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Technical and Economic Efficiency for Broiler Farms in Egypt. Application of Data Envelopment Analysis (DEA)

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Abstract: This study was aimed to economic evaluate of broiler farms in Egypt by using data Envelopment analysis (DEA). A total number of 50 farm records were collected from different broiler farms within different provinces (Sharkia, Dakhlia and Gharbia). The data collected from a cross-section survey of broiler farmers from a random sample using a face-to-face questionnaire. Farms having up to 5000 birds were classified as small, those with 5000-10000birds as medium and those over 10000 birds as large. Different efficiencies were analyzed by using data Envelopment analysis (DEA) and also different economic parameters were analyzed by SPSS. Results showed that, for the small farms, the mean economic efficiency estimated from DEA frontier was 62% for VRS (Variable Return to Scale). That indicates for the given the level of inputs used, the farms could produced 38 % more of output production or could have used 38% less input costs to obtain the same level of output. For medium farms the mean economic efficiency estimated from DEA frontier was 41% for VRS. Which indicates that for the given the level of inputs used, the farms could produced 59 % more of output production or could have used 59% less input costs to obtain the same level of output. For large farms, the mean economic efficiency estimated from DEA frontier are 84% for VRS. Which indicates that for the given the level of inputs used, the farms could produced 16% more of output production or could have used 16% less input costs to obtain the same level of output. The net profits are significant ($P< 0.05$) between different densities. They were 1.91, 1.50 and 3.04 LE/bird for small, medium and large farms respectively. The results indicated that the large farms are more economic efficient and small are economic efficient than medium farms. Finally, we concluded that the large scale farms are more efficient than small and medium farms due to the least total costs and best management methods and recommended the small and medium farms to follow up feeding programs and veterinary services that applied in these farms that in turn decrease the total costs and increase profits.

Key words: Broiler Farms · Economic Evaluations · Data Envelopment Analysis · Egypt

INTRODUCTION

Animals provide, globally, over 33% of protein consumed and about 16% of total food energy. Meanwhile in Egypt provide 15g protein/capita/day (50 % only of the global) [1]. Egypt production's of poultry meat in 2008 and 2009 accounts for 726 and 769 (1000 Metric ton) and important accounts for 21 and 27 (1000 Metric ton) [2]. So their shortage in the production of poultry farms in Egypt.

Measurement of the efficiency of agricultural production is an important issue in developing countries. If the farmers are inefficient in their practices, then it follows that output could be increased with less cost through extension and education. A measure of producer performance is often useful for policy purposes and the concept of economic efficiency provides a theoretical basis for such a measure [3].

Numerous researches have focused on measuring the relative level of technical and scale efficiency, by using the conventional DEA (Data Envelopment Analysis) approach. Researches have been conducted by examining the performance of poultry sector in different countries [4].

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DEA is a widely non-parametric and powerful data analytic tool, which is commonly applied in the research and practitioner communities to determine the relative efficiencies of the decision-making units (DMU). Any entity that receives a set of inputs and produces a set of outputs could be designated as a DMU, thus, any group of such entities could be subjected to DEA. Consequently, this method has been applied to evaluate productivity and performance of DMU. One of the fundamental assumptions of DEA is that all DMUs in the sample are functionally similar in the sense that all DMUs receive the same number and the same type of inputs and outputs [5-7].

The objectives of this research are to evaluate whether the existing production systems in poultry sector in different Provinces are profitable and economically efficient. Therefore, the study aims at to measure efficiency in production systems in poultry sector in some Egypt Provinces finding out better use of existing human and capital resources in the poultry production process and to locate reasons underlying inefficiency and suggest policy measures to enhance efficiency in poultry meat production.

MATERIALS AND METHODS

Data Collection: This work was carried out during the period from September 2012 till December 2012. The study was carried out in different Provinces (Sharkia, Dakhlia and Gharbia); the data were collected from a cross-section survey of broiler farmers from a random sample of 50 broilers farms using a face-to-face questionnaire.

Model Specification: DEA (Data Envelopment Analysis) is a linear programming method for efficiency measurement of efficiency of decision making units (DMUs) that in our research are poultry farms [8].

In this model we have chosen input-orientated method to use resources more efficiently by reducing inputs [9].

Technical Efficiency: Two types of Input orientated are used for calculating technical efficiency.

- Input orientated Constant Return to Scale (CRS). That requires every increase in all inputs well result in a proportional increase in out put [10].

Assume that there are k poultry farms (DMU) each producing m outputs by using n inputs, the mathematical programing model is

*Min*imize $\square_i^{CRS}$
Subject to $-y_i + Y = 0$ (1)
$\square\ x_i - X = 0$ (2)
$\square = 0$ (3)

where $\square_i^{CRS}$: Scalar of efficiency rate for farm i under CRS and it's value with boundaries of one and zero, if the value is one the farm is on the frontier and is technically efficient and if less than one it is technically inefficient.

yi: is the vector of outputs (m x1) produced by the i farm.
xi: is the vector of inputs (n x1) used by the i farm.
Y: is the matrix of outputs of all farms (m x k).
X: is the matrix of inputs of all farms (n x k).
□: is a vector of weights or constant (k x 1) attach to each of efficient
farm.

- Input Orientated Variable Return to Scale (VRS). That assume the convexity constraints so it is more flexible and envelops the data in higher tighter way than CRS [11]. The mathematical model as above and replacing equation (3) by $k1'\square = 1$ (4)

Where k1 is a new matrix with dimension kx1.and replace $\square_i^{CRS}$ with $\square_i^{VRS}$

Scale Efficiency: If there is a difference in the CRS and VRS technical efficiency scores for a particular farm, then this indicates that the farm has scale inefficiency, which equals the difference between the VRS and the CRS technical efficiency score. Thus, the input-oriented scale efficiency is defined as [12]:

Table 1: Number of Farms from Different Provinces.

Provinces	Sharkia	Dakhlia	Gharbia
Small farms(5000birds)	4	3	4
Medium farms (5000-1000 birds)	12	8	9
Large farms(10000 birds)	4	3	3
Total	20	14	16

Source: Data collected.

$$Se = TE\ CRS / TE\ VRS \quad (5)$$

Allocative Efficiency: Allocative efficiency is calculated by a cost minimizing vector of input quantities given the input prices is determined using:

$$Minimize \square\ w'x^{*} \quad (6)$$

Where *wi* is a vector of input prices for the *i*-th farm and *xi** (which is calculated by using linear programming) is the cost-minimizing vector of input quantities for the *i*-th farm, given the input prices *wi* and the output levels *yi*. [13,14].

Economic Efficiency: Based on the technical and allocative efficiency the economic efficiency can be determined as EE = AE (Allocative efficiency) * TE (Technical efficiency). (7)

Economic Measures

Costs of Broiler Production (LE/bird):

- Variable costs include: feed costs, labour costs, total veterinary management costs (service, treatment, disinfectant and veterinary supervision cost), uncertainly costs that calculated as the value for the cash price and includes the value of bird died and other variable costs as costs of chicks and other costs related to production [15,16].
- Fixed costs include: building and equipment depreciations [17, 18].

The depreciation rate calculated on the basis of 25 years for buildings and on 5 years for equipment [19, 20].

- Constituents of total costs: That inculdes the sum of the variable and fixed costs [21].

- Income parameters of broiler production (LE/ bird)

Variable factors of return [22,23].

- Total returns = Litter sale + broiler sale.
- Litter sale = Litter sale price / No. of broiler
- Broiler sale = Body weight at end of fattening x kg price.

Net income = Total return – Total costs [23].

Statistical Analysis:

- All the data were analyzed using SPSS/PCT, 2001 [24]. The statistical method was ANOVA test, to test the differences in productive and economic efficiency parameters of broiler farms. The Duncan multiple range test are also used.[25].
- Regression analysis has been used to estimate the factors associated with economic efficiency estimated from DEA.

$$E.E. = B_o + B_1 + B_2 + B_3 + B_4 + B_5 + E.$$

E.E. = Economic Efficiency estimated from DEA.
B_o = Constant of regression analysis.
B_1 = Size of the farm (total number of broiler).
B_2 = Feed cost (LE/ chick).
B_3 = Veterinary cost (LE/ chick).
B_4 = other variable cost (LE/ chick).
B_5 =fixed cost (LE/ chick).
E = Error term

RESULTS AND DISCUSSION

- Technical, Scale, Allocative and Economic efficiency for Small Farms.

Table (2) illustrated that mean TE measure for the small broiler farms under CRS and VRS DEA approaches were 70.0% and 79.0%. This result implies that the output of the farms potentially could be increased by 30% if the operation was technically efficient if CRS is assumed or by 21% if VRS is assumed. The scale efficiency measure may be used to determine the nature of returns to scale for any decision-making units. The scale efficiency for small farms was 88% which means that these farms could have further increase their output by about 12% if they have adopted an optimal scale.

The mean allocative (*AE*) estimated from DEA frontier are 86.0% for CRS and 78% for VRS. Which indicates that for the given the level of inputs used, the farms could produced 14 % more of output or could have used 14% less input to obtain the same level of output if CRS is assumed. If VRS is assumed, they could increase their production with the same level of inputs by 22% or decrease the use of inputs by 22% and produce the same level of output if VRS is assumed. The mean Economic efficiency estimated from DEA frontier are 62% for VRS.

Table 2: Technical, Scale, Allocative and Economic Eficiencies for Different Densities

		Technical Efficiency			Allocative Efficiency		Economic Efficiency	
Density	Number	CRS	VRS	Scale Efficiency	CRS	VRS	CRS	VRS
Small farms(5000 birds)	11	0.70	0.79	0.88	0.86	0.78	0.60	0.62
Medium farms (5000-10000 birds)	29	0.57	0.61	0.93	0.71	0.73	0.30	0.44
Large farms(10000 birds)	10	0.77	0.86	0.90	0.89	0.98	0.68	0.84

Table 3: Factors explaining of Economic Efficiency obtained from DEA

Regression model	Parameter	Coefficients	Standard error	T- value
Constant	B_0	3.190**	1.622	1.967**
Farm size	B_1	0.003*	0.011	1.502*
Feed cost	B_2	- 0.08	0.098	-0.843
Veterinary cost	B_3	- 0.129	0.161	-0.803
O. Variable cost	B_4	- 0.142	0.093	-1.523
Fixed cost	B_5	- 0.337**	0.201	-1.680
R^2	0.122			
Adjusted R^2	0.023			
Standard error of estimate	0.448			

Source: data analysis.

Note: * significant at 5 % level, ** significant at 10 % level

Table 4: Total costs, total returns and net profit (LE/ bird) for different densities

Density	Number	Total Variable costs (LE/bird)	Total Fixed costs (LE/ bird)	Total costs (LE/ bird)	Total returns (LE/ bird)	Net profit (LE/bird)
Small farms (5000 birds)	11	18.70± 0.33[a]	1.50± 0.14[a]	20.20± 0.29[b]	22.11± 0. 63[a]	1.91± 0.16[b]
Medium farms(5000-10000 birds)	29	19.40± 0.16[a]	1.36± 0.06[a]	20.77± 0.16[b]	22.27± 0.98[a]	1.50± 0.26[b]
Large farms (10000 birds)	10	18.87± 0.31[a]	1.17± 0.06[a]	19.65± 0.30[a]	22.53±0. 29[a]	3.04± 0.36[a]

Means within the same column in each category carrying different litters are significant at ($P \leq 0.05$).

Source: Data collected and analysed.

Which indicates that for the given the level of inputs used, the farms could produced 38 % more of output production or could have used 38% less input costs to obtain the same level of output.

Technical, Scale, Allocative and Economic Efficiency for Medium Farms: Technical Efficiency for the medium broiler farms under CRS and VRS DEA approaches were 57.0% and 61.0%. This result stated that the output of the farms potentially could be increased by 43% if the operation was technically efficient if CRS is assumed or by 39% if VRS is assumed. The scale efficiency for medium farms was 93% which means that these farms could have further increase their output by about 7% if they have adopted an optimal scale.

Allocative Efficiency was 71.0% for CRS and 73% for VRS. Which indicates that for the given the level of inputs used, the farms could produced 29% more of output or could have used 29% less input to obtain the same level of output if CRS is assumed. If VRS is assumed, they could increase their production with the same level of inputs by 27% or decrease the use of inputs by 27% and produce the same level of output if VRS is assumed. The mean Economic efficiency estimated from DEA frontier are 41% for VRS. Which indicates that for the given the level of inputs used, the farms could produced 59 % more of output production or could have used 59% less input costs to obtain the same level of output.

Technical, Scale, Allocative and Economic Efficiency for Large Farms: Table (2) showed that mean TE measure for the large broiler farms under CRS and VRS DEA approaches were 77.0% and 86.0%. This result implies that the output of the farms could be increased by 23% when farms are technically efficient if CRS is assumed or by 14% if VRS is assumed. The scale efficiency for large farms was

90% which means that these farms could have further increase their output by about 10% if they have adopted an optimal scale.

The mean allocative (*AE*) estimated from DEA frontier are 89.0% for CRS and 98% for VRS. Which indicates that for the given the level of inputs used, the farms could produced 11 % more of output or could have used 11% less input to obtain the same level of output if CRS is assumed. If VRS is assumed, they could increase their production with the same level of inputs by 2% or decrease the use of inputs by 2% and produce the same level of output if VRS is assumed. The mean Economic efficiency estimated from DEA frontier are 84% for VRS. Which indicates that for the given the level of inputs used, the farms could produced 16% more of output production or could have used 16% less input costs to obtain the same level of output. The results indicated that the large farms are more economic efficient and small are economic efficient than medium farms.

Factors explaining of Economic Efficiency obtained from DEA: Table (3) illustrated that the most factors affecting economic efficiency of poultry farms are farm size (positive correlation with economic efficiency) and total costs and (negative correlation with economic efficiency of poultry farms).

Total Costs, Returns and Net Profit (LE/ bird) for Different Densities: Table (4): The total costs are significant difference ($P< 0.05$) between different densities, where at the small farms it was 20.20 LE/bird and for medium and large farms were 20.77 and 19.65 LE/bird respectively. Also, it showed non significant difference at ($P > 0.05$) between different densities for the total return where at the small farms it was 22.11 LE/bird and for medium and large farms were 22.27 and 22.53 LE/bird respectively. The net profit are significant ($P< 0.05$) between different densities. They were 1.91, 1.50 and 3.04 LE/bird for small, medium and large farms respectively.

The reults showed the significance difference of large farms and could be due to the least total cost for the large sacle and good management of these farms and the next in signifcance is, the small farms and this could be due to the good management of these farms.

CONCLUSION

We concluded that the large scale farms are more efficient than small and medium farms due to the least total costs and best management methods and recommended the small and medium farms to follow up feeding programs and veterinary services that applied in these farms that in turn decrease the total costs.

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