# Ranking Method of Measuring a Specific Farm Technical Inefficiency

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## Abstract

Ranking method is used to measure a specific farm technical inefficiency for greenhouse, dairy product, and table-egg farms. The advantage of this technique is its simplicity over other complicated estimators. Moreover, it does not require a composed error term which allows OLS to be a good estimators. Results are reconciled with economic logic of existing a constant returns to scale in agricultural frontier production functions. Results show that efficiency are predominating in large farms.

## Introduction

There has been recently much concern with estimating a stochastic frontier production functions to provide insight about measuring technical and economic efficiency in production. Previous work on the estimation of paramteric frontier production functions begin with specifying a composed errors term either in additive or multiplicative forms to measure technical and economic efficiency, namely; negative disturbance error reflects that output must lie on or below the frontier production due to controllable factors of technical and economic inefficiency, and symmetric random error reflects that frontier production function is a stochastic process as a result of uncontrollable factors ( Schmidt 1976, Aigner et al. 1977, and Zellener et al. 1966). Furthermore, the technical inefficiency is decomposed into a persistent and a residual components in panel data model ( Kumbhaker and Heshmati 1995). Technical inefficiency was measured by parametric programming approach ( Aigner and Chu 1968, Timmer 1970) and statistical approach ( Schmidt 1976, Dawson et al. 1991, Zellner et al. 1966, Just and Pope 1978, Meeusen et al. 1977, Kumbhaker and Heshmati 1995, Parikh et al. 1995, and Kirkley et al. 1995), however, statistical approach appear to offer the best method for assessing technical inefficiency of farms. Maximum likelihood estimation technique has been used very often in many papers for measuring the technical efficiency or inefficiency, and allocative efficiency. This is due to that MLE is the best unbiased and asymptotic efficient estimator for frontier production under error term specification

(Aigner et al. 1977, Dawson et al. 1991, Daughety 1982, Meeusen et al. 1977, Aigner et al. 1976, Kumbhakar and Heshmati 1995, Afriat 1972, Parikh et al. 1995, and Kirkley et al. 1995). Corrected ordinary least squares (COLS) can be used since MLE tends to outperform COLS in sample sizes larger than 400 ( Olson et al. 1980, Richmond 1974, and Kirkley et al. 1995).

All former studies assumed independence of the technical inefficiency error term and explanatory variables. This is a strong assumption which might not be a realistic , especially, in agricultural production process. Consequently, erroneous conclusion of increasing returns to scale is existed in estimated agricultural production functions. Al-Kahtani and Sofian (1995) relaxed this assumption by assuming a correlation between the technical inefficiency error term and at least one of the explanatory variables. The outcome of overwhelming the erroneous conclusion is a harmonious with the reality of agricultural production characteristic functions of being either constant or decreasing returns to scale.

The main purpose of this paper is to explore the implication of Ranking method ,which has been suggested by Al-Kahtani and Sofian (1995), to measure technical and economic inefficiency through estimating a stochastic frontier production function and examining the following hypothesis; different technical inefficiency under the same technology, and agricultural production functions are characterized by consistent returns to scale. Where increasing returns to scale can be seen in non-agricultural production function such as public services and alike.

## Material and Methods

Data source:

Cross-section data of greenhouse, dairy product, and table-egg farms were used in this study. Data for greenhouses and specialized table-egg projects were collected from 42 and 25 farms , respectively; in the central region of Saudi Arabia for 1990. These farms constitute 60% , and 63% of total number of greenhouses and specialized table-egg projects in the central region , respectively. Dairy products were covered 25 farms of Saudi Arabia farms in 1990 and represent 63% of total number of dairy farms in Saudi Arabia.

Method:

Ranking method is a simple econometric tool to use and a straightforward of OLS application. Besides, it has an advantage over complicated econometric estimators, such as MLE, of having a proper conclusion of constant or decreasing returns to scale in agricultural frontier production functions. It does not require a composed error term, therefore, OLS estimated coefficients are unbiased and consistent. Ranking the variable which has a correlation with the inefficiency error term can be used to derive a proxy for the non-positive error term and then estimating error term variance. Cobb-Douglas function is used due to simplicity of calculating the elasticities and its statistical properties especially for constant returns to scale and increasing returns to scale. Let us assume a general Cobb-Douglas production function :

$$Y_i = \beta_0^* X1_i^{\beta_1} X2_i^{\beta_2} X3_i^{\beta_3} \qquad (1)$$

where

i = 1,2,3 where number 1 represent a model for greenhouse, number 2 represent a model for dairy farms , and number 3 is representing table-egg projects.

$Y_i$ = Total production of Tomato, Milk, and Table-eggs,
$X1_i$ = Pesticides in greenhouse, Metabolizable energy in dairy farms, and Forage in table-egg projects, respectively,
$X2_i$ = Maintenance in greenhouse, Labor in dairy farms, and Veterinary care in table-egg projects, and
$X3_i$ = Farm size which represented by number of greenhouses, Number of dairy cows, and Number of chicken shelter, respectively.

Taking the log form of equation (1) yields the following:

$$Ly_i = \beta_0 + \beta_1 Lx1_i + \beta_2 Lx2_i + \beta_3 Lx3_i \qquad (2)$$

This equation can be used to test the degree of returns to scale since it is a homogenous production function or under the assumptiom that farms use almost fixed proportions of farm inputs which means farm inputs are collinear or nearly collinear (AL-Qunaibet et al. 1995) . Thus, production function is a homogenous of degree one or a constant returns to scale when the sum of elasticities equal to one ($\beta_1 + \beta_2 + \beta_3 = 1$). Accepting the hypothesis that $\beta_1 + \beta_2 + \beta_3 = 1$ means a constant returns to scale , while rejecting it , means an increasing returns to scale if $\Sigma_j \hat{\beta}_j > 1$.

Ranking method which is suggested by Al-Kahtani and Sofian (1995) can overcome the wrong conclusion of having increasing returns to scale as a result of using OLS in estimating agricultural production functions such as equation (2). To apply ranking method , farm size is considered to be the variable that reflects the technical inefficiency variable. This is due to the importance of this factor under the agricultural policy at least in Saudi Arabia farms. Thus, large farms which take an advantage of economic size will be more efficient and grow up faster than inefficient smaller ons. Let assume, without loss of generality, that the inefficient variable is set to one for the most efficient farm and then all other farms , i.e., less efficient, will be descently ranked from one. This is can be done by ascently ranked farms from smallest farm (least efficient) to largest farm (most efficient), i.e., farms will be ranked from 1,2 ,.... to n. The least efficient farm will have a rank value equal to one i.e., r(X3)=1, and n for the most efficient farm i.e., r(X3)=n. Dividing the rank series by n will have one for the most efficient farm and 1/n for the least efficient farm and so on. The Ranking model in log form is as follows:

$$Ly_i = \beta`_0 + \beta_1 Lx1_i + \beta_2 Lx2_i + \beta_3 Lx3_i + \beta_4 Lrx3_i \qquad (3)$$

where

$\beta`_0$ = ($\beta_0$ - $\beta_4$ Log($n_i$)) which will adjust the constant term,
$Lrx3_i$ = Log of r($X3_i$), and
$n_i$ = Number of farm size.

## Results and Discussion

Ranking method is carried out by applying the usual regression analysis to estimate frontier production function, hence, to measure the technical inefficiency. Results of free , rank, and restricted models are presented in Table (1) for greenhouse, dairy products, and free models only for table-egg farms, respectively. In greenhouse farms; free model shows that the sum of the elasticities is greater than one (1.35) indicating there is an increasing returns to scale. It is important to test the finding of this hypothesis since it contradicts with the previous assumption. Wald F-test is conducted to test the null hypothesis. The null hypothesis is rejected at

.01 significance level, which means there is an increasing returns to scale. Rank model indicates that the sum of the elasticities are greater than one

Table(1): Results of production function estimation [(1)] of free, rank, and restricted models for greenhouse, dairy products, and table-egg farms.

| Commodity | Model | $\beta_0$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | $\beta_4$ | $\overline{R}^2$ | $\Sigma \beta_i$ | Testing of C.R.T.S |
|---|---|---|---|---|---|---|---|---|---|
| Green House | Free Model: | 0.906856<br>(3.004) | 0.465795<br>(4.468) | 0.348589<br>(4.721) | 0.535754<br>(3.971) | | 0.936 | 1.35013 | 32.45 |
| | Rank Model: | 1.020907<br>(3.227) | 0.317623<br>(1.925) | 0.375400<br>(4.870) | 0.498969<br>(3.614) | 0.128372<br>(1.155) | 0.937 | 1.191992 | 1.61 |
| | Restricted Rank Model: | 1.263302<br>(4.944) | 0.154428<br>(1.461) | 0.412759<br>(5.737) | 0.432813<br>(3.353) | 0.258272<br>(5.648) | 0.935 | 1.0 | 1.61 |
| Dairy Milk | Free Model: | 1.189014<br>(0.991) | 1.108322<br>(8.599) | 0.236122<br>(2.002) | | | 0.888 | 1.34444 | 12.34 |
| | Rank Model: | 5.245738<br>(2.264) | 0.736152<br>(3.321) | 0.132131<br>(1.081) | | 0.461412<br>(2.003) | 0.902 | 0.868283 | 0.27 |
| | Restricted Rank Model: | 4.075443<br>(8.494) | 0.836688<br>(8.010) | 0.163312<br>(1.563) | | 0.350380<br>(4.288) | 0.905 | 1.0 | 0.27 |
| Table-Egg | Free Model(a): | -0.3753<br>(-0.297) | 0.45629<br>(2.230) | -0.01126<br>(-0.133) | 0.54011<br>(1.993) | | 0.915 | 0.9851 | 0.03 |
| | Free Model(b): | | 0.38615<br>(18.368) | | 0.61296<br>(6.891) | | 0.998 | 0.9991 | 0.00 |

[(1)] Figures between parentheses represent the corssponding t-values.

Source: Cross-section data from filed survey of the central region for greenhouse and table-egg, and the Kingdom for dairy farms.

but not significant at 0.01, implying that the production function is a constant returns to scale. The restricted rank model indicates that the sum of the elasticities are equal to one and the null hypothesis can not be rejected at 0.01 significance level so that the production function is a constant returns to scale. In dairy farms; free model exhibit increasing returns to scale of production function. Wald F-test illustrates that the null hypothesis is rejected at 0.01 significance level which means increasing returns to scale is prevailed. Rank and restricted rank models show that production function is constant returns to scale. Testing the null hypothesis at 0.01 significance level indicates the correction of exhibiting constant returns to scale in the production function. Al-Qunaibet et al. (1995) reached to the same conclusion in milk production functions. In table-egg farms; free models show the sum of the elasticities are less than one, i.e., .985 for the free model(a) and .999 for the free model(b). The null hypothesis can not be rejected at .01 significance level which means constant returns to scale is existed in both models. Therefore, there is no need of conducting neither rank nor restricted rank models for these farms.

Restricted rank model will be implemented for measuring a specific farm technical inefficiency. A specific farm technical inefficiency can be calculated using an estimate of the inefficiency variable which is represented by the rank coefficient as follows:

$$e_i = Exp \{ \beta_4 (Lrx3_i - Log(n_i)) \} \qquad (4)$$

while, the effect of the specific farm technical inefficiency comparing with the most efficient farm is as:

$$e_i * Y_i \qquad (5)$$

where $Y_i$ is estimated farm production level at 100% efficiency.

As a result of having three different type farms with many observations, efficiency class has distributed to four interval levels as shown in table (2). Last column in Table (2) shows the impact of the efficiency, which is represented by the farm size, on average farm productivity. These findings are compatible with the assumption of high efficiency of large farms. The average productivity for greenhouse farmsare; 25.2, 24.25, 22.31, and 17.38 ton per hectare for greater than 90%, 75-90%, 50-75%, and less than 50% efficiency class, respectively.

In dairy farm, the average productivity are 9254.4, 9757.1, 7939.9, and 5855.7 ton per cow for the efficiency class greater than 90%, 75-90%, 50-

Table(2): Distribution of the sampled farms according to the efficiency class and its effect on average farm productivity

| Efficiency(1) Class % | No. of Farms # | % | Average Farm Size | Impact of farm size on average farm productivity |
|---|---|---|---|---|
| Green House: | | | | |
| 90 - | 5 | 11.9 | 50.20 | 25.20 |
| 75 - 90 | 6 | 14.3 | 30.30 | 24.25 |
| 50 -75 | 13 | 31.0 | 16.92 | 22.31 |
| - 50 | 18 | 42.8 | 9.06 | 17.38 |
| Dairy Milk: | | | | |
| 90 - | 3 | 12.0 | 1956 | 9254.4 |
| 75 - 90 | 4 | 16.0 | 1255 | 8757.1 |
| 50 -75 | 6 | 24.0 | 1017 | 7939.9 |
| - 50 | 12 | 48.0 | 519 | 5855.7 |

(1) The sampled farms of table-egg does not show any technical inefficiency.

Source: Computed from the sampled data and using production function coefficent of restricted rank model.

75%, and less than 50%, respectively. In table-egg farms, there is no efficiency class due to the lack of specific farm technical inefficiency variance among these farms and therefore farm size does not have an impact on average productivity.

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