Estimation of technical and scale efficiency and factors affecting technical efficiency of broiler farms in the northern region of IRAQ

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Abstract

The sensitivity of the production period and the working conditions of the broiler farms are the biggest obstacles in front of the farms to produce more optimal supply by working effectively and with high performance. The aim of the researcher is to determine the efficiency levels of farms producing broiler chickens under both technical efficiency and scale efficiency and to reveal the factors affecting efficiency level. To satisfy this objective, this study was conducted in the provinces of Duhok, Erbil and Sulaymaniyah in the northern region of Iraq, where broiler chicken production is intensive. The data for all farms in the region were tested using data envelopment analysis (technical efficiency, scale efficiency) and the Tobit regression model. As a result of the analysis, the efficiency scores of the farms in the region were found to be 0.615 and 0.700 under constant returns to scale (CRS) and variable returns to scale, respectively. In terms of scale efficiency, farms have 5.7% CRS, 9.7% decreasing returns to scale (DRS) and 84.6% increasing returns to scale (IRS) scores. It has been determined that farms that are technically inefficiency have less income than farms that operate effectively. In terms of the factors affecting the efficiency of the farms, it was determined that the weight of the chicks that came to slaughter positively affected the efficiency, while the increase in the age of the broilers and the death rate decreased the effective working scores of the farms. In order for farms to have optimum effective working conditions, it has been recommended that producers reduce unnecessary input uses, increase the input-output composition of farms with increasing returns on scale, and use methods and feeding programs to increase the weight of chicks coming to the slaughter period.

Keywords: Broiler farms. Technical efficiency. Scale efficiency. Tobit. Iraq.

1. Introduction

In the 21st century, where nutrition is the most important issue, with the increase in world population, the importance of concepts such as supply, production costs, technology, efficiency, and time in food products has increased. In this context, the production and supply of the main nutrients in human nutrition in a short time have become indispensable for both economic and nutritional adequacy. It has become one of the leading sectors in human nutrition worldwide because it is grown in a shorter time than broiler chicken breeding substitutes, has a lower price rate, and has less interaction with factors that directly affect production such as climate.

White meat production is one of the livestock activities that play an important role in meeting the nutritional needs of people. The majority of white meat production consists of broiler chickens produced on broiler farms. From past to present, its consumption is increasing day by day. White meat consumption has increased in recent years by meeting the demand for an increasing population in a short time. Especially in the first quarter of the 21st century, the occurrence of Covid-19 health problems in the world and bilateral disputes between countries have negatively affected the economies of countries and reduced the purchasing power of individuals. Iraq has considerable production potential and number of farms in broiler chicken production, led by the USA and Asian countries (Ullah et al., 2019). Based on Northern Iraq, there are more than 850 broiler chicken farms that continue their production as of 2015 (Azzez and Akbay, 2021). Although Iraq has a high number of broiler chicken farms, it is still an importer (Ullah et al, 2019). The main reasons for this are the inefficient operation of broiler farms and the optimal scale of the farms. However, the Iraqi region is highly suitable for broiler production, both in terms of its suitability for production and providing the necessary labor force. If broiler farms in Iraq are small-scale and unevenly distributed in the provinces, they will provide employment opportunities for thousands of people (Natali, 2010). Although broiler production has become widespread in Erbil, it does not meet domestic demand (Andeky, 2010; Akbay and Azzez, 2016). Because of this inadequacy in the northern region of Iraq, the Iraqi state government focused on increasing broiler production (Natali, 2010). On this basis, the governor of Erbil considers broiler production as an export investment as well as its competence in the country (Looney, 2008). Rather than increasing the number of broiler farms in Iraq, examining the work of existing farms and providing more effective working conditions will directly affect production in a positive manner. In this respect, it is known that by calculating the efficiency of farms in different parts of the world, optimum input-output usage suggestions have been brought to many farms.

The aim of the researcher is to determine the efficiency levels of the farms producing broiler chickens in the region under both technical efficiency and scale efficiency and to reveal the factors affecting the efficiency in the northern region of Iraq.

2. Literature Review

There are many efficiency studies in the literature regarding the technical working conditions of farms in the production of broiler chickens. Heady et al. (1956) calculated the output elasticity in order to reduce feed costs in farms at Lowa University and compared the two feed groups for farms and reached elasticity coefficients of 0.55 and 0.33, respectively. Ullah et al. (2019) surveyed 120 broiler chicken producing farms in the Khyber Paktunhwa province of Pakistan and determined the technical efficiency of the farms using stochastic limit analysis. They found that the average efficiency of these farms was 0.85. The results of this study suggest that producers should increase their production inputs to obtain more output. Alrwis and Francis (2003) calculated the technical efficiency of broiler farms in central Saudi Arabia. In this study, large and small farms were compared according to their efficiency scores using the stochastic limit analysis method. The average efficiency scores were found to be 0.82 for large farms and 0.83 for small farms. As a result of the study, the input usage levels of the farms that work effectively are shown as references for farms that do not work effectively. Ali et al. (2014) found the average technical efficiency of farms as 0.88 using the stochastic limit analysis technique in the Punjab province of Pakistan. Researchers have determined the necessity of saving the amount of inputs at varying rates to ensure technical efficiency in farms and emphasized that the age, education and membership status of individuals have a direct effect on technical efficiency. Sariozkan and Sakarya (2006) conducted a survey with 40 chicken farm managers to increase the technical efficiency and profitability of egg poultry farms in Afyon province of Turkey and to ensure optimal input amount distribution, and they found their average productivity as 97.4 for small scale farms, 98.7 for medium-sized farms and 98.3 for large-scale farms. As a result of the study, farms in this region were advised not to increase their farm scale. In another study conducted by Ezeh et al. (2015) in Nigeria, it was aimed to measure the productivity levels and determinants of 60 farms growing broiler chickens with the Stochastic limit analysis method. As a result of the study, they stated that the average technical activity scores of the farms were 0.75 and that the socio-economic determinants of their technical efficiency depended on household size, age and education levels. In Iraq, Hassan (2021) investigated the technical, economic and scale efficiency on broiler farms, and data envelopment method was used in the study. In the research conducted on 150 broiler farms, the technical efficiency scores of the farms were found to be 0.91 and 0.98 under CRS and variable return to scale (VRS), respectively. In addition, using the Tobit regression model, it was determined that age, education, experience and access to broadcasting services of the producers had an effect on the efficiency of the farms. In another study conducted by Mahjoor (2013) in Iran, the technical cost and economic efficiency of broiler farms were calculated. Data envelopment analysis was performed in this study. The average technical, cost and economic efficiency scores of farms were 82%, 70% and 57% under CRS, and 87%, 73% and 64% under variable return to scale (VRS), respectively. In the study conducted by Todsadee et al. (2012) on farms producing broiler chickens in Thailand, the technical efficiency of farms was investigated by using data envelopment analysis.

When the studies conducted in the literature are examined, it is determined that the studies conducted for the Northern Iraq region are quite insufficient, and in the existing studies, the activity scores of the farms are low and the situations affecting the effectiveness are important. In this respect, this study will reveal the current situation of the farms in the region and the reasons affecting the inefficiency of the farms. This study contributes to the completion of the literature gap in the region where broiler chicken production is intense.

3. Material and Methods

The main material of this study consists of input and output data from 801 broiler producing farms that continue to operate actively in Duhok, Erbil and Sulaymaniyah provinces of Iraq. The data of the study were analyzed in Deap 2.1 program using data envelopment analysis method (DEA).

In this study, the technical and scale efficiency scores of the farms were calculated. Annual income is valued as the output of the farm in the DEA. The total feed cost, chick cost, fuel cost, electricity cost, veterinary fee, labor cost, water used, repair and maintenance costs, and other expenses used in the farm in a year were accepted as inputs and arranged as one output and ten inputs. All the inputs were taken from the cost type of units because there are many farms in the analysis, and these farms show differences in the use of inputs. Afterwards, the input-output amounts were converted into Iraqi dinar-US dollars in terms of cost and used as the unit price. Technical efficiency (pure efficiency) was obtained using the Banker, Charnes, Cooper (BBC) method. Technical efficiency is examined under CRS and VRS, while scale efficiency is examined separately under IRS, CRS, and DRS. Scale efficiency is analyzed with the Charnes-Cooper-Rhodes (CCR) method and the BBC method always lowers or equals to the results of the CCR method (Bal, 2013). This is because the CCR model is globally inefficient and the BBC model is locally inefficient. Globally, while DMU's operation is due to its disadvantage under other conditions, while locally it results from the inefficient functioning of the DMU itself (Kutlar and Babacan, 2008). Technical efficiency can be defined as maximizing output by using certain inputs under certain conditions, or using minimum input while obtaining the same output amount (Kutlar et al., 2004). Here, the aim of the test was to provide the efficiency score by minimizing the same outputs and the amount of inputs, and to determine the input and output of the farms that are efficient and inefficient. The technical efficiency model in which the inputs are minimized is as follows:

$Min_{\theta,\lambda}\theta$ subject to $Y\lambda - y_i \geq 0$ and $\theta x_i - x\lambda \geq 0$

$\lambda \geq 0$

θ is scale and

λ is the Nx1 vector of the formula.

The process generates efficiency scores over the inputs and outputs of each farm for constant returns to scale (CRS) (Fraser and Cordina, 1999).

$n_{\theta,\lambda}\theta$ subject to $Y\lambda - y_i \geq 0$

and $\theta x_i - x\lambda \geq 0$ $N'\lambda \geq 0$

$\lambda \geq 0$

N is an Nx1 Vector of variable return to scale (VRS).

In the functional model, it produces a variable return to scale score for each farm (Huang and Wang, 2002).

Thus, a separate farm efficiency score (TE) is generated for each farm from the function. Scores are determined as farm efficient when TE = 1, and inefficient if TE < 1. Scale efficiency is obtained from the TE_{CRS}/TE_{VRS} process (Farhan et al., 2015). Here, however, the efficiency of scale does not indicate whether these scores are DRS, CRS, or IRS for each farm for farm productivity.

In order to achieve these results, it is necessary to add a constraint to the function. This constraint is non-increasing returns to scale (NIRS):

$N'\lambda = 1$

$N'\lambda \leq 1$

When the TE NIRS = TE VRS status is provided as a result of the transaction, the farm is in the state of decreasing return to scale. When TENIRS ≠ TEVRS occurs, it means that the farm has a situation of increasing returns to scale (Eze et al., 2013). Here, if ME = 1 (the sum of λj weights calculated for DMU), scale efficiency is constant, if ME > 1, increasing return to scale, ME < 1, decreasing return to scale (Özden, 2008).

Factors affecting the technical efficiency of producers in broiler production were determined using Tobit regression. In determining the factors affecting the efficiency in the Tobit regression model, the experience of the operator, the capacity of the farm, region, broiler age, average chick weight, chick mortality rate, nutrition, water source, use of automatic systems and ownership status were evaluated. The Tobit regression model is arranged as follows;

$$Y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \varepsilon_i \sim IN(0, \sigma 2)$$

where *Yi* is the efficiency level of broiler farms; X_i are farmer experience, farm capacity, city where the farm is located, age of broilers for sale, weight of broilers on sale, chick mortality rates, feed conversion rates, water resources, drinkers, automatic processes, farm property; β0 is constant coefficient, β_1 - β_{11} are regression coefficients associated with independent variables, and ε_i is error term with normally distributed with 0 mean and a variance of σ2.

Estimation of the dependent variable in data envelopment analysis is explained with the following equations (Hassan, 2021).

$Y_i = 1 \quad > \quad Y_i^* \geq 1$

$Y_i = Y_i^* \quad > \quad 0 < Y_i^* < 1$

$Y_i = 0 \quad > \quad Y_i^* \leq 0$

Efficiency scores for farms were obtained using the DEAP 2.1 program.

4. Results and Discussion

As a result of the survey conducted in Duhok, Sulaimaniyah and Erbil provinces in the Northern Iraq region, it was determined that approximately 18% of the individuals surveyed were illiterate in terms of their educational status. The proportion of those who know how to read and write together with primary and secondary school graduates is over 75%. In terms of farm size, more than 40% of farms are medium-sized, with the remaining 35% being small and close to 25% being large-scale. The average experience of the producers was found to be 8.4 years.

In this study, technical efficiency levels were calculated according to provinces and the results are given in Table 1. The technical efficiency score of three provinces under constant return to scale (CRS) is 0.615. These scores were 0.728 in Duhok, 0.572 in Erbil and 0.604 in Sulaymaniyah across the provinces. Similarly, the technical efficiency score of these three provinces under the VRS was 0.70. The efficiency scores of the provinces under variable returns to scale were 0.824 in Duhok, 0.676 in Erbil and 0.690 in Sulaymaniyah. While farms are more efficient under variable returns to scale, farms in Suleymaniyah operate more efficient in both cases (CRS-VRS) on a provincial basis. Farms in Erbil have the lowest technical efficiency scores. When previous studies were examined, the technical efficiency score was 0.970 under CRS in Nigeria (Sadiq et al., 2016), the technical efficiency score was 0.920 (CRS) and 0.930 (VRS) in the same sector in Iran (Heidari et al., 2011), and found as 0.910 (CRS) and 0.980 (VRS) in Egypt (Hassan, 2021), which are close to the results of this study.

Table 1: Efficiency statistics of farms under CRS and VRS by provinces

	CRS			VRS		
Cities	**Mean**	**Std. dev.**	**Min**	**Mean**	**Std. dev.**	**Min**
Duhok	0.728	0.175	0.439	0.824	0.159	0.482
Erbil	0.572	0.152	0.257	0.676	0.147	0.317
Sulaymaniyah	0.604	0.151	0.294	0.690	0.135	0.394
Average	**0.615**	**0.166**	**0.257**	**0.709**	**0.155**	**0.317**

The farms in Duhok, Erbil and Suleymaniyah are grouped according to whether they are efficient in terms of technical efficiency or not, and the total numbers of efficient-inefficient farms and the average technical efficiency scores are given below (Table 2). Out of the 801 farms in the three provinces, 39 farms under constant CRS and 71 farms under VRS are operating efficiently. The technical efficiency score of these farms is 1,000. On the other hand, 762 farms under CRS were not operating efficiently and the average efficiency scores of these farms were found to be 0.595. These farms have an average technical efficiency score of 0.673 for Duhok, 0.561 for Erbil and 0.597 for Sulaymaniyah. Under theVRS, 730 out of 801 farms do not have efficient operating scores. While the average of technical efficiency scores of these farms is 0.681, on the basis of provinces, Duhok has 0.758, Erbil 0.659 and Sulaymaniyah 0.675 technical efficiency scores.

Table 2: Efficient - inefficient farms and efficiency scores of broiler farms in Duhok, Erbil and Sulaymaniyah provinces

	Efficient Farms			Inefficient Farms		
Cities	**No**	**Mean CRS**	**Std. dev.**	**No**	**Mean CRS**	**Std. dev.**
Duhok	25	1	0	124	0.673	0.137
Erbil	8	1	0	307	0.561	0.137
Sulaymaniyah	6	1	0	331	0.597	0.143
Total	**39**	**1**	**0**	**762**	**0.595**	**0.145**
Cities	**No**	**Mean VRS**	**Std. dev.**	**No**	**Mean VRS**	**Std. dev.**
Duhok	41	1	0	108	0.758	0.136
Erbil	15	1	0	300	0.659	0.131
Sulaymaniyah	15	1	0	322	0.675	0.120
Total	**71**	**1**	**0**	**730**	**0.681**	**0.131**

The return to scale of each farm of the surveyed farms under CRS and VRS were analyzed separately, and their statistics by provinces are given in Table 3.

Table 3: Scale efficiency and returns to scale of farms by provinces

	CRS			DRS			IRS		
Cities	**No**	**Mean CRS**	**Std. dev.**	**No**	**Mean CRS**	**Std. dev.**	**No**	**Mean CRS**	**Std. dev.**
Duhok	27	0.970	0.109	12	0.763	0.164	110	0.665	0.131
Erbil	9	0.955	0.135	27	0.679	0.122	279	0.549	0.133
Sulaymaniyah	10	0.862	0.183	39	0.683	0.142	288	0.585	0.140
Cities	**No**	**Mean VRS**	**Std. dev.**	**No**	**Mean VRS**	**Std. dev.**	**No**	**Mean VRS**	**Std. dev.**
Duhok	27	0.970	0.109	12	0.810	0.191	110	0.790	0.146
Erbil	9	0.955	0.135	27	0.735	0.131	279	0.661	0.139
Sulaymaniyah	10	0.862	0.183	39	0.716	0.154	288	0.680	0.126

In terms of provinces, 18% of the 149 farms in Duhok have a constant return to scale status, 8% have a decreasing return status, and 74% have an increasing return to scale status. On the other hand, 3% of 315 farms in Erbil have CRS, 8.5% DRS and 88.5% incIRS. The distribution of these ratios in Sulaymaniyah is listed as 3% CRS, 11.5% DRS and 85.5% IRS out of 337 farms. When the scale efficiency of 801 farms under VRS is examined in terms of constant, increasing and decreasing returns to scale, they are the same as those under CRS and their technical efficiency scores are more tolerant. Farms with lower average technical efficiency scores on a provincial basis in terms of scale efficiency are in a situation of increasing returns to scale. Farms with averagely high efficiency scores are in constant return to scale.

Table 4: Average input-output levels of broiler farms in Northern Iraq by being efficient and inefficient under CRS

Variables			CRS Efficient		CRS Inefficient		
		Unit	Mean	Std. dev.	Mean	Std. dev.	%
Farm	% (no)		4.9(39)		95.1(762)		-95
CRS	Technical efficiency		1.000	0.000	0.595	0.145	68
Output	Income	$	115750.64	56633.91	71649.46	34040.98	62
Input 1	Feed costs	$	61641.02	34575.77	42861.14	21008.02	44
Input 2	Chick costs	$	13336.96	7839.49	9733.12	4472.26	37
Input 3	Fuel cost	$	4022.25	3403.53	4053.22	2568.80	-1
Input 4	Electric costs	$	372.47	432.11	633.59	588.74	-41
Input 5	Veterinary cost	$	2423.39	2646.61	3310.48	1791.55	-27
Input 6	Labour cost	$	3023.36	1738.67	2876.06	1232.93	5
Input 7	Water cost	$	52.87	210.77	124.80	377.54	-58
Input 8	Repair cost	$	1403.05	1542.79	1623.49	1030.96	-14
Input 9	Other cost	$	788.72	741.98	817.09	599.87	-3

While 4.9% of all farms work effectively under CRS, 95% do not work efficiently. Considering the total income of the farms during the year, the farms that work efficiently have an average of 62% more income than the farms that do not work efficiently. On the other hand, although the cost of feed used by inefficient farms is 44% less than that of efficient farms, they cannot work efficiently because they cannot provide sufficient output. In terms of electricity, veterinary and water costs, farms that do not work efficiently have 41%, 27% and 58% more costs, respectively, than farms that work effectively. In terms of fuel cost, labor cost and other expenses used in the heating of the farms, efficient and ineffective farms use approximate input amounts (Table 4).

The average of the input and output levels used by the farms under VRS is given in Table 5. When the ratios are analyzed, it shows similarity with the input-output utilization ratios under CRS.

Table 5: Average input-output levels of broiler farms in northern Iraq under VRS by efficiency and inefficiency.

Variables	VRS Efficient	VRS Inefficient

		Unit	Mean	Std. dev.	Mean	Std. dev.	%
Farm	% (N)o		8.9(71)		91.1(730)		-90
VRS	Variable efficiency		1.000	0.000	0.681	0.131	47
Output	Income	$	101476.54	68673.62	71104.56	30677.40	43
Input 1	Feed costs	$	56301.00	46846.03	42557.28	17705.48	32
Input 2	Chick costs	$	11810.68	8837.79	9723.59	4105.73	21
Input 3	Fuel cost	$	3741.57	4018.01	4081.87	2435.53	-8
Input 4	Electric costs	$	444.75	583.10	638.01	582.30	-30
Input 5	Veternery cost	$	2331.76	2562.64	3358.28	1741.15	-31
Input 6	Labour cost	$	2983.37	2158.84	2873.49	1138.83	4
Input 7	Water cost	$	118.18	447.42	121.60	363.52	-3
Input 8	Repaire cost	$	1434.76	1626.92	1630.06	989.21	-12
Input 9	Other cost	$	714.95	786.81	825.50	586.39	13

While 8.9% of all farms work efficiently under VRS, 91% do not work efficiently. Considering the total income of the farms during the year, the farms that work efficiently have an average of 43% more income than the farms that do not work efficiently. On the other hand, although the cost of feed used by the farms that are not working efficiently is 32% less than the farms that are efficient, they do not have an efficient working status because they cannot provide sufficient output. In terms of electricity, veterinary and repair maintenance costs, farms that do not work efficiently have 30%, 31% and 12% more cost inputs, respectively, than farms that work efficiently. In the part of fuel cost, labor cost and other expenses used in the heating of the farms, the farms that work efficiently and do not work efficiently use approximate input amounts. The average input-output usage of efficient and inefficient farms under CRS and VRS by province is given below Table 6 and Table 7. Among the farms, the ratio of farms working efficiently in Duhok under CRS is 16.7% and the rate of inefficient farms is 83.3%. It has been revealed that while 2.5% of the farms in Erbil are working efficiently, 97.5% are not working efficiently. There is a similar result in Suleymaniya (1.7% efficient and 98.3% inefficient). Suleymaniyah has the highest average income in terms of total income averages of efficient farms and Duhok is in the 2nd place. While the farms that are not working efficiently have the same ranking on the basis of provinces, it is seen that the average incomes are close to each other, but considerably lower than the farms that are efficient.

Table 6: Average input-output levels of broiler farms in Duhok, Erbil and Sulaymaniyah according to efficiency and inefficiency under CRS

	CRS Efficient	CRS Inefficient

	Variables	Duhok	Erbil	Sulaymaniyah	Duhok	Erbil	Sulaymaniyah
CRS	Efficiency ($)	1.000	1.000	1.000	0.673	0.561	0.597
Output	Income ($)	111400.05	86409.04	173000.23	73873.39	66234.24	75838.89
Input 1	Feed costs ($)	63143.53	37990.82	86914.14	44659.63	39731.68	45089.93
Input 2	Chick costs ($)	13228.03	9553.16	18835.91	9881.82	9651.87	9752.77
Input 3	Fuel cost ($)	4051.63	3186.77	5013.84	3355.69	4138.08	4235.82
Input 4	Electric costs ($)	251.01	354.86	902.06	469.83	733.72	602.07
Input 5	Veterinary cost ($)	1556.06	3577.37	4498.62	2140.49	3377.50	3686.63
Input 6	Labour cost ($)	3392.78	2460.27	2234.87	3020.03	3111.65	2603.61
Input 7	Water cost ($)	73.88	0.00	35.80	127.16	120.23	128.15
Input 8	Repaire cost ($)	1155.00	1544.94	2247.40	1283.10	1813.22	1575.02
Input 9	Other cost ($)	767.03	746.62	935.23	673.00	833.25	856.07

In terms of the input usage of the farms on the basis of provinces, the farms that are efficient in Duhok use more inputs under the CRS in terms of feed cost, chick cost, fuel cost, labor, water and other costs compared to the inefficient ones. In Erbil, on the other hand, efficient farms use more input on average than inefficient farm only in terms of veterinary costs. Efficiently operating farms in Sulaymaniyah have a higher input level than inefficient farms in all other costs except labor. In general, when the efficient farms are compared with the inefficient ones, it is seen that the inefficient farms use more input despite having less income.

The factors affecting the efficiency in the Tobit analysis are listed in Table 8. Model results were analyzed under CRS and variable returns to scale (VRS). As a result of the model, it was determined that the experience of the producer, cooling-ventilation systems, automatic systems, the distance of the farms to the city center and the number of daily working personnel did not have a statistically significant effect on the efficiency of the farms in this region under constant return to scale ($P < 0.05$). The farms were evaluated in 3 different scale dimensions and the large scale of the farms under the CRS is a statistically significant factor on efficiency ($P<0.05$). Farm sizes are not statistically significant under VRS. The reason for this is due to the working conditions in the scale efficiency of the farm.

Table 7: Average input-output levels of broiler farms in Duhok, Erbil and Sulaymaniyah according to efficiency and inefficiency under VRS

		VRS Efficient			VRS Inefficient		
	Variables	Duhok	Erbil	Sulaymaniyah	Duhok	Erbil	Sulaymaniyah
VRS	Efficiency ($)	1.00	1.00	1.00	0.76	0.66	0.68
Output	Income ($)	99588.83	85947.42	122165.43	72797.77	65786.58	75491.28
Input 1	Feed costs ($)	60536.76	40618.65	60405.60	42910.88	39640.91	45155.80
Input 2	Chick costs ($)	12058.81	10029.14	12913.99	9829.96	9630.38	9774.76
Input 3	Fuel cost ($)	3564.89	3950.30	4015.75	3437.36	4122.10	4260.57
Input 4	Electric cost ($)	370.28	385.21	707.83	456.97	741.04	602.73

Input 5	Veterin. cost($)	1431.70	3491.02	3632.65	2274.28	3377.15	3704.28
Input 6	Labour cost ($)	3227.52	2798.45	2500.95	3027.54	3109.94	2601.52
Input 7	Water cost ($)	112.10	238.64	14.32	120.55	111.11	131.73
Input 8	Repaire cost ($)	1145.13	2094.71	1566.49	1305.82	1792.00	1587.95
Input 9	Other cost ($)	647.22	927.05	687.95	704.55	826.25	865.38

Table 8: Tobit regression analysis of socio-economic factors affecting efficiency of broiler farms in Duhok, Erbil and Sulaymaniyah

Independent variables	**TE_{CRS}**	**Std. dev.**	**TE_{VRS}**	**Std. dev.**
Constant	0.912***	0.060	1.010***	0.064
Capacite2	0.016*	0.009	−0.014	0.010
Capacite3	0.035***	0.012	−0.014	0.012
Erbil	−0.121***	0.017	−0.096***	0.018
Suleymanyah	−0.129***	0.012	−0.138***	0.013
Experiences Farmer	0.000	0.001	0.001**	0.001
Age Chicken Sold	−0.002***	0.001	−0.004***	0.001
Average Weight	0.105***	0.015	0.103***	0.016
Mortality by Percent	−0.002***	0.001	−0.003***	0.001
Artesian Well	−0.028***	0.010	−0.026**	0.011
Haed Spring	−0.026*	0.014	0.018	0.015
In Farm	0.050***	0.015	0.038**	0.016
Cooler	−0.014	0.018	−0.002	0.019
Auto	0.022	0.015	0.003	0.017
Distance Farm	4.150	3.300	0.000	3.529
Daily Workers	0.001	0.001	−0.001*	0.000
FCR	−0.155***	0.013	−0.084***	0.014
Log-likelihood	513.352		405.714	
Test statistic: Chi-square(2)	245.400		192.128	

TE_{CRS}: Technical efficiency at constant returns to scale; TE_{VRS}: Technical efficiency at variable returns to scale; *,,***: significant at 10%, 5%, 1% level.**

5. Conclusion and Recommendations

The study was carried out by analyzing the data obtained from 801 broiler farms in Duhok, Erbil and Sulaymaniyah in the Northern Iraq region. Three different analyzes were made, namely technical efficiency, scale efficiency and Tobit regression analysis. Technical efficiency was analyzed under CRS and VRS. Efficiency of scale was calculated as IRS, CRS and DRS for each farm by using BBC and CCR methods.

As a result of the analyses, the average technical efficiency scores of all farms were calculated as 0.615 under CRS and 0.70 under VRS, but they were found to be lower than the scores of similar studies in the literature. It has been determined that the efficiency scores of broiler production farms in this region show a low distribution under CRS and VRS based on provinces. Considering efficiency scores, the farms in Sulaymaniyah worked more efficiently than the other two farms. Considering the scale efficiency of the farms, 5.7% of 801 farms based on provinces are in the case of constant returns to scale, 9.7% are in the case of decreasing returns to scale and 84.6% are in the case of increasing returns to scale. In this sense, it will be useful for farms to continue production by maintaining their farm scales, and farms with a constant return to scale are ideal size in terms of scale efficiency. However, farms with increasing returns to scale must increase their input-output mix to achieve technical efficiency. On the other hand, in the case of decreasing returns to scale, farms must reduce the input-output combination to reach optimum utilization. When the technical efficiency scores of the farms are examined under the scale efficiency, the farms with constant returns to scale operate with 90% efficiency. While more than 70% of farms with decreasing returns to scale operate effectively, those with increasing returns to scale operate with a technical efficiency score of 60%. As can be seen from the ratios, the technical efficiency scores of farms with increasing returns to scale are quite low. These farms should increase the input-output combination to reach the optimum efficiency point. When the input and output use of efficient and inefficient farms for the three provinces is evaluated under CRS, the income of efficient farms is 62% higher than that of inefficient farms. Inefficient farms had more input use in electricity costs (41%), veterinary fees (27%), and water costs (58%). Inefficient farms must reduce their input costs to achieve the same level of income at lower costs. When the ratios of efficient and inefficient farms in Duhok, Erbil and Sulaymaniyah provinces are compared in terms of input-output amounts and input usage, 16.7% of farms operating in Duhok operate effectively and it is in the 2nd place. Moreover, 2.5% of the farms in Erbil are working effectively and these farms, which are more efficient than the three provinces, have the lowest average input usage. This is a reference point for other inefficient farms in Erbil. About 1.7% of the farms in Duhok worked effectively, and these farms had the highest input usage amounts among efficient farms. In terms of inefficient farms, farms in Sulaymaniyah use more inputs in terms of feed costs, fuel costs, veterinary fees, and water costs than other provinces. However, by reducing these input levels, they will be able to become efficient farms. Inefficient farms in Erbil use more inputs than the other two provinces in terms of electricity costs, labor costs and repair and maintenance costs. The input usage of farms that are efficient and inefficient under the VRS are similar in all provinces. In the Tobit regression analysis, the levels of the factors affecting efficiency were measured. The

Tobit regression model showed that the weight of broilers slaughtered on farms positively and significantly affected the efficiency of the farm.

It will be more effective for farms to work on issues such as nutrition, which will increase broiler weight during the slaughter period. In addition, the age of broilers and the increase in mortality rate reduce the technical efficiency of the farms. In this context, shortening the time of broiler slaughter and taking measures to reduce mortality will make farms more efficient. On the other hand, the farms located in Erbil or Suleymanyah are at a disadvantage. Therefore, the conditions in Duhok province are a reference for other provinces, and policy makers, agricultural extension organizations and local institutions should develop broiler farms in other regions by taking the farms in Duhok as an example.

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