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Using Stochastic Frontier to Estimates and Analysis the Technical Efficiency for Rice Production in Behera Governorate, Egypt

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ABSTRACT

This paper used stochastic frontier production function to estimate the technical efficiency in Behera rice production using a survey data of 291 farms. Variations in the technical efficiency across rice production (sampled) farms ranges from 62.5 to 95.7 percent with an average of 85.9%. Indicating that there is a possibility to increase rice production by 14.1% (in average) given the use of the same amount of inputs. Moreover, the level of experience and education in addition to farming (as a main job) and employment of family labor are the main factors affecting inefficiency in rice production.

Key words: Technical efficiency; Production frontier; Rice; Behera.

Introduction

Rice is considered one of the most important cash crops and exportable in Egypt In addition, its cultivated area constitutes about 1.3 million Feddan representing about 21% of the summer cultivated area in 2013. Behera cultivated area constitutes about 189 thousand Feddan represent about 14 % of rice are in Egypt about and produced about 765 thousands tones.

The concept of technical efficiency relates to whether a firm uses the best available technology in production process (Chavas and Cox, 1988). Also, technical efficiency is a more elaborate concept i.e. it is a component of the broader notion of "economic efficiency" (Pascual 2001). In other words, the technical efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs, or uses the minimum feasible amount of inputs to produce a given level of output.

Old studies which try to measurer efficiency differentials among firms are use of simple measures, such as yield per Feddan and cost per unit of output, which are easy to calculate and understand. Also simple cost comparisons do not tell us what portion of the cost differences is due to inefficient. In addition, neither yield nor unit cost measures tell us anything about the existence, or otherwise, of scale economies. (Coelli *et al.,* 2002).

Aim of the Study:

The study attempts to measures the technical efficiency for rice farm production in Behera Governorate.

Data:

The study used surveyed data of 291 rice farms allocation between 9 villages in Behera governorate that have been randomly selected. Table (1) shows that the mean, standard deviation, minimum and maximum levels of total product and inputs. Table (1) shows that each farmer cultivated around 1.11 feddan of rice, used on average about 230 Kg / feddan and 206 Kg / feddan of nitrogenous and phosphate fertilizer respectively, 43 working day of labor, LE 468 for machinery and LE 99 for pesticides. Moreover, each farmer produced 4.39 tons of rice in average. There are five Varity of seeds used to producing the rice in this study: Sakha 101, Giza 178, Sakha 104, Giza 177 and Sakha 102.

Table 1: Descriptive Analysis of Rice production in Behera Governorate during 2010.

Item	Min.	Max.	Mean	S.D
Y Rice output (Ton)	1.00	20.00	4.39	2.44
x_1 Cultivated area (Feddan)	0.25	5.00	1.11	0.60
x_2 Seed (Kg)	5.00	240.00	54.66	35.78
x_3 Nitrogenous fertilizer (Kg)	25.00	1250.00	230.07	137.90
x_4 Phosphate fertilizer (Kg)	50.00	750.00	206.81	133.32
x_5 Labor (working day)	6.00	157.00	43.00	22.00
x_6 Machinery (LE)	52.00	6215.00	468.18	526.11
x_7 Pesticides (LE)	8.75	507.00	99.34	69.48

Source: *calculated by the authors.*

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Methodology:

There are many studies have been used a variety of methods to measure efficiency (Llewellyn and Williams, 1996). These methods can distribute for deterministic or stochastic, also and we can study these methods due to measurement into parametric or non-parametric.Farrell (1957) developed a deterministic nonparametric frontier model. This model cannot separate deviations from the frontier technology into their systematic and random components and thus, attributes all deviations from the frontier technology to inefficiency of the observed firm and may overstate inefficiencies. However, this methodology has the advantage of imposing no a priori parametric restrictions on the underlying technology, because it does not require a specific functional form for the frontier to be specified. As noted by (Fare *et al*., 1985) this nonparametric approach does not impose unwarranted structure on the technology that might create a distortion in the efficiency measures. Also, it can handle disaggregated inputs and multiple output technologies and can be used in evaluating technical, allocative and scale efficiencies.

This study used the parametric approach; this approach estimation of production functions consists of specifying a parametric form for the function and then fitting it to observed data by minimizing some measures of their distance from the estimated function. This method attributes variation from the most efficient farms to technical inefficiency (Chavas and Aliber 1993) and also the parametric approach has an important weakness, in that the maintained hypothesis of parametric form can never be detected directly (Varian, 1984; Banker and Maindiratta, 1988).

The parametric approach imposes restrictions on the technology that may not hold and that affect the distribution and measurement of the efficiency terms.

The technical efficiency may be defined as the ability of a firm to produce as much output as possible with a specified level of inputs, given the existing technology.

Tim Coelli (1996), (Pitt and Lee, 1981) have estimated stochastic frontiers and predicted firm-level efficiencies using these estimated functions, The study adopts the model developed by Battese and Coelli (1992) that may be expressed as:

$$Ln(Y) = \beta_0 + \beta_1 Lnx_1 + \beta_2 Lnx_2 + \beta_3 Lnx_3 + \beta_4 Lnx_4 + \beta_5 Lnx_5 + \beta_6 Lnx_6 + \beta_7 Lnx_7 + \beta_8 Lnx_8 + \beta_9 Lnx_9 + \beta_{10} Lnx_{10} + \beta_{11} Lnx_{11} + (v_{it} - u_{it})$$

Where:

LnYi: is the logarithm of the production of the i-th firm.

$\beta 0$- β_{11}: are the unknown parameters.

X_1: seeds (kg /farm).

X_2: labor (working day /farm).

X_3: machinery in LE.

X_4: minor (kg/farm).

X_5: fertilizer (nitrogenous) (Kg).

X_6: fertilizer (phosphate) (Kg).

X_7: pesticides in LE.

D_1: Varity 1 (Dummy: one for Varity Sakha 101, zero for others)

D_2: Varity 2 (Dummy: one for Varity Giza 178, zero for others)

D_3: Varity 3 (Dummy: one for Varity Sakha 104, zero for others)

D_4: Varity 4 (Dummy: one for Varity Giza 177, zero for others)

Vi: random variables which are assumed to be independent identical distributed and independent of the Ui.

Ui: non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be independent identical distributed.

The study used a computer program for Stochastic Frontier Production Function (Frontier Version 4.1), that developed by Coelli (1996) to achieve goal of estimating rice farm technical efficiencies for this study.

Results:

The Stochastic Frontier production coefficients:

Table (2) shows the OLS estimated coefficients of the production function. The intercept and results of 11 variables are significant except (minor, Pesticide, D1, D2 and D4). The OLS estimates of coefficients are taken as the starting values for the maximum likelihood estimation of the frontier function where from β 1 to β 11 are related to the variables from x1 to x11, and σ2 and γ are the coefficients of the log likelihood function. Where $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma_v^2 + \sigma_u^2$

Table 2: Maximum Likelihood estimation for stochastic production frontier model.

Item	P	Coefficient	S E	T	S
Constant	β_0	-2.884	0.148	-19.470	**
Seed	β_1	0.447	0.037	12.063	**
Labor	β_2	0.227	0.032	7.059	**
Machinery	β_3	0.161	0.032	4.968	**
Minor	β_4	0.004	0.005	0.760	-
Nitrogenous fertilizer	β_5	0.146	0.036	4.118	**
Phosphate fertilizer	β_6	0.012	0.003	4.113	**
Pesticide	β_7	-0.003	0.003	-1.039	-
D1	β_8	-0.003	0.061	-0.045	-
D2	β_9	-0.056	0.064	-0.871	-
D3	β_{10}	-0.181	0.083	-2.176	*
D4	β_{11}	-0.138	0.076	-1.824	-
	$\sigma 2$	0.055	0.016	3.438	**
	γ	0.460	0.300	1.533	-

*Log likelihood value = 58.6 , *: statistical significant at <0.05, **: statistical significant at <0.01*

Source: *calculated by the authors.*

Technical Efficiency Index:

Table (3) shows that the mean of the technical efficiency for each firms, The overall mean of the technical efficiency for all firms is 0.859 which explains that firms are producing 85.9 % of the potential output that could be produced using the observed input. Indicating that rice production can be increased by 14.1% in average using the same levels of inputs. Moreover, the technical efficiency is ranges from 62.5 to 95.7 percent with an average of 85.9%. Table (3) show that the majority of rice farms (62.2%) are producing within a range of technical efficiency (0.8-0.9), while 2% of farms at a relatively low range of (0.6-0.7), whereas, 69 farms out of 291 (23.7%) are producing at 90%-100% of technical efficiency.

Table 3: Distribution of Technical Efficiency.

Technical Efficiency Range	Number of Firms	%
0.6-0.7	6	2.06
0.7-0.8	35	12.03
0.8- 0.9	181	62.20
0.9- 1.0	69	23.71
	291	100

Source: *table (4)*

Table 4: Stochastic Frontier Analysis for Rice Production in Behera Governorate for 291 Farmers:

TE	firm	TE	firm firm	TE	firm	TE	firm	TE	firm firm o	TE	firm
0.877	251	0.927	201	0.875	151	0.886	101	0.919	51	0.893	1
0.889	252	0.879	202	0.753	152	0.899	102	0.895	52	0.925	2
0.898	253	0.882	203	0.752	153	0.840	103	0.827	53	0.771	3
0.907	254	0.876	204	0.792	154	0.857	104	0.906	54	0.957	4
0.890	255	0.869	205	0.732	155	0.841	105	0.898	55	0.776	5
0.923	256	0.883	206	0.772	156	0.879	106	0.903	56	0.856	6
0.906	257	0.882	207	0.812	157	0.869	107	0.898	57	0.915	7
0.819	258	0.891	208	0.721	158	0.851	108	0.808	58	0.938	8
0.814	259	0.876	209	0.712	159	0.886	109	0.858	59	0.871	9
0.869	260	0.923	210	0.660	160	0.879	110	0.853	60	0.846	10
0.864	261	0.828	211	0.781	161	0.903	111	0.773	61	0.861	11
0.861	262	0.828	212	0.794	162	0.856	112	0.793	62	0.888	12
0.776	263	0.955	213	0.884	163	0.835	113	0.851	63	0.813	13
0.847	264	0.824	214	0.714	164	0.828	114	0.811	64	0.844	14
0.827	265	0.744	215	0.721	165	0.896	115	0.923	65	0.936	15
0.873	266	0.811	216	0.625	166	0.873	116	0.676	66	0.838	16
0.902	267	0.834	217	0.864	167	0.876	117	0.872	67	0.836	17
0.878	268	0.852	218	0.701	168	0.870	118	0.890	68	0.869	18
0.812	269	0.786	219	0.884	169	0.828	119	0.913	69	0.838	19
0.895	270	0.910	220	0.821	170	0.877	120	0.872	70	0.945	20
0.762	271	0.742	221	0.672	171	0.880	121	0.850	71	0.886	21
0.773	272	0.840	222	0.873	172	0.885	122	0.893	72	0.900	22
0.673	273	0.839	223	0.866	173	0.829	123	0.935	73	0.933	23
0.781	274	0.807	224	0.823	174	0.927	124	0.882	74	0.931	24
0.951	275	0.830	225	0.898	175	0.849	125	0.868	75	0.933	25
0.882	276	0.859	226	0.849	176	0.874	126	0.907	76	0.887	26

Table 4: Cont.

0.918	277	0.905	227	0.888	177	0.738	127	0.826	77	0.907	27
0.899	278	0.834	228	0.834	178	0.879	128	0.914	78	0.906	28
0.929	279	0.876	229	0.819	179	0.834	129	0.871	79	0.855	29
0.938	280	0.870	230	0.869	180	0.887	130	0.865	80	0.930	30
0.741	281	0.832	231	0.882	181	0.847	131	0.928	81	0.934	31
0.908	282	0.900	232	0.932	182	0.859	132	0.881	82	0.909	32
0.709	283	0.936	233	0.861	183	0.906	133	0.885	83	0.849	33
0.728	284	0.923	234	0.875	184	0.880	134	0.914	84	0.886	34
0.887	285	0.897	235	0.875	185	0.903	135	0.879	85	0.782	35
0.776	286	0.923	236	0.878	186	0.873	136	0.927	86	0.780	36
0.921	287	0.925	237	0.873	187	0.884	137	0.861	87	0.913	37
0.757	288	0.901	238	0.875	188	0.884	138	0.900	88	0.838	38
0.908	289	0.904	239	0.896	189	0.862	139	0.876	89	0.922	39
0.941	290	0.899	240	0.835	190	0.899	140	0.846	90	0.934	40
0.936	291	0.898	241	0.882	191	0.839	141	0.896	91	0.934	41
		0.690	242	0.857	192	0.857	142	0.881	92	0.889	42
		0.922	243	0.876	193	0.835	143	0.851	93	0.936	43
		0.887	244	0.902	194	0.871	144	0.842	94	0.890	44
		0.860	245	0.856	195	0.871	145	0.821	95	0.911	45
		0.901	246	0.866	196	0.812	146	0.861	96	0.916	46
		0.879	247	0.903	197	0.883	147	0.853	97	0.887	47
		0.901	248	0.804	198	0.749	148	0.845	98	0.906	48
		0.892	249	0.749	199	0.870	149	0.875	99	0.786	49
0.859	Mean	0.845	250	0.867	200	0.753	150	0.882	100	0.908	50

T E: technical efficiency
Source: *stochastic frontier analysis for Rice Production in Behera Governorate for 291 farmers.*

Summary and Conclusion:

Rice is considered one of the most important cash crops and exportable in Egypt. In addition, its cultivated area constitutes about 1.3 million Feddan (representing nearly 21% of the summer cultivated area in 2013) in this paper; a stochastic frontier production function was estimated for rice farms in Behera governorate to measure their technical efficiency. The analysis was estimated for 291 farms. The overall mean of the technical efficiency for all groups is 0.859 which explains that firms are producing 85.9 % of the potential output that could be produced using the observed input. Indicating that rice production can be increased by 14.1% in average using the same levels of inputs equal about 125 thousands tones from rice. Moreover, the technical efficiency is ranges from 62.5 to 95.7 percent with an average of 85.9%. Table (3) show that the majority of rice farms (62.2%) are producing within a range of technical efficiency (0.8-0.9), while 2% of farms at a relatively low range of (0.6-0.7), whereas, 69 farms out of 291 (23.7%) are producing at 90%-100% of technical efficiency.

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