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ECONOMIC EFFICIENCY OF BROILER FARMS IN VOJVODINA REGION[1]

Nataša Vukelić[2], Nebojša Novković[3]

Summary

Measurement of the efficiency of agricultural production is very important issue especially in developing countries. The major problem of the broiler production in Vojvodina region is low level of productivity and inefficiency in resource allocation and utilization.

The objective of this study was to measure the economic efficiency of broiler farms using a nonparametric approach, Data Envelopment Analysis (DEA) which is used to quantify economic efficiencies of broiler farms in Vojvodina region by determining which farms are located on the production frontier and which are not. Data Envelopment Analysis method, one of new methods of operations research, is used very successfully in the last several years for assessing relative efficiency of organizational units having multiple inputs to produce multiple outputs. It was originated by Charnes, Cooper and Rhodes in 1978. It is an efficiency estimation technique but it can be used for solving many problems of management such as ranking Decision Making Units (DMU). DEA develops a function whose form is determined by most efficient producers and indentifies a "frontier" on which the relative performance of all utilities in the sample can be compared: DEA benchmarks firms only against the best producers.

Furthermore, in order to fulfill the objective of the study, the authors were analyzing the performance of the broiler farms in Vojvodina region, their economic efficiencies. Data were collected from 30 broiler farms from which the input-output data were collected by using a structured questionnaire. The multiple-input, single-output production units (the broiler farms) were evaluated with the individual farms being referred to as individual Decision Making Unit (DMU). For the purpose of efficiency analysis, output (y) were aggregated into one category namely, gross margin of the broiler farms, and inputs were aggregated into five categories, namely, feed, day-old chickens, productivity, used energy and capital.

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Analyzed broiler farms were classified into three categories according to their production capacities. The first category included farms with production capacity between 5000 birds and 10000 birds per production cycle. The second category included farms with capacity of more than 10000 and less that 30000 birds per production cycle and the third category included farms with capacity of more than 30000 birds per production cycle.

Key words: *Broiler production, economic efficiency, DEA method, Vojvodina*

JEL classification: *C67, Q12*

1. Introduction

Poultry meat production worldwide indicates a steady growth, whereas the situation in Serbia as well as Vojvodina region differs markedly. Since the 1990s, there has been a decline in chicken population, poultry meat production and its consumption (Vukelic et al. 2010). Major reasons for mentioned situation above are low productivity level and inefficiency in resource allocation and utilization, non-existence of vertical integration of poultry producers, a large share of grey economy, lack of institutional support, and obsolete facilities. Moreover, the production takes place in a large number of small- scale farms which are badly organised, non competitive and also lack of concentration and specialisation. Finally, the low living standards and purchasing power have contributed to this situation as well (Rodic et al, 2009, Rodic et al., 2010).

Measurement of the efficiency of agricultural production is very important issue especially in developing countries. The measurement of the efficiency has become very popular for researchers since Farrell published a scientific paper in 1957 in which he developed the concept of technical efficiency based on the relationships between inputs and outputs (Farrell, 1957). Since then, many researchers have been analyzing economic efficiency of agricultural production (Bravo-Ureta and Evenson 1994, Sharma et al. 1999, Wilson et al. 2001, Alvarez and Arias, 2004, Hansson 2007, Manevska-Tasevska, 2012, Galanopoulos et al. 2006, Coelli et al. 2002). Some of them have been analyzing efficiency (technical, allocative and economic efficiency) in poultry production (Heidari M.D. et al 2011 (a), Mahjoor, 2013, Todsadee et al. 2012, Begum et al. 2010, Beshir Hussien, 2011).

The objective of this study was to measure the economic efficiency of broiler farms using a nonparametric approach, data envelopment analysis (DEA) which is used to quantify economic efficiencies of broiler farms in Vojvodina region by determining which farms are located on the production frontier and which are not.

2. Material and Method

The theory and concept of measurement of efficiency has been linked to the use of production functions. Different techniques have been employed to either calculate or estimate the efficient frontiers (Beshir Hussien, 2011). These techniques are classified as parametric and non-parametric methods. The two most popular techniques used to measure farm level efficiency are the stochastic frontier approach, SFA, introduced by Aigner et al. 1977 and the data envelopment analysis, DEA, which was initiated by Farell in 1957 and reformulated as a mathematical programming problem by Charnes et al. 1978. The DEA uses mathematical linear programming methods, whereas the SFA uses econometric methods. Both methods are empirical approaches, both base their efficiency assessments on the best practice in the sample at hand so that the best farms define the efficient frontier and indentified as "best practice units" are given a rating of one or 100%. The remaining farms get efficiency scores according to their relative position to the efficient frontier and it implies how the least efficient farms can become as efficient as the best practice farms (Hansson, 2007). In general, a large number of studies on efficiency measurements argue that a researcher can safely choose any of the methods since there are no significant differences between the estimated results (Coelli et al. 2002).

Data Envelopment Analysis method, one of new methods of operations research, is used very successfully in the last several years for assessing relative efficiency of organizational units having multiple inputs to produce multiple outputs. It is an efficiency estimation technique but it can be used for solving many problems of management such as ranking Decision Making Units (DMU). Each DMU used varying quantities of inputs to produce different levels of outputs.

A few of the characteristics of DEA that make it powerful are: DEA can handle multiple input and multiple output models; It doesn't require an assumption of a functional form relating inputs to outputs; DMUs are directly compared against a peer or combination of peers; Inputs and outputs can have very different units (Heidari et al. 2011 (b)).

One of the options in DEA is a choice between constant return to scale (CRS) and variable returns to scale (VRS). CRS assumes that all DMUs are operating at the optimal scale. Thus, it is assumed that large poultry farms are just as efficient as small ones in converting inputs to outputs. The main problem of the CRS assumption is that in reality it is rear that all farms run their production activities optimally especially in the developing countries due to their heterogeneous farms conditions (Begum et al. 2010). Therefore, VRS overcomes this problem and the specifications of VRS ca permit the calculation of efficiency scores devoid of scale efficiency effects. Another option is to make the choice between output-oriented and input-oriented DEA model. In output-oriented model the objective is to continue using the same amount of inputs while producing more outputs where as in input-oriented model the objective to produce the same amount of outputs by using fewer inputs. Begum et al. 2010 explains that it is better and more logical for less developed countries, such as Serbia (Vojvodina), to use input-oriented DEA so that scarce resources can be saved and these resources can be used more efficiently to produce the same output. Furthermore, Galanopoulos et al. 2006, interpreted that input-oriented model is more appropriate in the agricultural sector as a farmer has more control over inputs rather than output levels. According to mention above, in order to compute the efficiency of broiler farmers in Vojvodina region, input-oriented model DEA was used in this study using both CRS and VRS specification. The economics of poultry meat production depends on numerous factors, but the most important is general economic policy. Other factors, include the choice of the production technology, labor organization and productivity, and the extent of the exploitation of the productive factors (Heidari et al. 2011). Variable costs (direct costs) in broiler farms include one-day-old chickens, feed costs, costs of used energy (water, electricity, gas, fuel), labor costs, health care costs (medication, disinfection and vaccinations), etc. A number of multiple-input, single-output production units (broiler farms) were evaluated with the individual farms being referred to as individual Decision Making Unit (DMU). Each DMU used varying quantity of inputs to produce different levels of output. DEA method compares each producer with only the “best” producer. For the purpose of efficiency analysis, output (y) were aggregated into one category namely, gross margin of the broiler farms (rsd per 1 kg of produced poultry meat), and inputs were aggregated into five categories, namely, feed (rsd per 1kg of produced poultry meat), one day-old chicks (rsd), labor (wages in rsd), used energy (rsd per 1 kg of produced poultry meat) and capital (rsd per 1000 $bird^{-1}$). These variables were used as main variable costs because they cover 75 to 80% of the total cost (Begum et al, 2010).

In the DEA methodology, formerly developed by Charnes, Cooper and Rhodes (1978) (CCR), efficiency is defined as a weighted sum of outputs to a weighted sum of inputs, where the weights structure is calculated by means of mathematical programming and constant returns to scale returns to scale (CRS) are assumed. Input oriented model (CRS):

$$Min \quad \theta + \varepsilon \left[\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+ \right] \tag{1}$$

$s\,t$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r^+ = y_{rp} \quad , r = 1, \ldots, s \tag{2}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + S_i^- = \theta x_{ip} \;, i = 1, \ldots, m \tag{3}$$

$$\lambda_j \geq 0 \qquad j = 1, \ldots, n \tag{4}$$

$$S_r^+ \,,\, S_i^- \geq 0 \qquad r = 1, \ldots, s \;, i = 1, \ldots, m \tag{5}$$

Banker, Charnes and Cooper developed a model (BCC) with variable returns to scale (VRS). Input oriented model (VRS):

$$Min \quad \theta + \varepsilon \left[\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+ \right] \tag{6}$$

$s\,t$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r^+ = y_{rp} \quad , r = 1, \ldots, s \tag{7}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + S_i^- = \theta x_{ip} \;, i = 1, \ldots, m \tag{8}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{9}$$

$$\lambda_j \geq 0 \qquad j = 1, \ldots, n \tag{10}$$

$$S_r^+ \,,\, S_i^- \geq 0 \qquad r = 1, \ldots, s \;, i = 1, \ldots, m \tag{11}$$

Data were collected from 30 broiler farms in Vojvodina region from which the input-output data were collected by using a structured questionnaire. The period of investigation covered one calendar year from Januar 2011 to Decembar 2011 but the data was collected during the perod of April 2012 to Jun 2012. The date was compiled in Exel and then analyzed using DEA program DEAOS[1]. Analyzed

[1] www.deaos.com

broiler farms were classified into three categories according to their production capacities. The first category included farms with production capacity between 5000 birds and 10000 birds per production cycle. The second category included farms with capacity of more than 10000 and less that 30000 birds per production cycle and the third category included farms with capacity of more than 30000 birds per production cycle.

3. Results and discussion

In order to improve broiler production in Vojvodina region, Data Envelope Analysis (DEA) was used to compute the efficiency of farms. In Table 1 descriptive statistics of the variables of DEA model are presented.

Table 1: Descriptive statistics of the variables in the DEA model

Variable	Minimum	Maximum	Mean	SD
Feed	71.9878	85.14	79.3658	3.4488
One-old-day chickens	192500	6000000	1138248.3333	1327828.9053
Labour	40000	840000	169498.6667	155472.598
Capital	2822.4	121350	24791.13	28826.301
Bruto margine	4.41	22.03	11.0813	4.6951

Source: The result of the study

The frequancy distribution of efficiency estimates form DEA models and their summery statistics are presented in Table 2. This Efficiency scores were clustered into 6 groups: 0-50, 51-60, 61-70, 71-80, 81-90 and 91-100 to explain their relative position from the highest efficincy frontier 100%. There is a noticable variability in the gain results (lowest efficiency score of 31.63% (CRS) and 85.85% (VRS) and highest score of 100%). Similar result were gain by Todsade et al. 2012 and Begum et al. 2010. Efficiency scores CRS and VRS models, peer group and frequency are displayed in Table 3.

The estimated mean values of efficiency were 73.55% for CRS DEA and 95.97% for VRS DEA (Table 2). Presented results of broiler farms in Vojvodina imply that the inputs of the farms could potentially be reduced by 26.45% if CRS is assumed or 4.03% if VRS is assumed. Moreover, results also show considerable inefficiencies of broiler farms in Vojvodina especially in CRS DEA model. There is a real need to enhance the efficiency of broiler production in Vojvodina by reducing the cost of production while attaining the same level of output. Based on the result presented in Table 3, 9 broiler farms (CRS model) and 12 broiler farms (VRS model) are fully efficient. In Table 4, Frequancy distribution of efficiency estimates from DEA models based on farm size are displayed. The distribution of efficiency scores show that larger farms have higher efficiency scores that smaller ones.

Table 2: Frequancy distribution of efficiency estimates from DEA models

Number of farms		
Efficiency index (%)	**CRS**	**VRS**
0-50	7	0
51-60	4	0
61-70	2	0
71-80	3	0
81-90	1	4
91-100	13	26
Mean	73.55%	95.97%
Min	31.63%	85.85%
Max	100%	100%

Source: The result of the study

Table 3: Efficiency scores CRS and VRS models, peer group and frequency

DMU	CRS			VRS		
	Efficiency %	**Peer Group**	**Frequency**	**Efficiency %**	**Peer Group**	**Frequency**
Farm 1	90.70	Farm 2, farm 7	0	93.36	Farm 2, farm 7	0
Farm 2	100.00	Farm 2	15	100.00	Farm 2	19
Farm 3	100.00	Farm 3	4	100.00	Farm 3	1
Farm 4	30.95	Farm 2, farm 6, farm15	0	94.87	Farm 2, farm 6, farm15	0
Farm 5	57.20	Farm 2, farm 24	0	94.33	Farm 2, farm 25	0
Farm 6	100.00	Farm 6	10	100.00	Farm 6	10
Farm 7	100.00	Farm 7	5	100.00	Farm 7	2
Farm 8	100.00	Farm 8	2	100.00	Farm 8	3
Farm 9	41.54	Farm 2, farm8	0	90.57	Farm 2, farm 6, farm 8	0
Farm 10	45.05	Farm 2, farm 6	0	98.03	Farm 2, farm 6	0
Farm 11	66.97	Farm 12, farm 24	0	100.00	Farm 11	4
Farm 12	100.00	Farm 12	7	100.00	Farm 12	2
Farm 13	31.63	Farm 2, farm 7	0	89.98	Farm 2	0
Farm 14	47.20	Farm 3, farm 7, farm 24	0	85.85	Farm 2	0
Farm 15	100.00	Farm 15	3	100.00	Farm 15	3

DMU	CRS			VRS		
	Efficiency %	Peer Group	Frequency	Efficiency %	Peer Group	Frequency
Farm 16	48.11	Farm 3, farm 12	0	91.24	Farm 2, farm11, farm25	0
Farm 17	65.52	Farm 12, farm 24	0	99.29	Farm 2, farm 11, farm 25	0
Farm 18	73.98	Farm 2, farm 6	0	88.88	Farm 2,farm 6	0
Farm 19	92.97	Farm 12, farm 24	0	93.48	Farm 2, farm 12, farm 24	0
Farm 20	33.82	Farm 2, farm 7	0	84.59	Farm 2	0
Farm 21	77.22	Farm 2, farm 6	0	94.67	Farm 2, farm 6	0
Farm 22	91.81	Farm 12, farm 24	0	98.83	Farm 2, farm 11, farm 25	0
Farm 23	79.15	Farm 2, farm 6	0	96.18	Farm 2, farm 6	0
Farm 24	100.00	Farm 24	8	100.00	Farm 24	2
Farm 25	80.91	Farm 3, farm 12, farm 24	0	100.00	Farm 25	5
Farm 26	50.90	Farm 2, farm 6	0	92.51	Farm 2, farm 6	0
Farm 27	95.29	Farm 2, farm 6	0	100.00	Farm 27	1
Farm 28	50.19	Farm 2, farm 6, farm 15	0	96.57	Farm 2, farm 6, farm 15	0
Farm 29	55.30	Farm 2, farm 6	0	95.76	Farm 2, farm 6, farm 8	0
Farm 30	100.00	Farm 30	1	100.00	Farm 30	1

Source: The result of the study

In DEA studies, the peer group is a group of best practice DMUs with which a relatively inefficient DMU is compared.

Table 4: Frequancy distribution of efficiency estimates from DEA models based on farm size

Efficiency	CRS			VRS		
	Capacity (no. of birds)			Capacity (no. of birds)		
	5000 - 10000	10001 - 30000	Over 30000	5000 - 10000	10001 - 30000	Over 30000
No. of farms	10	14	6	10	14	6
Mean	69.29%	72.68%	82.66%	96.53%	94.46%	98.54%
Min	41.54%	31.63%	48,11%	90.57%	84.59%	91.24%
Max	100%	100%	100%	100%	100%	100%

Source: The result of the study

4. Conclusion

Poultry meat production worldwide indicates a steady growth, whereas the situation in Serbia as well as Vojvodina region differs markedly. Since the 1990s, there has been a decline in chicken population and poultry meat production. Major reasons are low productivity level and inefficiency in resource allocation and utilization, non-existence of vertical integration of poultry producers, a large share of grey economy, lack of institutional support, and obsolete facilities. Moreover, the production takes place in a large number of small-scale farms which are badly organised, non competitive and also lack of concentration and specialisation. Finally, the low living standards and purchasing power have contributed to this situation as well. A general objective of the study was to calculate the efficiency of broiler farms in Vojvodina region by using DEA approach. The result have shown that under costant return to scale, CSR and variable returns to scale (VRS) specification, efficiency are on average 73.55% and 95.97% respectively. Presented results of broiler farms in Vojvodina imply that the inputs of the farms could potentially be reduced by 26.45% if CRS is assumed or 4.03% if VRS is assumed. Among 30 broiler farms that are included in this research, 9 broiler farms (CRS model) and 12 broiler farms (VRS model) are fully efficient. There is a real need to enhance the efficiency of broiler production in Vojvodina by reducing the cost of production while attaining the same level of output. The distribution of efficiency scores show that larger farms have higher efficiency scores that smaller ones.

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