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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Production Efficiency Analysis in Egg Production in Khorasan Razavi Province, Iran: An Application of the Transcendental Frontier Model

Seyed Ahmad Mohaddes
Agricultural and Natural Resources Research Center of Khorassan Razavi Province, Iran

Abstract: The objective of this study is to determine the production efficiency of egg production in Khorasan Razavi. A cross-sectional data collected from 47 farms in the Khorasan province, as well as secondary data from the Iranian Statistical Year Book, were used to estimate production functions. The analysis was carried in three stages. In the first stage, the Transcendental and Cobb-Douglas production functions were estimated using OLS method. It was found that the transcendental production fit the data better than the Cobb-Douglas production function. The result showed that feed, pullet and cost of Energy inputs are the important factors in egg production. The second stage of the analysis estimated a Transcendental Stochastic production frontier model. The mean Technical, Allocation and Economic efficiency indices were 0. 92, 0.92 and 0.85 respectively. The results showed that farmers did not have major inefficiency in egg production with this current technology and should improve it for increasing production.

Key words: Economic efficiency, frontier production function, transcendental, Khorasan Razavi province, Iran

INTRODUCTION

The egg production industry is one of the most important agricultural economic activities in Iran. According to the latest information in Iran, there were about 1432 poultry eggs farms producing about 576,478 tons of edible eggs in 2005. On other hand, it provides a good source of animal protein that is rich in the essential amino acids required for bodily functions. Also poultry meat and eggs offer considerable potential for meeting human needs for dietary animal supply (Folorunsho and Onibi, 2005). Additionally, eggs are cheaper than other sources of animal protein. On average, an egg costs about 1000 Rials (0.10 US) and can is therefore affordable to poor people (Mohaddes, 2009). It also could as well be exported for foreign exchange from excess released because egg has comparative advantage in Iran, according to the Agriculture Planning and Economic Research Institute (APERI).

The Egg farmers, however, complained that the cost of production was very high and they failed to gain considerable profit from their farming operations. On the other hand, the consumers protested that the egg price was very high.

Determining the efficiency status of farmers is very important for policy purposes. In an economy where technologies are lacking, efficiency studies show the possibility of raising productivity by improving efficiency without increasing the resource base or developing new technology. It also helps to determine the under-utilization or over-utilization of factor inputs. Production efficiency is usually analyzed by separately examining two components-technical efficiency and allocative efficiency-and combine both measures into one system (Jirong *et al*., 1996). This approach enables more efficient estimates to be obtained by simultaneously estimating the system (e.g. Kumbhakar, 1989; Kalirajan, 1990).

Stochastic frontier production functions have been widely used to assess the economic efficiency of agricultural production in recent years (e.g. Battese and Coelli, 1992; 1995; Coelli and Battese, 1996; Dey *et al*., 2000a,b; Sharma and Leung, 2000; Chianga *et al*., 2004; Yusuf and Malomo, 2007).

The purpose of this study is to determine Technical, Allocation and Economic Efficiency level of the industry so that a more sustainable and high efficient production system can be developed. For this objective, Khorasan Razavi province in Iran is selected.

Khorasan Razavi province is located between 34°-51′ till 37°-45′ latitude and 56°-45′ till 67°-17′. The average altitude of the province is 1000 m and the summit is located in Binalood mountain range with 3200 m elevations and lowest part is in Sarakhs Township with 275 m elevation (Mohaddes *et al*., 2002).

Table 1 details the number and capacities of chicken farms in the province in 2005, while Table 2 shows the quantity and value of production in Iran and Khorasan Razavi province. There were 1432 farms with 5096 halls and 76 million capacities. Those numbers were 249, 638 and 9167 million in Khorasan Razavi respectively.

Overall, in 2005, the farms produced 576,478 tons of edible eggs, 10,712 tons broken and shell-less egg, 7,476,525 flows sold pullets, 23,301 tons cull and 4,983,21 tons manure. Therefore, the total value of their production was 3,313,075 million Rials ($331 million).

Table 1: Number and capacity(1) of layer chicken and pullet farms

Province	No. of farms	No. of poultry halls	Capacity (1000 fowls)
Iran	1432	5096	76046
Khorasan Razavi	249	638	9167936

1. Capacity refers to the number of chickens-hen or cock-that can be reared with regard to installations and equipment available on the farm. 2. Excluding farms raising pullets. Source: Statistical Centre of Iran

Table 2: Quantity and value of production at of layer chicken and pullet farms (ton; mln rials)

	Edible eggs		Broken and shell-less eggs		Sold pullets (fowl)	
Year and Province	Quantity	Value	Quantity	Value	Quantity	Value
Iran	576478	3021222	10712	27670	7476525	127098
Khorasan Razavi	57232	304048	557	1412	725531	13523

	Cull (1)		Manure	
Year and Province	Quantity	Value	Quantity	Value
Iran	23301	91212	498321	45873
Khorasan Razavi	2373	11337	52783	5795

Chicken culled for various reasons or delivered to slaughterhouses at the end of raising period can be used as meat. Source: Statistical Centre of Iran

MATERIALS AND METHODS

The data for this study were primary data and secondary data. Primary data was collected from 47 egg farms in Khorasan Razavi province. The sampling method used was category and circle systematic. Data were collected through the use of a structured questionnaire designed to collect information on output, input, price of output and input and some major social-economic characteristics of the farmers in the study area. Secondary data was taken from the Statistical Center of Iran (2005).

Theoretical framework: The measurement of Technical, Allocation and Economic Efficiency has been intimately linked to the use of frontier functions. A production frontier represents the maximum output attainable for each input level. Farrel introduced a method to decompose the overall efficiency of a production unit into its technical and Allocation components (Farrel, 1957).

The analysis of efficiency carried out by Farrel (1957) can be explained in Terms of Fig. 1.

Assuming the Constant Returns to Scale (CRS) as Farrel (1957) initially did in his paper, the technological set is fully described by the unit isoquant YY/ that captures the minimum combination of inputs per unit of output needed to produce a unit of output. Thus, under this framework, every package of inputs along the unit isoquant is considered technically efficient, while any point above and to the right of it, such as point P, defines a technically inefficient producer, since the input package that is being used is more than enough to produce a unit of output. Hence, the distance RP along the ray OP measures the technical inefficiency of producer located at point P. This distance represents the amount by which all inputs can be divided without decreasing the amount of output. Geometrically, the technical inefficiency level associated with package P can be expressed by the ratio RP/OP and therefore, the Technical Efficiency (TE) of the producer under analysis (1-RP/OP) would be given by the ratio OR/OP.

If information on market prices is known and a particular behavioral objective such as cost minimization is assumed in such a way that the input price ratio is reflected by the slope of the iso-cost-line CC’, allocative inefficiency can also be derived from the unit isoquant

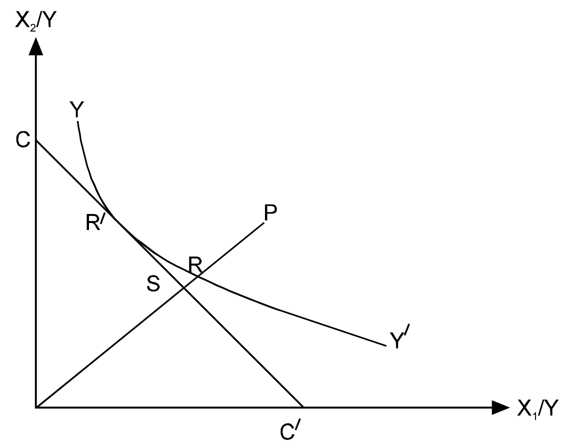

Fig. 1: Technical, allocation and economic efficiency

plotted in Fig. 1. In this case, the relevant distance is given by the line segment SR, which in relative terms would be the ratio SR/OR. With respect to the minimum cost combination of inputs given by point R/, the above ratio indicates the cost reduction that a producer would be able to reach if it moved from a technically but not allocatively efficient input package (R) to a both technically and allocatively efficient one (R/). Therefore, the Allocative Efficiency (AE) that characterizes the producer at point P is given by the ratio OS/OR.

Together, with the concepts of technical efficiency and allocative efficiency, Farrel (1957) describes a measure of what he termed overall efficiency and later literature has renamed Economic Efficiency (EE). This measure comes from the multiplicative interaction of both technical and allocative components:

$$EE = TE * AE = OR/OP * OS/OR = OS/OP$$

Cost reduction can also be analyzed where the distance involved in its definition (SP) (Luis and Murillo, 2004).

The basic model used to measure technical and Allocative inefficiencies in the case of one variable input and output is illustrated in Fig. 2. The curve TPP_m shows the maximum possible total output as input X is increased, while the curve TPP_a shows the input response on an 'average' farm. All below TPP_m are

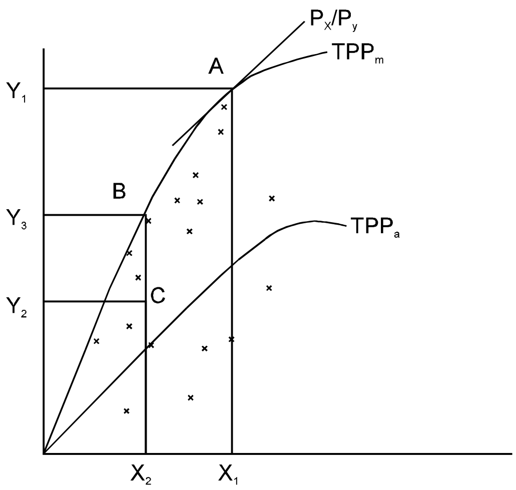

Fig. 2: Frontier and OLS production function and Technical, Allocative and Economic efficiency

technically inefficient because they give less output at given levels of input. The profit-maximization criterion suggests that a producer will choose to utilize level X_1 of input (where the marginal value of X is equal to its price, P_x) and will produce the technically and allocatively efficient output, Y_1. A producer who uses X_2 and produces Y_3 is technically efficient but allocatively inefficient. On the other hand, if he is producing Y_2 by using X_2, he is both technically and allocatively inefficient. Technical efficient is defined as the ratio of a farmer's actual output to the technically maximum possible output at the given level of resources:

$$(Y_2/Y_3) \tag{1}$$

Allocative efficiency is expressed as the ratio of the technically maximum possible out put at the farmer's level of resources to the output obtainable at the optimum level of resources:

$$(Y_3/Y_1) \tag{2}$$

Economic efficiency is simply the product of technical- and allocative efficiencies:

$$[(Y_2/Y_3)*(Y_3/Y_1)] = Y_2/Y_1 \tag{3}$$

Technical, Allocative and Economic inefficiencies are measured as $(1-Y_2/Y_3)$, $(1-Y_3/Y_1)$ and $(1-Y_2/Y_1)$, respectively.

The production function is defined as the relationship that describes the 'maximum possible' output for the given combination of input (Ferguson, 1966). However, a production function estimated by the Ordinary Least-Squares (OLS) method shows an 'average' response (TPP_a in Fig. 2) and does not qualify for the theoretical definition of a production function frontier (Ali and Chaudhry, 1990).

The stochastic frontier production function in efficiency studies is employed in this study. The modeling, estimation and application of stochastic frontier production functions to economic analysis assumed prominence in econometrics and applied economic analysis during the last two decades. The stochastic frontier production function was independently proposed by Aigner *et al.* (1977) and Meeusen and Van Den Broeck (1977).

Transcendental production function defines as (Halter *et al.*, 1957):

$$Q = aX1^b\,X2^c\,e^{dx1+fx2} \tag{4}$$

Where e is the natural logarithmic base, b and c are partial coefficients of X1 and X2 respectively. d and f are trans-parameters measuring the variability of b and c in response to changes in production scale and input substitution (complementarily). If d and f are zero equation, (4) becomes Cobb-Doglas production function. For non-zero trans-parameters, the Cobb-Duglas special case is rejected because, in this case, equation (4) is nonlinear and characterized by variable marginal products, short-run input elasticity and marginal rate of technical substitution (Halter *et al.*, 1957). Even so, equation (4) can still be estimated by conventional regression methods because its natural logarithmic version is linear in the parameters:

$$LnQ = lna + blnX1 + clnX2 + dX1 + fX2 \tag{5}$$

The biggest advantage of Transcendental production function from Cobb-Doglas is that Transcendental can show up to three stage of production. The model estimated by software FRONTIER Version 4.1 (Coelli, 1996).

The empirical model: In this study Transcendental and Cobb-Douglas production functions were estimated using OLS method. It was found that the Transcendental production fit the data better than the Cobb-Douglas production function. The production function was first estimated using the OLS method. The transcendental production function is estimated as:

$$\ln Q = -7.1 + 0.39\ln FED + 0.38\ln P + 0.40\ln E + 1.28^{-5}FED - 7.5^{-6}P - 4.8^{-9}E$$

	(1.56)	(0.14)	(0.21)	(0.17)	(0.0001)	(1.3^{-5})	(9.7^{-9})	(6)
t	4.5	2.8	1.8	2.4	0.11	-0.7	-0.5	

P = Pullet, E = Energy

R^2 = 0.98, R^2 Adjustment = 0.98, DW = 1.95, F = 354

Where, Fed is amount used fed in unit's farm. Pullet is amount chicken in unit's farm. Energy is cost of Energy in unit's farm. The R^2 shows 98% changing explain with three inputs (Fed, Pullet and Energy).

Table 3: Technical efficiency for different size

Size	Amount sample	Average	Min	Max	Standard errors
X<10000	7	0.92	0.82	0.96	0.05
10000<X<20000	12	0.93	0.84	0.98	0.05
20000<X<30000	17	0.92	0.82	0.97	0.04
X>30000	11	0.92	0.88	0.97	0.05
Mean	47	0.92	0.82	0.98	0.04

The average Allocative efficiency was 0.92 in the sample that is a good ratio. Minimum and maximum theses ratio are 0.83 and 1

Table 4: Allocative efficiency in difference size

Size	Amount sample	Average	Min	Max	Standard errors
X<10000	7	0.89	0.84	0.98	0.05
10000<X<20000	12	0.93	0.87	0.97	0.03
20000<X<30000	17	0.92	0.83	1	0.04
X>30000	11	0.92	0.88	1	0.05
Mean	47	0.92	0.83	1	0.04

Table 5: Economic efficiency in difference size

Size	Amount sample	Average	Min	Max	Standard errors
X<10000	7	0.82	0.70	0.94	0.08
10000<X<20000	12	0.87	0.73	0.95	0.07
20000<X<30000	17	0.85	0.68	0.97	0.07
X>30000	11	0.86	0.72	0.96	0.05
Mean	47	0.85	0.68	0.97	0.07

Maximum likelihood techniques were used to estimate transcendental production frontier. The (6) transformed into a stochastic frontier production function as follows:

$$\ln Q = -6.9 + 0.39 \ln FED + 0.38 \ln P + 0.40 \ln E + 1.28^{-5} FED - 7.5^{-6} P - 4.8^{-9} E \quad (7)$$

P = Pullet, E = Energy

The OLS Function portrays the response of the ‘average farmer,’ while the frontier function elected the response of the ‘best–practices farmer’ (Ali and Chaudhry, 1990). In this study, the stochastic frontier approximates the OLS estimate, the only difference occurring in the estimate intercept. The intercept of the frontier model is lower than that obtained by OLS. Olson *et al.* (1980) showed that, in the case of a cost function, the OLS estimate of all parameters except the intercept are unbiased and frontier estimation has effect of lowering the intercept in the estimation of a cost function.

RESULTS AND DISCUSSION

Technical, Allocative and Economic efficiency were measured using Equations 1, 2 and 3, respectively. The results are shown in Table 3, 4 and 5.

The average technical efficiency was 0.92. This average was the same in all categories. These ratios ranged from 0.82 in categories 1 and 3 to 0.98 in category 2. This means that there exists a 2-18% potential for increasing farmers’ income at existing level of their resources in some farmer, but there was not a main inefficiency in egg farmers. Therefore, with current technology, one cannot expect a main increasing income and farmers should improve the current technology.

The combined effect of Technical and Allocative factors shows that the average economic efficiency level for this sample was 85%, with a low of 0.68% and a high of 97%. These figures indicate that, if the average farmer in the sample were to reach the EE level of its most efficient, then the average farmer could experience a cost savings of 30% (i.e., 1-[68/97]). The average economic efficiency was 0.85. This implies that there exists a potential for increasing the gross income of the farmers by more 15%, simply by adopting a technology of the ‘best-practice farmers’ and through optimal resource allocation.

Conclusion: This study has presented measures of Technical, Allocative and Economic efficiency for a sample of 47 farmers in Khorasan. Maximum likelihood techniques were used to estimate transcendental production frontier.

The analysis reveals average levels of Technical, Allocative and Economic efficiency equal to 92%, 92% and 85%, respectively. These efficiencies indicated that there exists a 15% potential for increasing the gross income of the farmer at existing levels of farmer technology, but there was not a major gap between ‘average’ and ’best-practice’. These results suggest that substantial gains in output and/or decreases in cost cannot be attained, given existing technology. Hence, research efforts directed toward the generation of new technology should receive attention. If egg producers and government want an increase in egg production, they should change current technology and improve it with things such as better feed and better poultry species. Additionally, egg producers believe

Technological development (using better feed and better poultry species), institution adjustment and a reformation input-market that can ensure supply of cheap inputs profits them.

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