The economic efficiency analysis of some rice mills in Egypt by using DEA and SFA

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The Economic Efficiency Analysis of Some Rice Mills in Egypt by Using DEA and SFA

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Abstract

The main aim of this paper is measuring the economic efficiency of the rice mills public sector in Egypt and comparing the best company according to the economic efficiency. This aim is achieved by estimating the economic efficiency using Data Envelopment Analysis (DEA) and Stochastic Frontier Approach (SFA). This paper is based on some unpublished secondary data which is obtained from the rice mills of the public sector in Egypt from 2003 to 2014. The paper focuses on five main companies which are Domyat and Belqas, Dakahlia, Gharbia, Behiera and Kafer El-Sheikh. The most important results are that according to the dependent variable production (Y1), there is economic efficiency in rice mills **Domyat and Belqas and Kafer El-Sheikh** score by 1. While in rice mills **Gharbia, Dakahlia and Behiera** score by 40%, 49.3%, 38% (efficiency = 0.401, 0.507, and 0.622) respectively. While according to the dependent variable sales (Y2), there is economic efficiency in rice mills **Domyat and Belqas, Gharbia, Dakahlia and Kafer El-Sheikh** score by 1. While **Behiera rice mills** has economic inefficiency score by 21% (efficiency = 0.791).

تحليل الكفاءة الاقتصادية لبعض مضارب الأرز في مصر باستخدام تحليل مغلف البيانات والمنهجية الحدودية العشوائية

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الملخص

الهدف الرئيسي من هذه الورقة البحثية هو قياس الكفاءة الاقتصادية لمضارب الأرز القطاع العام في مصر ومقارنة أفضل الشركات حسب كفاءتها الاقتصادية، وتم تحقيق هذا الهدف من خلال تقدير الكفاءة الاقتصادية باستخدام تحليل مغلف البيانات والمنهجية الحدودية العشوائية. واستند البحث على بيانات ثانوية غير منشورة تم الحصول عليها من مضارب الأرز بالقطاع العام في مصر خلال الفترة من عام **2003** إلى عام **2014**. وركز البحث على خمس شركات رئيسية هي دمياط وبلقاس، الدقهلية، الغربية، البحيرة وكفر الشيخ . وكانت أهم النتاج وفقاً للإنتاج كمتغير التابع **(Y1)**، هناك الكفاءة الاقتصادية في مضارب الأرز دمياط وبلقاس وكفر الشيخ تساوي **1**، أما بالنسبة في مضارب أرز الغربية والدقهلية والبحيرة فتبين أنه يوجد نقص كفاءة بنسبة **40%**، **49.3%**، **38%** (الكفاءة = **0.401**، **0.507**، **0.622**) على التوالي. بينما وفقاً للمبيعات كمتغير تابع **(Y2)**، وتبين أن هناك كفاءة اقتصادية في مضارب أرز دمياط وبلقاس، الغربية، الدقهلية وكفر الشيخ بنسبة **100%**، في حين أن مضارب أرز البحيرة لديها عدم كفاءة اقتصادية بنسبة **21%** (الكفاءة =**0.791**).

Introduction

Rice Mills in Egypt are divided into public sector and private sector. Public sector consists of 8 companies which are Domyat and Belqas, Sharkia, Dakahlia, Gharbia, Behiera, Kafer El-Sheikh, Rashid and Alexandria, while Rice Mills of private sector can have divided them into rice mills which make export rice, and other which make local rice. Also, there is another type of rice mill called Village Mills are support the needs of the people in villages with white rice, which is homemade. **The paper problem** is even though the rice production increased in Egypt, there is self-sufficiency and there is surplus for export, the rice mills' public-sector productivity decreased, and those companies subjected to liquidation; which was a result of the lack of liquidity in these companies. This led to the lack of funding paddy to the rice mills of the public sector. The previous point leads to a great result which is that there are economic and financial problems at the rice mills' public sector in Egypt. **The main aim of this paper** is measuring the economic efficiency of the rice mills public sector in Egypt and comparing the best company according to the economic efficiency. This aim is achieved by estimating the economic efficiency using Data Envelopment Analysis and Stochastic Frontier Approach. **This paper is based on** some unpublished secondary data which is obtained from the rice mills of the public sector in Egypt from 2003 to 2014. This paper focuses on five main companies which are Domyat and Belqas, Dakahlia, Gharbia, Behiera and Kafer El-Sheikh.

This paper uses data envelopment analysis (DEA) and stochastic frontier approach (SFA) to calculate economic efficiency (EE) for Rice Mills of public sector in Egypt during the period 2003-2014 by using variable returns to scale (VRS) according to Input Oriented Measure and calculate Scale Efficiency. Outputs include production (Y1) and Sales (Y2), while Inputs include Raw Materials, Salaries, and Fixed Assets by using DEAP program and FRONTIER 4.1.

There are two major approaches to measure and estimate efficiency exists which are the parametric approach and non-parametric approach. The parametric approach relies on econometric techniques while the non-parametric approach uses mathematical programming techniques. The most popular under the parametric and non-parametric approaches used in efficiency analysis is the Stochastic Frontier Analysis (SFA) production function approach and the Data Envelopment Analysis (DEA), respectively.

Testing stochastic effect is used to know if the model is constant or stochastic. This is according to the error, if it is positive number or negative one that is by using statistical tests. There are two hypotheses: Null Hypothesis (H0) which represents the constant model and Alternative Hypothesis (H1) which represents the stochastic model (H0: $b1 = b2 = \ldots. bk = 0$).

This paper uses two tests to estimate the stochastic of the model:

- **Gamma Test:** it is estimate the significant of gamma for the stochastic model. In fact, if (t) Calculated is bigger than (t) in the table at significant 5% and degrees of freedom equal number of independent variables (X). Refuse the null

hypothesis (constant model) and accept the alternative hypothesis (stochastic model).

- **Likelihood Ratio Test:** this test estimates the difference between logarithmic of likelihood functions (LLF)at null hypothesis (H_0) and its amount at alternative hypothesis (H_1). the function is:

$$\mathbf{LR = -2\ (Ln\ H_0 - Ln\ H_1) = -2\ (LLH_0 - LLH_1)}$$

In fact, if Chi-Square Calculated is bigger than Chi-Square in the table at significant 5% and degrees of freedom equal number of independent variables (X). Refuse the null hypothesis (constant model) and accept the alternative hypothesis (stochastic model).

Conclusion, if gamma and likelihood ratio are not significant that's means there is not stochastic at the model, the paper will depend on the constant model and use the statistical methods represents in ordinary least square (OLS) after testing the hypotheses or use the linear programing represents in data envelopment analysis (DEA). Also, there is no use to measure the partial tests.

Analysis

1. Stochastic Frontier Approach:

From testing stochastic effect with significant 5% and degrees of freedom equal 3 and from t table and Chi-Square table: (gamma =2.35 and Chi-Square = 7.8), it seems that:

1.1 Domyat and Belqas Rice Mills Company:

1.1.1 Production (Y1):

LR = -2(45.13 – 46.39) = 2.52
Gamma = 0.95

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.1.2 Sales (Y2):

LR = -2(36.81-36.81) = 0
Gamma = 0.32

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.2 Gharbia Rice Mills Company:

1.2.1 Production (Y1):

LR = -2(10.5-13.04) = 5.08
Gamma = 0.999

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There foraccept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.2.2 Sales (Y2):

LR = -2(29.61-29.9) = 0.58
Gamma = 0.952

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There foraccept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.3 Dkahlia Rice Mills Company:

1.3.1 Production (Y1):

LR = -2(37.1-37.56) = 0.92
Gamma = 0.95

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for; accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.3.2 Sales (Y2):

LR = -2(29.4-31.9) = 5
Gamma = 0.999

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for; accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.4 Behiera Rice Mills Company:

1.4.1 Production (Y1):

LR = -2(9.62-9.94) = 0.64
Gamma = 0.839

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for; accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.4.2 Sales (Y2):

LR = -2(8.94-10.3) = 2.72
Gamma = 0.999

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for; accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.5KaferEl-Sheikh Rice Mills Company:

1.5.1 Production (Y1):

LR = -2(29.63-31.4) = 3.54
Gamma = 0.999

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for; accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

1.5.2 Sales (Y2):

$$LR = -2(19.4-19.4) = 0$$

$$Gamma = 0.000024$$

From the results, it seems that Chi-Square is bigger than Likelihood Ratio calculated, and t is bigger than gamma. There for; accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model).

From these results, it seems that all the rice mills companies are constant models. There for, accept the null hypothesis (constant model) and Refuse the alternative hypothesis (stochastic model). Data envelopment analysis (DEA) is a more efficient method than the stochastic frontier approach (SFA) method. Also, it seems that Ordinary Least Square is better than Maximum Likelihood estimation and there is no use to measure the partial tests.

2. Data Envelopment Analysis (DEA):

Economic Efficiency score summary statistics for the 6 Rice Mills are presented in table (36) and table (37).

2.1. Production (Y1):

The Economic Efficiency (EE) score according to VRS ranges from a minimum of 0.401 and a maximum of 1, while the mean EE score is 0.755. There is economic efficiency in rice mills 1 and 5 score by 1. While in rice mills 2, 3 and 4 score are 0.401, 0.507 and 0.622 respectively. This means that they must increase the production with 60.9%, 49.3% and 37.8% respectively without any increase in the amount and the value of the economic resources used, as it can get the same amount of production using less quantity or value of economic resources used by about 40.1%, 50.7% and 62.2% respectively. Which mean that they are economically inefficient.

The Scale Efficiency (SE) score ranges from a minimum of 0.129 and a maximum of 1, while the mean EE score is 0.280. There is economic efficiency in rice mill 1 score by 1. while in rice mills 2, 3, 4 and 5score are 0.201, 0.161, 0.129 and 0.131 respectively, this means they must increase production with 79.9%, 83.9% 87.1% and 86.9% respectively without any increase in the amount and the value of the economic resources used, as it can get the same amount of the production using less quantity or value of economic resources used by about 20.1%, 16.1%, 12.9 % and 13.1% respectively. Which mean that they are economically inefficient.

2.2 Sales (Y2):

The Economic Efficiency (EE) score according to VRS ranges from a minimum of 0.791 and a maximum of 1, while the mean EE score is 0.958. There is economic efficiency in rice mills 1, 2, 3 and 5 nearly score by 1. while rice mill 4 (Behiera) has economic inefficiency score by 0.791, this means it must increase the

sales with 20.9% without any increase in the amount and the value of the economic resources used, as it can get the same amount of the sales using less quantity or value of economic resources account for about 79.1%.

The Scale Efficiency (SE) score ranges from a minimum of 0.714 and maximum of 1, while the mean EE score is 0.943. There is economic efficiency in rice mills 1, 2, 3, 4 and 5 nearly score by 1.

Table (1): Efficiencies of production (Y1) in the five Rice Mills by using DEA during the period 2003-2014

DMU	VRS	Scale	
Rice Mill 1 (Domyat and Belqas)	1	1	-
Rice Mill 2 (Gharbia)	0.401	0.201	irs
Rice Mill 3 (Dakahlia)	0.507	0.161	irs
Rice Mill 4 (Behiera)	0.622	0.129	irs
Rice Mill 5 (Kafr El-shiekh)	1	0.131	irs

Source: Calculated, The Financial Statements, The Five Rice Mills Companies, by using DEAP Program.

Table (2): Efficiencies of sales (Y2) in the five Rice Mills by using DEAP during the period 2003-2014

DMU	VRS	Scale	
Rice Mill 1 (Domyat and Belqas)	1	1	-
Rice Mill 2 (Gharbia)	0.972	0.996	irs
Rice Mill 3 (Dakahlia)	0.983	0.988	irs
Rice Mill 4 (Behiera)	0.791	0.958	drs
Rice Mill 5 (Kafr El-shiekh)	1	1	-

Source: Calculated, The Financial Statements, The Five Rice Mills Companies, by using DEAP Program.

2.3 Slack and Targets of Inputs:

There are input slacks at **Gharbia Rice Mills Company** by using production output in Salaries by 7 thousand, while **Dakahlia Rice Mills Company** and **Behiera Rice Mills Company** have input slacks in raw materials score by 7 million and 33 million respectively. By using sales output, there are input slacks at Gharbia Rice Mills Company in salaries score by 8 million and in fixed assets score by 28 million, while **Dakahlia Rice Mills Company** has input slacks in salaries and fixed assets score by 2 million and 34 million respectively.

Table (3): Summary of Input Slacks and Targets of the five rice mills "Production (Y1)" during the period 2003-2014

(Million L.E)

DMU	Actual			Target			Input Slacks		
	input 1	**input 2**	**input 3**	**input 1**	**input 2**	**input 3**	**input 1**	**input 2**	**input 3**
Rice Mill 1 (Domyat and Belqas)	192	5	79	0	5	79	0	0	0
Rice Mill 2 (Gharbia)	173	14	97	69	5	3	0	0.7	0
Rice Mill 3 (Dakahlia)	138	8	86	62	4	3	7	0	0
Rice Mill 4 (Behiera)	172	10	48	73	6	30	33	0	0
Rice Mill 5 (Kafr El-shiekh)	80	7	20	80	7	20	0	0	0

Source: Calculated, The Financial Statements, The Five Rice Mills Companies, by using DEAP Program.

Table (4): Summary of Input Slacks and Targets of the five rice mills "Sales (Y2)" during the period 2003-2014

(Million L.E)

DMU	Actual			Target			Input Slacks		
	input 1	**input 2**	**input 3**	**input 1**	**input 2**	**input 3**	**input 1**	**input 2**	**input 3**
Rice Mill 1 (Domyat and Belqas)	192	5	79	0	5	79	0	0	0
Rice Mill 2 (Gharbia)	173	14	97	69	5	3	0	8	28
Rice Mill 3 (Dakahlia)	138	8	86	62	4	3	0	2	34
Rice Mill 4 (Behiera)	172	10	48	73	6	30	21	1	0
Rice Mill 5 (Kafr El-shiekh)	80	7	20	80	7	20	0	0	0

Source: Calculated, The Financial Statements, The Five Rice Mills Companies, by using DEAP Program.

3. Forecasting:

By using Eviews program, this paper predicts the following:

3.1 The economic efficiency of Domyat and Belqas Rice Mills Company **(Rice Mill 1)** using production as output 1 is equal 0.999 during the period from 2015 to 2019, while the economic efficiency using sales as output 2 is also equal 0.999. This means that the rice mill 1 will has economic efficiency according to VRS during the next five years.

3.2 The economic efficiency of Gharbia Rice Mills Company **(Rice Mill 2)** using production as output 1 will increase according to Scale efficiency by mean 0.840 during the period from 2015 to 2019, while the economic efficiency using sales as output 2 according to VRS will increase by mean 0.961. This means that rice mill 2 must increase the amount of production without any increase in the amount and the value of the economic resources used, as it can get the same amount of production using less quantity or value of economic resources to achieve the economic efficiency during the next five years.

3.3 The economic efficiency of Dakahlia Rice Mills Company **(Rice Mill 3)** according to VRS using production as output 1 will decrease from 1 in 2003 to 0.973 in 2015, which means that it will decrease by mean 0.969 during the period from 2015 to 2019, while the economic efficiency using sales as output 2 will decrease from 1 in 2003 to 0.965 in 2015, which means that it will decrease by mean 0.960 during the period from 2015 to 2019. This means that the rice mill 3 must increase the amount of production without any increase in the amount and the value of the economic resources used, as it can get the same amount of production using less quantity or value of economic resources to achieve the economic efficiency during the next five years.

3.4 The economic efficiency of Behiera Rice Mills Company **(Rice Mill 4)** according to scale efficiency using production as output 1 will increase from 0.759 in 2003 to 0.929 in 2015, which means that it will decrease by mean 0.957 during the period from 2015 to 2019, while the economic efficiency using sales as output 2 will increase from 0.767 in 2003 to 0.881 in 2015, which means that it will decrease by mean 0.906 during the period from 2015 to 2019, which means that the rice mill 4 must increase the amount of production without any increase in the amount and the value of the economic resources used, as it can get the same amount of production using less quantity or value of economic resources to achieve the economic efficiency during the next five years.

3.5 The economic efficiency of Kafer El-Shiekh Rice Mills Company **(Rice Mill 5)** according to VRS using production as output 1 will increase from 0.919 in 2014 to 0.939 in 2015, which means that it will increase by mean 0.931 during the period from 2015 to 2019, while the economic efficiency using sales as output 2 will increase from 0.931 in 2014 to 0.959 in 2015, which means that it will increase by mean 0.953 during the period from 2015 to 2019. which means that the rice mill 5 must increase the amount of production without any increase in the amount and the value of the economic resources used, as it can get the same amount of production using less quantity or value of economic resources to achieve the economic efficiency during the next five years.

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