Instituto de Economía y Finanzas, Facultad de Ciencias Económicas, Universidad Nacional de Córdoba, cceballos@estudios-energeticos.com

[♣] Instituto de Economía y Finanzas, Facultad de Ciencias Económicas, Universidad Nacional de Córdoba, dario_freitag@hotmail.com

[•] Instituto de Economía y Finanzas, Facultad de Ciencias Económicas, Universidad Nacional de Córdoba, fedepriotti@gmail.com

## "Efficiency in Argentine Agricultural Sector"

### I. Introduction

Efficiency is frequently defined as the ratio between the inputs used and output obtained. To analyze the efficiency of the agricultural sector is necessary to adopt a uniform and consistent measure of firms (and sector) performance. One of the methods considered as most appropriated to measure efficiency is the Data Envelopment Analysis (DEA).

Data Envelopment Analysis emerges as an extension of the work of Farrell (1957) who developed a method to calculate empirical indexes to measure production efficiency, which takes into account all inputs used, as well as to separate the technical and allocative components of efficiency. Farrell applied this method to analyse the U.S. agricultural production.

Farrell assumptions to define the efficiency indexes are:

- Constant returns to scale; it allows production technology be represented by a unitary Isoquant.
- Convex Isoquant to the origin with negative slope: it allows to define diminishing marginal productivity for each production factor (and to determine the allocative efficiency point).
- Efficient production function is known.

It is necessary to differentiate the concepts of productivity with respect to productive or technical efficiency. As specified by Alvarez (2001) productivity refers to the concept of average productivity of a factor; that is, units of output per unit of input used; while efficiency is linked to the comparison of actual firms performance regarding the optimal performance. However, due to lack of knowledge of the underlying technology in the production process, usually it is necessary to recourse to a comparison between the performance of a firm (or sector) and the performance of another firm (sector) with similar characteristics.

For the definition and quantification of the different concepts of efficiency, Coll and Blasco (2003) assume the existence of four companies, which use two inputs for the production of a single product. Graphically on a Cartesian coordinate system, the technically efficient firms are located on an isoquant formed by combinations of the smallest possible amounts of inputs to produce one unit of output. Firms that are located to the right of the given isoquant are inefficient since they use more inputs to achieve the same product as used by other firms that are on the isoquant. Thus technical efficiency arises from comparing the observed value for each company with the value of the best companies (isoquant or border).

Analytically, the (relative) technical efficiency score can be determined graphically as the relationship or ratio between the distance from the origin to the projected point on the isoquant and the distance between the origin and the target point for the company in question.

This technical efficiency ratio assumes values in the range 0-1. Nearest 1 the ratio is, the more efficient the analyzed company, as it would be very close to the efficient isoquant.

Economically this concept of technical efficiency provides a measure of the ability of each company to obtain the maximum output with the least possible use of inputs.

Allocative efficiency is also known as price efficiency. Economically this type of efficiency refers to the ability of firms to use different factors in optimal proportions depending on the relative prices of them. Allocative efficiency will be given only at the point of tangency between the isoquant and the isocost. For the technically efficient firms but are not tangent to the isocost, score allocative efficiency is given by the ratio of the distance between the origin and the projection of the point located at the isoquant on isocost with respect to the distance between the origin and the observed point on the isoquant.

A significant contribution of the above methodology is that it allows to determine an overall efficiency index, also known as economic efficiency.

As with all efficiency indexes defined above, the value of the Global Efficiency score also will be between zero and one. The company (sector) will be more efficient as the index approaches one.

**Hypothesis**

A high degree of efficiency of the Argentine agricultural sector is expected, driven by the strong technological change and production management occurred in latest years, which partially offset the discrimination of the Argentine agricultural policy against the agricultural sector.

**Objectives**

The general objective of this paper is to investigate the efficiency of agricultural production in the Pampean Region of Argentina.

The specific objectives are:

-Survey of production models according to regions.

-Estimation of efficiency frontiers for aggregate agricultural production.

-Estimation of efficiency frontiers for wheat, corn and soybeans, for the major agricultural regions of Argentina.

-Comparison of results of efficiency estimates.

The paper will be organized as follows: section I, Introduction (including hypothesis and objectives); section II, Previous works. Section III, Methodology. In Section IV Empirical work. Section V, Some Conclusions and extensions.

## II. Previous works

In Argentina the Data Envelopment Analysis model have been used for efficiency analysis of different areas of the economy. Amilcar Arzubi and Julio Berbel[1] used DEA CCR model to analyze the relative efficiency of dairy farms in the South Basin Abasto of Buenos Aires. In that paper they arrived at the conclusion that the average levels of overall technical efficiency in the sector is 78.2%. Amilcar Arzubi et. al. (2009)[2] used DEA model to determine technical and economical efficiency in sheep farms located in Buenos Aires province. Efficiency of sheep farms indicate that it is possible to save 31% of the resources in Buenos Aires sheep production. If all the entreprises produce efficiently, their products (wool and meat) could be increased by 26% with the same area and flock size. Economical efficiency was low, 55%, affected by a great spread of values, due to the lack of homogeneity and the size range of the studied regions.

Agustín Arieu (2004)[3] identifies the comparative efficiency level for 14 grain terminals in Argentina, located on its Atlantic coast and in the Parana River. The paper shows that the overall performance of Bahía Blanca´s Terminals is good enough.

Catalina Lucía Alberto, Claudia Carignano and Raúl Ercole (2010)[4] aims to evaluate the performance of State Universities in Argentina using DEA model to identify the radial technical efficiency, the pure technical efficiency, the scale efficiency, the type of scale returns, and the origins of mixed inefficiency.

It is also found efficiency studies using DEA model in electricity distribution and gas distribution in Argentina, such as: Andrés Loza, Paula Margaretic and Carlos Romero (2003)[5], just to mention one.

---

[1] Amilcar Arzubi y Julio Berbel (2001): "DETERMINACION DE EFICIENCIA USANDO DEA EN EXPLOTACIONES LECHERAS EN ARGENTINA"; In *IV Congreso de la Asociación Española de Economía Agraria*.

[2] Arzubi, A., Mc Cormick, M., Simonetti, L., & Lynch, G. (2009). Análisis de Eficiencia Técnica y Económica de Explotaciones Ovinas en la Provincia de Buenos Aires. *Revista Argentina de Economía Agraria*, *11*, 115-126.

[3] Arieu, A. (2004). Eficiencia técnica comparada en elevadores de granos de Argentina, bajo una aplicación de análisis de envolvente de datos. La situación del puerto de Bahía Blanca. *Universidad Tecnológica Nacional. Consorcio de gestión del Puerto de Bahıa Blanca*.

[4] Alberto, C. L., C. Carignano, & R. Ercole, (2010) ANÁLISIS DE EFICIENCIA DE LAS UNIVERSIDADES PÚBLICAS EN ARGENTINA MEDIANTE MÉTODOS NO PARAMÉTRICOS, Projeto Saber > Educere et Educare > Vol. 5, N. 10 (2010): Dossiê Educação Básica e Superior: Políticas de Gestão e Financiamento

[5] Loza, A., Margaretic, P., & Romero, C. (2003): Consistencia de medidas de eficiencia basadas en funciones de distancia paramétricas y no paramétricas: una aplicación al sector de distribuidoras de electricidad en la Argentina, Online at http://mpra.ub.uni-muenchen.de/15269/MPRA Paper No. 15269, posted 16. May 2009 09:45 UTC.

Antequera Germán, J. L. Navarrete, G. Starobinsky, and W. Robledo this paper analyzes the productive efficiency of olive producers from the province of La Rioja using the Data Envelopment Analysis (DEA) to calculate the efficiency scores for the analyzed firms, and to compare their relative efficiency. The results show that there are significant differences between the evaluated units. Additionally, the findings suggest that the scale of production and the amount of labor employed are the main factors which influence the relative efficiency.

However it is not found efficiency analysis of the Argentine agricultural sector using the nonparametric method of Data Envelopment Analysis DEA. Therefore we must refer to studies for other countries.

Atici and Podinovski (2013)[6] mention different variables used in DEA applications in agricultural sectors. They identify some common inputs and outputs taken into consideration by the majority of the studies. On the output side, most common output used is the *agricultural production*. On the *Inputs* side various inputs have been taken into account in agricultural efficiency evaluation studies. *Land* and *labor* are the variables that are considered in the majority of the studies. *Land* is generally defined as the utilized agricultural area and measured in hectares or homologous measures. *Labor* is approached by different measures such as *number of workers, labor costs* or *labor hours.* Naturally, *costs* are among the key factors which are considered as inputs in agricultural DEA studies. *Costs* are taken into account through different variables. On one hand, in many studies, *costs* are integrated into the models as an aggregated variable which can represent the sum of costs on various items in agricultural production process, such as: energy, fertilizer, feed, fuel, seed. On the other hand, in several studies those items are considered as separate inputs.

The outputs and inputs are either in the form of monetary values or in physical amount produced or used.

## III. Methodology

One of the assumptions of Farrell analysis is that the efficient production function is known; however, this situation rarely occurs in practice, reason why is necessary to estimate such a boundary.

Methods for the estimation of efficiency frontiers are classified according to the following criteria:

According to the specification of the frontier functional form, methods may include: parametric (with defined functional form and estimated parameters); or nonparametric, where it is not necessary to define the frontier functional form, but simply identifying the companies with the best practices.

To estimate the functional forms, statistical or non-statistical methods (mathematical programming) can be applied.

Finally estimation methods can be deterministic or stochastic.

### Data Envelopment Analysis (DEA)

For the purpose of determining efficiency scores for the sector, called non-parametric models DEA-CCR will be implemented.

The DEA-CCR denomination is due to that the authorship of these Data Envelopment Analysis (DEA) models is attributed to Charnes, Cooper and Rhodes (1978).

There are broadly three ways of mathematically specifying a DEA-CCR model, namely:

1- Fractional Form
2- Multiplicative Form
3- Envelope Form. (Dual Method).

[6] Atici, Kazim Baris and Podinovski Victor V.(2013): "A REVIEW OF DATA ENVELOPMENT ANALYSIS STUDIES IN AGRICULTURE", Warwick Business School, University of Warwick, CV4 7AL, Coventry, United Kingdom.

## 1- DEA -CCR in Fractional Form

A first approach to the efficiency of a company or economic unit is given by the ratio between output and input. Thus the most efficient firms will be those who obtain the highest level of product per unit of input used.
In the case of multi-product and multi-inputs firms, to use this measure of efficiency, it is necessary to assign weights to the products and inputs, so you can get a unique index or efficiency score.
So, following Coll y Blasco (2003), the mathematical specification of this model is as follows:
Max u, v

$$h_0 = \frac{\sum_{r=1}^{s} u_r \times y_{r0}}{\sum_{i=1}^{m} v_i \times x_{i0}} \qquad [5]$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r \times y_{rj}}{\sum_{i=1}^{m} v_i \times x_{ij}} \leq 1 \qquad [6]$$

$$u_r, v_i \geq \varepsilon \qquad [7]$$

Where:
The existence of n units or operators are considered.
Xij represents the amounts of input i, which are used by firm j
Yrj represents r product quantities, which are generated by firm j
$u_r$, $v_i$ weights of the various products and weights of different inputs for each of the firms.
Thus a (nonlinear) mathematical programming is proposed, which aims to maximize the efficiency score of each of the economic units. Given this, efficiency score for the relationship between a "unique" virtual product and a "unique" virtual input are estimated.
The variables that allow such optimization are the weights of each of the products and each of the inputs. That is, it attempt to find the values of input and output weights that maximize the efficiency of each unit.
The restrictions set out to the system are that the efficiency scores of other economic units, with the weights defined for the unit under assessment, do not exceed unity.
Additionally, it is stipulated that there are no zero weights, i.e. to be excluded from consideration of the efficiency certain inputs or outputs.
The problem posed above must mathematically solve the efficiency score for each of the economic units considered.
So, economic units having an efficiency score of 1 are efficient, while those with values less than unity are inefficient.
For the case of inefficient units are other units, that with the same weights, have efficiency scores equal to 1; these units are called pairs, and they are the references to improve efficiency of inefficient units.

## 2- DEA -CCR in Multiplicative Form

This mathematical specification of model DEA arises from the linearization of the fractional form.
Running through the transformation of Charnes and Cooper a couple of variables (μ, δ) must be selected so as to normalize the virtual input to the unit, i.e.

$$\sum_{i=1}^{m} \delta_i \times x_{i0} = 1 \qquad [8]$$

Normalizing variables are defined through the following specifications:

$$\mu_r = t \times u_r \qquad [9]$$

$$\delta_i = t \times v_i \qquad [10]$$

$$t = \frac{1}{\sum_{i=1}^{m} v_i \times x_{i0}} \qquad [11]$$

Operating properly you can arrive at the following mathematical specification of the programming model

Max u, v

$$w_0 = \sum_{r=1}^{s} \mu_r \times y_{r0} \qquad [12]$$

Subject to:

$$\sum_{i=1}^{m} \delta_i \times x_{i0} = 1 \qquad [13]$$

$$\sum_{r=1}^{s} \mu_r \times y_{rj} - \sum_{i=1}^{m} \delta_i \times x_{ij} \leq 0 \qquad [14]$$

$$\mu_r , \delta_i \geq \varepsilon \qquad [15]$$

Analogously to the provisions in the case of the fractional form of DEA methodology, the value resulting from the objective function will be the efficiency score for the evaluated economic unit.

The mathematical specification included in equations 12 and 15 must be solved for each of the n considered economic units, so as to obtain two efficiency scores for each.

For a unit shall be efficient must be satisfied that $w_0$ is equal to 1 and also that there is an optimal set (μ *, δ *) such that both values greater than zero.

If a unit is inefficient will be one or more other units that with the same set of weights will have an efficiency score equal to 1. Such units are called reference set of inefficient units.

The importance of the application of DEA method, either in its fractional or multiplicative form, is that by determining the weights allow us to infer the importance of each of the different inputs or outputs have in determining the efficiency score for each of the units.

## 3- DEA -CCR in Envelope Form

DEA model in its envelope formulation consist in stating and solving the dual problem associated with the linear problem expressed as a Multiplicative Form.

The analytical model specification is as follows:

Min ɵ, λ

$$Z_0 = \theta \qquad [16]$$

Subject to:

$$\sum_{j=1}^{s} Y_{rj} \times \lambda_j \geq y_{r0} \qquad [17]$$

$$\theta X_{i0} \geq \sum_{j=1}^{s} X_{ij} \times \lambda_j \qquad [18]$$

Where r and i respectively symbolize the amount of outputs and inputs produced and used for each of the j analyzed firm.
The importance of solving the problem in its dual DEA form is that allows identification of the set of reference to improve efficiency; i.e., for each economic unit you can identify the unit or linear combination of them that are on the efficiency frontier.
In this way the model in its Dual form besides the efficiency score of each firm, provides the reference set of efficiency and quantify possible reductions in inputs or ouputs increases that will allow such firm achieve efficiency.
This movement towards efficiency with Dual method can be divided into its components: radial motion (proportional of all inputs or outputs) and slack movement.
The methodology specifies in detail how to quantify such movements, which are critical to firms' management. And the disquisition between the concept of Koopmans efficiency and Farrel efficiency arises.
Another advantage of the problem statement in the envelope shape is that the Dual generally has fewer restrictions than the Primal. Thus, the primal constraints are n +1, where n is the number of evaluated companies and 1 due to the linearity restriction of the input of the unit tested, while for the Dual problem restrictions are M + S, M = amount of outputs and S = amount of Inputs. To the extent that the number of firms is greater than the number of outputs and inputs generated and used by them will be advantageous to use the dual approach.

**Advantages and Disadvantages of Data Envelopment Analysis (DEA)**

Advantages:

1. Characterizes each of the units by a single score of relative efficiency.
2. By projecting each inefficient unit on the efficient envelope highlights areas of improvement for each of the units
3. DEA's no consideration for alternative and indirect approach of specifying statistical models and make inferences based on residual analysis and parameters coefficients. (Coll Serrano & Blasco, 2006).
4. The ability to adjust to exogenous variables as well as categorical variables.
5. Handle situations of multiple inputs and outputs.
6. The non-parametric approach is free from the misspecification of functional form and other restrictions.

Disadvantages:

1. Relative weights can allow a unit to qualify as efficient.
2. It is a deterministic approach; so, does not take into account influences of random nature nor uncertainty on the production process.
3. By DEA approach a substantial number of units are characterized as efficient unless the sum of the number of inputs and outputs is small relative to the number of observations. DEA probably works best when the number of observations is approximately twice the sum of the inputs and outputs. (Coll Serrano & Blasco, 2006) p.25).
4. DEA model is vulnerable to outliers' observations.
5. DEA converges slowly to the absolute efficiency, i.e., does not tell us how a unit behaves in relation to a "theoretical maximum".

## IV. Empirical work

### Data and Assumptions

In determining the agricultural frontier, five areas have been identified:
1 - Core zone (North of Buenos Aires, South of Santa Fe and South East Córdoba)
2 - South of Entre Rios

3 - South East of Buenos Aires
4 - Southern Córdoba
5 - West of Buenos Aires
The choice of these areas is determined by the availability of published data. Unfortunately, Argentina from the National Agricultural Census 2002, has not returned to conduct a reliable census. So, for this type of study and due to the changes experienced by the Argentine agricultural sector since the 2002 devaluation, those data have become obsolete.
Consequently, it is not possible to work with aggregate variables. It is necessary to work at the micro level, by selecting a comparable unit of analysis. In this study, we work at hectare level.
In relation to the considered variables, with respect to outputs, production obtained per hectare was taken. The analyzed grains, due to the amount of production and its geographical importance, are the following:
1. Soya
2. Maize
3. Wheat
As for inputs, we worked with only one input which is the result of aggregating all costs. Within this variable was included:
1 Tillage: planting activities and sprays.
2. Agrochemicals: Herbicides and insecticides used in production.
3. Seeds.
4. Fertilizers.
5. Harvest costs.
Then the DEA-CCR model proposed contains one input and three outputs.
Inputs are presented in monetary terms, while outputs in physical volume.

**Analysis of Results**

Table 1 shows the results of efficiency analysis for the five considered areas.
Through the solution of the problem, we reach at the same results in both primal and dual approaches.
For the primal and dual version it has been found that the efficient zone, of the analyzed area, is zone 1, that is, the core area (North of Buenos Aires, South of Santa Fe and Southeast Córdoba). It then follows zone 5, West of Buenos Aires. In the third place Zone 2, South of Entre Rios. Fourth is zone 4, South of Córdoba; and fifth zone 3, Southeast of Buenos Aires.
These results confirm what was *a priori* supposed about the core region, which is considered as the most efficient zone in Argentina. These results could also serve as a reference for negotiating the values per hectare in agricultural land leases. The value of the lease in each area is based on the capacity of the land in terms of revenue generation.

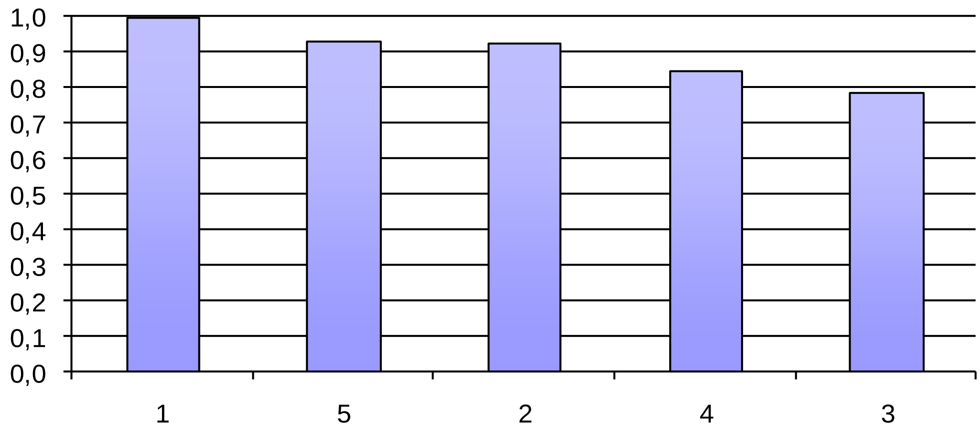
Table 1: Efficiency analysis for the five considered areas

| PRIMAL SOLUTION | | | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| **Multiply** | **Efficiency** | **1,0000** | **0,9266** | **0,7884** | **0,8466** | **0,9328** |
| **Soya** | **u1** | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| **Maize** | **u2** | 0,0125 | 0,0000 | 0,0149 | 0,0146 | 0,0141 |
| **Wheat** | **u3** | 0,0000 | 0,0265 | 0,0000 | 0,0000 | 0,0000 |
| **Input** | **v2** | 0,0008 | 0,0008 | 0,0009 | 0,0009 | 0,0009 |
| **WEIGTH OUT-INP OVER/EFFICIENCY** | **OUT1** | **0,0032%** | **0,0025%** | **0,0023%** | **0,0025%** | **0,0025%** |
| | **OUT2** | **99,9928%** | **0,0066%** | **99,9944%** | **99,9951%** | **99,9944%** |
| | **OUT3** | **0,0040%** | **99,9909%** | **0,0033%** | **0,0024%** | **0,0031%** |
| | **INP1** | **100,0000%** | **100,0000%** | **100,0000%** | **100,0000%** | **100,0000%** |
| **DUAL SOLUTION** | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 |
| **Envelopment** | **Efficiency** | **1,0000** | **0,9267** | **0,7884** | **0,8466** | **0,9328** |
| **MULTIP** | **LA** | 1,000 | 0,875 | 0,663 | 0,725 | 0,825 |
| | **LB** | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| | **LC** | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| | **LD** | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| | **LE** | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| **SLACK VARIABLE** | **INP 1** | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| | **OUT 1** | 0,000 | 5,000 | 3,200 | 2,200 | 3,400 |
| | **OUT 2** | 0,000 | 9,000 | 0,000 | 0,000 | 0,000 |
| | **OUT 3** | 0,000 | 0,000 | 0,500 | 8,500 | 4,000 |

Source: Own, estimates obtained based on the methodology and data mentioned above

In all zones, except zone 2, the major contribution to efficiency is given by corn. In zone 2, is given by wheat. These results suggest that to further increase efficiency in the Pampas have to increase the area planted to maize (wheat in zone 2), since the other grains are relatively less efficient.

Figure 1: Efficiency for different selected zones




Performing benchmarking of efficiency, the potential improvement would be achieved by increasing the output by using the same inputs.

Table 2: Benchmarking

| Efficiency benchmark | | | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| **OBJECTIVES VALUES** | **INP 1** | 1255,8 | 1098,8 | 831,9 | 910,4 | 1036,0 |
| | **Soya** | 32,0 | 28,0 | 21,2 | 23,2 | 26,4 |
| | **Maize** | 80,0 | 70,0 | 53,0 | 58,0 | 66,0 |
| | **Wheat** | 40,0 | 35,0 | 26,5 | 29,0 | 33,0 |
| **OBSERVED VALUES** | **INP 1** | 1255,8 | 1185,7 | 1055,2 | 1075,4 | 1110,6 |
| | **Soya** | 32,0 | 23,0 | 18,0 | 21,0 | 23,0 |
| | **Maize** | 80,0 | 61,0 | 53,0 | 58,0 | 66,0 |
| | **Wheat** | 40,0 | 35,0 | 26,0 | 20,5 | 29,0 |

Table 3: Potential improvement

| Potential improvement | | | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | **INP 1** | 0,00 | -86,96 | -223,23 | -165,01 | -74,60 |
| | **Soya** | 0,00 | 5,00 | 3,20 | 2,20 | 3,40 |
| | **Maize** | 0,00 | 9,00 | 0,00 | 0,00 | 0,00 |
| **ABSOLUTE CHANGES** | **Wheat** | 0,00 | 0,00 | 0,50 | 8,50 | 4,00 |
| **RADIAL MOVEMENT** | **INP 1** | **0,00** | **-86,96** | **-223,23** | **-165,01** | **-74,60** |
| | **INP 1** | **0,00** | **0,00** | **0,00** | **0,00** | **0,00** |
| | **Soya** | **0,00** | **5,00** | **3,20** | **2,20** | **3,40** |
| | **Maize** | **0,00** | **9,00** | **0,00** | **0,00** | **0,00** |
| **MOVEMENT SLACK** | **Wheat** | **0,00** | **0,00** | **0,50** | **8,50** | **4,00** |

Source: Author's calculations based on the methodology and data mentioned above

**Difficulties**

- The information was obtained from the magazine “Margenes Agropecuarios” spreads, so, as is evident from the results, there are relatively efficient production approaches for the considered zones.
- The variables considered are too many relative to the number of units selected, so that should reduce the first or increase the latter. It would seem that the best is the second alternative.
-Differences in objective values of the primal and dual for each region are observed.

## V. Some Conclusions and extensions

The postulated hypothesis: a high degree of efficiency of the Argentine agricultural sector is expected, driven by the strong technological change and production management occurred in latest years, which partially offset the discrimination of the Argentine agricultural policy against the agricultural sector, is confirmed through the obtained results.
Also is confirmed that the "core area" composed by North of Buenos Aires, South of Santa Fe and South East Córdoba (equivalent to what in the U.S.A. is called “corn belt”) is the most efficient productive zone. becoming the "border" to which other areas should aim. However, this could not be fully achieved because that area (the core zone) is the most fertile in the country for grain production. We found different levels of efficiency among crops within areas, which could be a key element to discuss the amount payable for land renting.
It should be emphasized that these results are subject to further study since, due to the use of a single input (costs) out of three outputs, values of efficiency are biased toward those with higher relative grains weight.
Lack of information from a reliable census is a negative point to this sort of studies because it

is necessary to collect information from non-official sources. In this case, the productive farmer schemes used are provided by a specialized magazine. Consequently, the quantity of farms considered is low.

Finally the extension of this research work is postulated - subject to obtaining information - for the OECD countries and Mercosur, looking for comparisons.

## V. Bibliography


- Alberto, C. L., Carignano, C., & Ercole, R. ANÁLISIS DE EFICIENCIA DE LAS UNIVERSIDADES PÚBLICAS EN ARGENTINA MEDIANTE MÉTODOS NO PARAMÉTRICOS.
- Álvarez, A. (2001). La medición de la eficiencia y la productividad. World Bank Institute. Madrid.
- Amilcar Arzubi y Julio Berbel (2001): "DETERMINACION DE EFICIENCIA USANDO DEA EN EXPLOTACIONES LECHERAS EN ARGENTINA"; In *IV Congreso de la Asociación Española de Economía Agraria*.
- Arzubi, A., Mc Cormick, M., Simonetti, L., & Lynch, G. (2009). Análisis de Eficiencia Técnica y Económica de Explotaciones Ovinas en la Provincia de Buenos Aires. *Revista Argentina de Economía Agraria*, *11*, 115-126.
- Arbolave, Mario R. MARGENES AGROPECUARIOS, Buenos Aires (several numbers).
- Arieu, A. (2004). Eficiencia técnica comparada en elevadores de granos de Argentina, bajo una aplicación de análisis de envolvente de datos. La situación del puerto de Bahía Blanca. *Universidad Tecnológica Nacional. Consorcio de gestión del Puerto de Bahıa Blanca*.
- Arzubi, A., Mc Cormick, M., Simonetti, L., & Lynch, G. (2009). Análisis de Eficiencia Técnica y Económica de Explotaciones Ovinas en la Provincia de Buenos Aires. *Revista Argentina de Economía Agraria*, *11*, 115-126.
- Atici K. y Podinovski V. (XXX). "A review of data envelopment analysis studies in agriculture". Warwick Business School, University of Warwick, United Kingdom.
- Bjorndal, T. y Adhikari, C. (2010) "Analyses of Technical Efficiency Using SDF and DEA Models: Evidence from Nepalese Agriculture". Applied Economics.
- Coelli, T.; Prasada Rao, D. y G. Battese (1998). An introduction to efifiency and productivity analysis. Kluwer Academic Publishers.
- Coll; V. y O. Blasco (2003). Evaluación de la eficiencia mediante el análisis envolvente de datos. Universidad de Valencia.
- Farrell, M. J. (1957). "The measurement of productive efficiency"; Journal of the Royal Statistics Society, serie A, 120 (3), 253-281.
- Ferreres, Orlando J. (2005), Dos siglos de economía argentina (1810-2004): historia argentina en cifras. *El Ateneo*, Buenos Aires.
- Gardner, B.L. (1987), *The Economics of Agricultural Policies*, McGraw-Hill, New York.
- Gomes E., Moreira T. y Souza G. (2010). "Potential improvement of agricultural output for major producers based on dea efficiency measurements". Brazilian Operations Research Society.
- Gomes E. (2008) "Uso de modelos dea em agricultura: revisão da literatura". Engevista, v.10, n.1, p. 27-51.
- Loza, A.; Margaretic, P. y Romero, C. (2003). "Consistencia de medidas de eficiencia basadas en funciones de distancia paramétricas y no paramétricas. Una aplicación al sector de distribuidoras de energía eléctrica en la Argentina". Anales de XLI Reunión Anual de la Asociación Argentina de Economía Política..
- MAGPyA. Estadísticas de Producción Agrícola en Argentina [en línea]. <www.sagpya.gov.ar>, consulta: Enero a Mayo 2008.
- Salhofer, K. (1997), *Efficiency of Income Redistribution through Agricultural Policy: A Welfare Economic Análisis*, Peter Lang, Frankfurt.
- Shahabinejad V., Yaghoubi M., Zamanian V. (2013). "Application of DEA and SFA on the Measurement of Agricultural Technical Efficiency in MENA1 Countries". International Journal of Applied Operational Research, vol. 3, n°2, pp 43-51.