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TECHNICAL EFFICIENCY ANALYSIS FOR WHEAT PRODUCTION IN EGYPT

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تحليل الكفاءة الفنية لإنتاج القمح في مصر

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ABSTRACT

This study has focused on estimate the technical efficiency of the main governorates of wheat production in Egypt during the time period 1990-2012. We apply the stochastic frontier approach for efficiency measurement. The specification of Battese and Coelli (1992) is employed. The results indicate that the levels of technical efficiency vary among the different governorates of wheat production in Egypt.
Keywords: wheat, stochastic model, efficiency, Egypt

INTRODUCTION

The technical efficiency of wheat production in Egypt is very important indicator because it provides more precise information about what happen in the production process. The study aims to examine the input-output relationship of wheat production and estimate the technical efficiency of the main governorates of wheat production in Egypt during the time period 1990-2012. The paper is organized as follows: the next section presents the methodology; section 3 describes the data; section 4 indicates the results, and the final section presents the conclusions.

Methodology

The translogarithmic function and the Cobb-Douglas functional form are the two most common functional forms which have been used not only in empirical studies on frontier production, but in the studies on production behavior in general. The Cobb-Douglas production function is an adequate representation of our data. The Cobb-Douglas production function can be defined as:

$$\ln y_{it} = \beta_0 + \sum_{j=1}^{3} \beta_j \ln \mathrm{x}_{jit} + \beta_t t + v_{it} - u_{it} \qquad (1)$$

where y_{it} is the wheat production of the *i-th* governorate at the *t-th* time period; x_{jit} is the *j-th* input of the *i-th* governorate at *t-th* time period; β is unknown parameter to be estimated; *t* is the time variable; v_{it} is a vector of random errors that are assumed to be independently and identically distributed iid $N(0,\sigma_v^2)$; and u_{it} is a one sided (u_{it} ≥ 0) efficiency component that captures the technical inefficiency of the *i-th* governorate. The two error components (v_{it} and u_{it}) are independent of each other.

As defined by Battese and Coelli (1992), the non-negative inefficiency effect u_{it} is an exponential function of time. Considering the condition of the analyzed time period, the systemically time-varying inefficiency model can be written into an equation:

$$u_{it} = u_i \exp(-\eta(t-T)) \quad (2)$$

where the distribution of u_i is taken to be the non-negative truncation of the normal distribution $N(\mu, \sigma_u^2)$ and η is a parameter that represents the rate of change in technical inefficiency. A positive value $(\eta > 0)$ is associated with the improvement of governorate' technical efficiency over time.

The Maximum Likelihood estimates for the parameters of the stochastic frontier model, defined by equations (1) and (2) can be obtained by using the FRONTIER 4.1 program, in which the variance parameters are expressed in terms of (Coelli, 1996):

$$\sigma_s^2 = \sigma_u^2 + \sigma_v^2 \; ; \gamma = \frac{\sigma_u^2}{\sigma_s^2} \; and \; 0 \le \gamma \le 1 \; .$$

The technical efficiency level of the *i-th* governorate at the *t-th* time period (TE_{it}) is defined as the ratio of the actual output to the maximum potential output as follows:

$$TE_{it} = \exp(-u_{it}) .$$

Data

The data employed for the stochastic frontier analysis are taken from the Ministry of Agriculture and Land Reclamation (MALR), Egypt. The panel data composed of 253 observations for eleven governorates represents the main governorates of wheat production in Egypt during the time period 1990-2012. The summary statistics for the variables used in the analysis are presented in Table 1. The production inputs comprise three input variables (land, labor and machinery) while there is only one output (wheat production). Wheat production is expressed in thousand tons and land in thousand hectares. Labor and machinery have been estimated in thousand hours.

Table 1. Summary statistics for variables in the stochastic frontier production function.

Variables	Units	Maximum	Minimum	Mean	Std. Dev.
Output (y_{it})	Tons (thousands)	1144.62	195.00	474.46	192.47
Land (x_{1it})	Hectares (thousands)	178.52	20.92	74.46	29.22
Labor (x_{2it})	Hours (thousands)	110466.20	13191.72	46973.43	18421.22
Machinery (x_{3it})	Hours (thousands)	12321.23	1045.38	4325.39	1799.44

Source: Own elaboration from the data (Ministry of Agriculture and Land Reclamation, Egypt)

RESULTS

The Maximum Likelihood estimates of Battese and Coelli (1992) specification for the main governorates of wheat production in Egypt are presented in Table 2. The coefficients of the Cobb-Douglas production function can be directly illustrated as production elasticities of inputs in the production process. The Maximum Likelihood estimates of Battese and Coelli (1992) specification for the main governorates of wheat production in Egypt shows that the coefficient of land is positive and significant according to the prior expectations. The coefficient of labor is positive and significant. The coefficient of machinery is negative and insignificant. This may be due to that the average farm size in Egypt is about 0.6 hectare (FAO, 2006). In the small farm size, machinery cannot work efficiently and this requires the implementation of land consolidation system (Hõna, 2005) to increase the efficiency of machinery and reduce costs. The technical change coefficient is positive and insignificant.

Table 2. Maximum Likelihood estimates of the Cobb-Douglas stochastic frontier production function.

Variables	Coefficients	Standard error
Constant	0.5802	(0.9777)
X_{1it}	0.5798	(0.2838)*
X_{2it}	0.3379	(0.1540)**
X_{3it}	-0.0611	(0.1297)
t	0.0071	(0.0128)
σ^2	0.0068	(0.0087)
γ	0.0940	(0.7604)
μ	0.0064	(0.6163)
η	0.0737	(0.2720)
Log likelihood function	264.3412	
LR test	19.8840***	
Total number of observations	253	

Source: Own elaboration
*****, ** and * indicates significance at 1, 5 and 10% level, respectively**
All the variables are in log form except time

Table 3 shows the annual levels of technical efficiency of the total sample. The mean of technical efficiency for the time period 1990-2012 vary from a minimum level of 0.8922 in 1990 to a maximum level of 0.9773 in 2012 and the mean of the period is 0.9444. The annual average percentage growth rate is 0.4150%. The technical efficiency makes clear improving in the levels of technical efficiency during the time period 1990-2012**.**

Table 3. Technical efficiency by year.

Year	Technical efficiency	Year	Technical efficiency
1990	0.8922	2002	0.9533
1991	0.8993	2003	0.9566
1992	0.9059	2004	0.9596
1993	0.9122	2005	0.9624
1994	0.9181	2006	0.9650
1995	0.9236	2007	0.9674
1996	0.9287	2008	0.9697
1997	0.9335	2009	0.9718
1998	0.9381	2010	0.9737
1999	0.9421	2011	0.9756
2000	0.9462	2012	0.9773
2001	0.9499		
Mean (1990-2012)	0.9444		
Rate[a]	0.4150		

Source: Own elaboration
([a]) Annual average percentage growth rate (1990-2012)

Table 4 presents the mean of technical efficiency for the different governorates during the time period 1990-2012. Fayoum governorate has the minimum level of technical efficiency (0.8924), while Dakahlia governorate has the maximum level of technical efficiency (0.9908).

Table 4. Technical efficiency by governorate[a].

Governorate	Technical efficiency
Sharkia	0.9705
Dakahlia	0.9908
Behairah	0.9725
Menia	0.9804
Fayoum	0.8924
Assuit	0.9296
Suhag	0.9089
Gharbia	0.9243
Beni Suef	0.9328
Menoufia	0.9199
Kafr Elshikh	0.9668

Source: Own elaboration
([a]) Mean of the time period (1990-2012)

CONCLUSIONS

This paper aims to examine the input-output relationship of wheat production and estimate the technical efficiency of the main governorates of wheat production in Egypt during the time period 1990-2012. The data used in this study is a panel data at the governorates level, it represents the time period 1990-2012 and taken from the Ministry of Agriculture and Land Reclamation, Egypt. We apply the stochastic frontier approach for efficiency measurement and the Cobb-Douglas production function is used. The

specifications of Battese and Coelli (1992) is employed. The coefficient of land is positive and significant, implying that increasing the wheat area could significantly enhance the production of wheat. The coefficient of labor is positive and significant. The coefficient of machinery is negative and insignificant, therefore the implementation of land consolidation system could significantly decrease the inefficiency of machinery. The technical change coefficient is positive and insignificant. The levels of technical efficiency vary among the different governorates the minimum mean level of technical efficiency is 89.24% at Fayoum governorate, while the maximum mean level of technical efficiency is 99.08% at Dakahlia governorate. The technical efficiency takes an average value of 94.44%, this implying that little potential exists to improve resource use efficiency in wheat production. From this work we suggest the following recommendations, increase the area of wheat production through the reclaimed agricultural areas; implement the land consolidation system to increase the efficiency and reduce the costs; improve and increase the training of labor, especially the skills of cultivation and harvesting of wheat; improve the technology of wheat production; and increase the research with the purpose of taking advantage of genetic improvements, which should enable the introduction of new wheat varieties with higher productivity.

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ركّزتْ هذه الدراسةِ على تقدير الكفاءة الفنية للمحافظات الرئيسيةِ لإنتاجِ القمح في مصر. بياناتَ هذه الدراسةِ (panel data) علي مستوى المحافظاتَ و تمثّلُ الفترةَ الزمنية 1990-2012 وجمعت مِنْ وزارةِ الزراعة وإستصلاح الأراضي فى مصر. فى هذة الدراسة نطبق نظرية استوكاستك (Battese and Coelli (1992 لقياسِ الكفاءة الفنية وتم استعمال دالة إنتاج كوب دوجلاسِ . إنّ معاملَ الأرضِ إيجابيُ ومعنوي، و يُشير إلى أنَّ زيَأدَة المساحة المزروعة تؤدى الى تُحسّنَ إنتاجَ االقمح بشكل ملحوظ. معاملَ العملِ إيجابيُ ومعنوي. معاملَ المكائنِ سلبيُ وغير معنوي، لذا فان تطبيق نظامِ تجميع الأراضى الزراعية يُمْكِنُ أَنْ يقلل عدمَ الكفاءة بشكل ملحوظ. معاملَ التغييرِ التقني إيجابيُ ومعنوي. متوسط الكفاءة الفنية لانتاج القمح 94.44 %، وذلك يشير الى وجود امكانية بسيطَة لتَحسين الكفاءة الفنية لإنتاجِ القمح في مصر (5.56 %). تَتفاوتُ مستويات الكفاءة الفنية لانتاج القمح في مصر بين المحافظاتِ المختلفةِ، حيث محافظةِ الفيوم لها المستوى المتوسط الأدنى للكفاءة الفنية (89.24 %) ، بينما المستوى المتوسط الأقصى للكفاءة الفنية في محافظةِ الدقهلية (99.08 %). مِنْ خلال هذا العملِ نَقترحُ التوصياتَ التاليةَ، زيادة إنتاجِ االقمح في مصر من خلال التوسع في زراعتة بالاراضي الزراعيةِ الجديدة؛ تطبيق نظامُ تجميع الأراضى الزراعية لزيَأدَة الكفاءةِ وتقليل التكلفة؛ تحسين وزيادة تدريب االعمالة؛ زيادة التكنولوجيا في عملية انتاج القمح واستخدام الاصناف ذات الانتاجية العالية.