Efficiency and Functional analysis of cotton production in Turkey: case of Kahramanmaraş Province

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Serhan Candemir
PhD in Agriculture Economics
Institution: East Mediterranean Transitional Zone Agricultural Research of Institute
Address: East Mediterranean Transitional Zone Agricultural Research of Institute, 46140, Kahramanmaraş, Turkey
E-mail: **serhan_candemir@hotmail.com**

Abstract

The aim of this study was to determine the efficiency measurements of the cotton enterprises in Kahramanmaraş province of Turkey and the factors affecting the economic efficiency. Besides, the relationship between the income of the cotton enterprises and the effective factors on the income was analyzed by functional analyses. The data were obtained from 67 cotton producers in Kahramanmaraş province. Data envelopment analysis was used in order to determine the efficiency in cotton production. Two-stage approach was used in order to determine the effects of several variables on efficiency. The econometric analysis of the factors effective on cotton production was performed by Cobb-Douglas production function. In the study, technical efficiency, pure technical efficiency, scale efficiency, allocative efficiency and economic efficiency were calculated as 0.822, 0.907, 0.908, 0.682 and 0.616, respectively. Besides, it was concluded that 34.33% of the enterprises had constant return to scale, 46.27% of the enterprises had decreasing return to scale and 19.40% of the enterprises had increasing return to scale. According to Tobit model results, it was determined that the education period and land size affected the economic efficiency positively and stock farming activity and credit use affected the economic efficiency negatively. In functional analysis, the fertilizer costs and fuel costs variables were determined as statistically significant. The efficiency coefficients were calculated as 0.18 for labor, 1.38 for fertilizer, -0.20 for pesticide, 0.72 for seed, 0.07 for equipment rent and 1.24 for fuel. According to the results, in can be concluded that the efficient use of inputs will contribute to the reduction of the costs and increment of the profit margin.

Key words: Cobb-Douglas. Cotton production. Efficiency.

1. Introduction

The cotton plant has a great economic importance in terms of humanity with the common and essential usage area and in terms of the countries with the added value and employment opportunities. Cotton is the raw material of the threshing industry in terms of processing and besides, it is the raw material of textile industry with the fiber, oil and forage industry with the seed and paper industry with the linter. The oil of the cotton seed, which is alternative to the petrol, is used as raw material in biodiesel production in increasing amount. Besides these, the increment of the population and life standard increase the demand to the cotton plant (Anonymous, 2016).

According to Food and Agriculture Organization (FAO) data, more than 24 million tons of cotton production occurred around the World in 2018. China was the country where the cotton production was done with 6.1 million tons and India and USA followed China with 4.7 million tons and 4 million tons, respectively. Turkey was the sixth country in the World in cotton production with 976 thousand tons of production amount in 2018 and this value descended to 814 thousand tons in 2019. Turkey was the second country in the World after China with 762 thousand tons of cotton import. World cotton import reached to 9.2 million tons and 2.1 million tons of import was performed by China. Pakistan and India were the most importer countries after Turkey. In 2018, more than 26 million tons of cotton were used in the production by different sectors around the World. The highest cotton use was done by China with 8.6 million tons and India with 5.2 million tons, Pakistan with 2.3 million tons and Turkey with 1.5 million tons followed China (Anonymous, 2020).

The cotton crop has a particular importance in Turkey as in the World within the industrial agriculture products. The high added value makes the cotton a considerably significant strategic crop. With the main and by-products, cotton is known to create socio-economic added value in many disciplines such as threshing, thread and cloth, textile, oil, biodiesel, chemistry, paper industries, moreover medicine and cosmetics (Keskinkılıç, 2014).

Turkey is one of the prominent countries in cotton production. In the last 30 years, planted cotton areas decreased due to the reasons such as the development of the alternative crops, variability in the prices, support policies, immigration to the city and land split. The planted area was 7.6 million decare in 1998 but this value fell below 5 million decare in 2019. In spite of the decline in the planting areas, cotton production (unginned) continued between 2 million and 2.5 million tons in long term. Concordantly, fiber cotton production continued between 700 thousand and 1 million tons. In 2019, 2.2 million tons of cotton unseed and 814 thousand tons of fiber cotton production were executed on 4.8 million decare area (Anonymous, 2020).

Kahramanmaraş province which is one of the significant production areas of cotton in Turkey, has a considerably rich crop design due to the geographical location because Kahramanmaraş province has borders in three different basins and it has a transition zone characteristic (Candemir et al., 2017). Cotton production is an important means of existence for the producers in Kahramanmaraş in terms of the suitability to the climate conditions and supply the raw material of cotton industry. In 2018, cotton production amount was 44931 tons in Kahramanmaraş province but the production amount was 23692 tons in 2019 (TUIK, 2020).

By means of the efficiency measurements which enable the inter-firm comparison, the failing factors are determined in inefficient production activity and they can be provided to operate more effective by taking some precautions. This can directly contribute to the reduction of the unit costs and provision of the profit maximization (Aktürk and Kıral, 2002).

The increase of the contribution of the agriculture sector to the national economy and the increase of the wealth level of the sector employee depend on the efficient use of the production factors of the agricultural enterprises such as natural resources, labor and capital (Çelik and Bayramoğlu, 2007). In each production activity, supply of the production factors with appropriate prices and optimum use of the production factors provide the sustainable use of the natural resources and decrease the costs. The producers cannot use the agricultural production factors in optimum level due to the inadequacies in the operation capitals and lack of technical information and this state affect the crop yield and consequently the income of the farmer negatively. For this reason, the studies which determine the input use levels of the farmers for each crop and put forward the optimum use of the inputs, should be conducted (Gündoğmuş, 1997). In terms of agricultural production, it is critical to determine the efficiency of inputs employed for cultivation, to identify the saving amounts from these inputs that would secure the efficiency and the factors of efficiency to clarify the required measures for implementation (Aydın, 2019).

In this study, the efficiency measurements of the cotton enterprises in Kahramanmaraş province of Turkey were done and the factors affecting the economic efficiency were put forward. Besides, the relationship between the income of the cotton enterprises and the effective factors on the income was analyzed by functional analyses. Within the study, it was determined whether the production factors in cotton production were used efficiently by the producers or not. In comparison with the other crops in the research area, more input use in cotton production increase the significance of the subject of this study.

2. Literature Review

Günden (1999) measured technical efficiency of cotton production in Menemen using Data Envelopment Analysis and determined the production and input losses caused by inefficiency. Technical efficiency score was 0.697 in the left side and 0.608 in the right side and generally 0.677 in the province. With respect to these results, current production could be realized by using %32.3 less input or the production could be increased the same percentage with current input.

Aktürk ve Kıral (2002) measured and analyzed the efficiency of cotton production activities in cotton farms in Söke Valley in Turkey. Technical efficiency, pure technical efficiency and scale efficiency were found as 0.839, 0.864 and 0.971, respectively.

Chakraborty et al. (2002) examined the technical efficiency for cotton growers using both stochastic (SFA) and non-stochastic (DEA) production function approaches. On average, irrigated farms were 80% and non-irrigated farms were 70% efficient.

Binici et al. (2006) examined the efficiency of cotton production on the Harran Plain of Turkey. According to the results, 72% of the farms are using inefficient levels of inputs.

Çelik and Bayramoğlu (2007) examined the relationship between the inputs and the yield used in cotton production by Cobb-Douglas production function. As a result of functional analysis yield per decare, insecticide use, irrigation number, labor and machinery power were significant. The determination coefficient (R^2) was found as 82.8%.

Anwar et al. (2009) examined the factors affecting cotton production in Multan region using primary source of data. The Cobb-Douglas Production Function results revealed that the coefficients for cultivation (0.113) and seed (0.103) were found statistically significant at 1% level.

Gül et al. (2009) analyzed the technical efficiency of cotton farms in Çukurova region of Turkey. Technical efficiency, pure technical efficiency and scale efficiency were found as 0.720, 0.890 and 0.809, respectively. Factors strongly affecting efficiency level of the farmers were found to be farmers’ age, education level and groups of cotton growing areas.

Neba et al. (2010) evaluated the technical efficiency of cotton farms in the northern part of Cameroon through the use of a parametric production frontier. About 30% of cotton producers had technical efficiency indexes less than or equal to 50%, meanwhile less than 74% have efficiency indexes less than 75%. Also, a large number of producers had technical efficiency indexes between 50 and 75%. The calculated low technical efficiency entails a loss of 40% of production.

Abid et al. (2011) examined the resource use efficiency of small Bt cotton farmers of Punjab province of Pakistan using the production function approach. Regression results indicated that Fertilizer, Spray Number, Irrigation acre inch and labor cost were significantly affecting Bt cotton production while farm size was found non-significant. Bt cotton production for small Bt farmers had an increasing return to scale with elasticity of production 1.27.

Ashfaq et al. (2012) examined the resource use efficiency and return to scale of the medium sized Bt cotton farmers in the Punjab province of Pakistan. The elasticity of production (Ep) for medium sized Bt cotton farmers was found to be 0.77 showing decreasing returns to scale.

Adzawla et al. (2013) estimated the technical efficiency of cotton production in Yendi Municipality in Northern Ghana. The average technical efficiency level was 0.88, ranging from 0.70 and 0.99.

Çobanoğlu (2013) determined the productive efficiency of a sample of farmers in Turkey's Aegean region by estimating a stochastic frontier production function (SFA), constant returns to scale (CRS) and variable returns to scale (VRS) using output-oriented data envelopment analysis (DEA). The mean efficiency score (0.91) obtained from the stochastic frontier was higher than that calculated from pure technical efficiency (0.77) and technical efficiency (0.25) scores.

Solakoğlu et al. (2013) measured the technical efficiency of cotton production, incorporating support premium payments as one of the background variables to capture the effect of premiums on efficiency scores for cotton production using stochastic frontier model. The mean efficiency was estimated around 65% for cotton production when 8 years and 14 cities are taken into account.

Hameed and Salam (2014) reported that the average technical efficiency score of cotton growers in Dera Ghazi Khan was 94% with a maximum value of 100% and minimum 62% efficiency level. Similarly, the average economic efficiency was noted to be 54%, with a minimum value of 17%. The average allocative was 57%, with a minimum value of 18%.

Karimov (2014) examined the factors affecting the efficiency of cotton producers in North-western Uzbekistan by conducting a frontier efficiency analysis. The model displayed that farmers' educational background, farm size, water availability, the application of manure, access to formal credit, Water User Association's services, farmers' participation in off-farm work and poor drainage systems, significantly contribute to input use efficiency.

Sarker and Alam (2016) determined the technical, allocative, and cost efficiencies of cotton farmers in Bangladesh. Mean technical efficiency (CRS) was 83.6% while technical efficiency (VRS) was estimated at 89.1%. Allocative, cost and scale efficiencies were 78.1%, 69.7% and 93.9% respectively. Seventy five percent cotton farms exhibited increasing returns to scale while only 10% and 14% respectively displayed evidence of decreasing and constant returns to scale. Experience, number of working adult person, access to credit, extension service and size of cotton cultivated land were the significant factors determining technical efficiencies.

Semerci and Çelik (2018) examined the relationship between the income and the affective factors in cotton production by Cobb-Douglas production function. According to cotton production function analysis results, total elasticity of the coefficients was found as 0.976. This situation indicates that decreasing returns to scale, the result that obtained is very close to constant returns to scale. Among the variables that are in the equation, highest marginal activity coefficients were; seed (X1) with 13.64 and fertilizer input (X2) with 4.18

Kumar et al. (2019) determined the sources of inefficiency of cotton farmers in Palwal district of Haryana. Results showed that mean efficiency scores for technical, scale, allocative and cost were 97.3%, 93.7%, 87.6% and 85.2%, respectively. Efficiency scores imply that cotton farmers were technically efficient, but there is a scope in improving their allocative and cost efficiencies by 12% and 15%, respectively, thereby making cotton cultivation cost effective and profitable.

Örük (2020) measured the technical efficiency for cotton farms in Diyarbakir province in Turkey. The mean values of overall technical, pure technical and scale efficiency were 0.87, 0.97 and 0.89, respectively. The Tobit analysis results showed that factors such cotton yield, N and K fertilizers have a positive effect on efficiency, whereas land size, P fertilizers, pesticides, machine, fuel, labor and seed have a negative effect on efficiency.

Wei et al. (2020) estimated the cost and revenue along with different factors affecting the cotton production in southern Punjab. The present study applied data envelopment analysis to evaluate the technical, allocative, and cost-efficiency of the cotton farmers. The second stage regression analysis was also conducted to explore the factor affecting cotton production by using the Cobb-Douglas production function. The technical efficiency, allocative efficiency and economic efficiency were found as 0.90, 0.59 and 0.53, respectively. The regression results revealed that farming experience, education, land preparation cost, and irrigation cost has a positive impact on total revenue, whereas, chemicals and fertilizers cost showed a negative effect.

3. Material and Method

The survey studies, executed with the cotton enterprises in Kahramanmaraş province composed the main material of the study. Besides, it was utilized from the literature related with the subject of this study and the statistics.

In the study, the sample size was calculated according to simple random sampling method and 10% error margin and 95% confidence level were used. The sample size was determined as 67 cotton producers. In simple random sampling method, the following formula was used (Yamane, 1967).

$$n = \frac{N\ x\ S2}{(N-1)D2 + S2}$$

n = Sample size

N = Total number of the enterprises

S = Standard deviation

$D^2 = (d/Z)^2$

d = 0.10 * X (acceptable error),

Z = Reliability coefficient (1.96, which represents the 95% reliability)

It was utilized from the descriptive statistics such as averages and percentages and cross tables on the analysis of the data. In continuous data, in order to determine whether there were differences in terms of the variables, t test was used when the number of the groups was two and variance analysis was used when the number of the groups was three or more.

Data envelopment analysis was used in the efficiency analysis. Data envelopment analysis is a non-parametric method and it is used in order to measure the efficiency in the decision making units which are used in order to produce some outputs from many inputs. This method assumes that all of the data have certain numeric values (Mugera, 2013).

Data envelopment analysis is a linear programming based method which enables the measurement of the profitability of the production units by using multiple inputs and outputs. This method is suitable for the relative measurement of the profitability (Charnes and Cooper, 1984). Data envelopment analysis was developed for eliminating the problems in the profitability measurements which were executed by ratio analysis and parametric methods. Contrary to the parametric methods basing the regression line for the optimization of the production units, data envelopment analysis evaluates each production unit according to the position to the profitability border.

The main data envelopment analysis models are the CCR model which was developed by Charnes, Cooper and Rhodes (1978) and BCC model which was developed by Banker, Charnes and Cooper (1984). CCR model provides the measurement of total efficiency under constant return to scale assumption whereas BCC model measures the technical efficiency under variable return to scale assumption. Return to scale is defined as the changes in the output amounts due to the changes in the input amounts. When the increase rate in the output amounts is the same as the increase rate in the input amounts, it means there is constant return to scale. If the increase rate in the output amounts is higher than the input amounts, it means there is increasing return to scale and if the increase rate in the output amounts is lower than the input amounts, it means there is decreasing return to scale (Bakhshoodeh and Thomson, 2001).

Total efficiency (TECRS) value, obtained with constant return to scale, is divided into two components as scale efficiency and pure technical efficiency. If the technical efficiency values according to constant return to scale and variable return to scale are different from each other, it means that the production unit has scale inefficiency. In this case, scale efficiency can be stated as follows by utilizing from the technical efficiency values obtained with the two assumptions.

$TECRS = TEVRS \; x \; SE$ or

$Total\ technical\ efficiency = Pure\ technical\ efficiency\ x\ scale\ efficiency$

Scale efficiency indicates whether or not the enterprises are in optimal scale and presents the losses arising from not performing production in optimal scale. If the efficiency value decreases due to the decrease or increase of the scale of the activity, it can be concluded that the production unit has scale inefficiency. Pure technical efficiency is calculated by the sortation of the scale efficiency. Besides, the source of the inefficiency can be put forward by this sortation.

Farrell (1957) defined the efficiency of an enterprise as the success of producing maximum output from the inputs. He stated that this use could be generally accepted on condition that the accurate measurement of all the inputs and the outputs. Farrell defended that the economic efficiency of an enterprise included two factors such as technical efficiency and allocative efficiency. Technical efficiency is defined as the ability of obtaining maximum output from the inputs. Allocative efficiency is defined as the ability of using the inputs in optimal ratios when the prices and the production technology are the data (Farrell, 1957).

These two measurements are combined for the measurement of total economic efficiency (Coelli, 1996).

$Economic\ efficiency = Allocative\ efficiency\ x\ technical\ efficiency$

In the efficiency analysis, enterprises with efficiency coefficients between 0.95 and 1 are considered as effective, those with efficiency coefficients between 0.90 and 0.95 are considered as less effective and those with efficiency coefficients less than 0.90 are considered as ineffective enterprises (Charnes et al., 1978).

As the producers are in tendency to control the inputs rather than the outputs, the input oriented efficiency measurements of Farrell (1957) was used in this study. Gross production value was accepted as output and labor costs, fertilizer costs, pesticide costs, seed costs, equipment rent costs and fuel costs were accepted as inputs in the model. In other words, a model with one output and six inputs was composed. DEAP 2.1 package program, developed by Coelli (1996), was used on the estimation of the efficiency measurements.

Two-stage approach was used in order to determine the effects of several variables on efficiency. In the first stage of this approach, efficacy coefficients for each enterprise are obtained. In the first stage, the relationship between the variables and the efficiency is estimated by a proper regression model (Coelli et al., 1998).

As the efficiency coefficients vary between 0 and 1, Tobit regression was used in this study as the classical least squares method would estimate the coefficients overmuch.

In Tobit model, the dependent variable was economic inefficiency and the independent variables were taken as producer's age, education period, agricultural experience, family size, land size, cooperative membership, stock farming activity and credit use.

The econometric analysis of the factors effective on cotton production was performed by Cobb-Douglas production function. Cobb-Douglas production function equations are generally used in the functional analysis of the agricultural production (Gündoğmuş, 1998). The general notation of Cobb-Douglas production function is given below.

$Y = \alpha . X^{\beta}$

The variables can be converted to the linear form as $\log Y = \log\alpha.\beta\log X$ by taking the logarithms. The logarithmic values provide easier and more reliable statistical tests and elasticity. Taking the logarithms of the data eliminates the changing variance problem. In multiple exponential regression models, the sum of the coefficients gives information about returns to scale (Gujarati, 1995).

e = 1 (constant return to scale)

e < 1 (decreasing return to scale)

e > 1 (increasing return to scale)

The marginal yield of the variables used in the production by taking the geometric means from Cobb-Douglas production function was calculated by means of the following formula (Zoral, 1973).

$$Mpi = \beta i.Yi/Xi$$

Xi average of the production source, Yi average of the production output

If there are k variable sources in the production function, average production is calculated for each source. As logarithmic transformation is used in Cobb-Douglas or logarithmic production function, the averages of X and Y are geometric mean. The marginal income is found by multiplying the marginal yield and crop price.

The following formula was used on the calculation of the efficiency coefficient of the factors (Karkacıer, 2001).

$$Efficiency\ coefficient = \frac{Marginal\ income}{Marginal\ cost}$$

EK = 1 (factor is used efficiently)

EK > 1 (factor is underused, the factor use should be increased)

EK < 1 (factor is used excessively, the factor use should be decreased)

The autocorrelation in the econometric model was analyzed by durbin-watson test. Multicollinearity existence was investigated by using Variance Inflation Factor (VIF) and Tolerance Value (TV) methods. If VIF is calculated as equal to 10 or more (VIF≥10), this means that multicollinearity problem is present in the model (Pallant, 2005). Low VIF and high TV values indicate that there is not any multicollinearity problem.

4. Results and Discussion

Descriptive statistics of the variables used in the efficiency analysis are given in Table 1. It was determined that an enterprise obtained 2373.29 \$ ha^{-1} income on average from cotton production in the research area. Besides, it was determined that the enterprises made expenses of 348.95 \$ ha^{-1} labor, 307.28 \$ ha^{-1} fertilizer, 159.91 \$ ha^{-1} pesticide, 76.75 \$ ha^{-1} seed, 255.48 \$ ha^{-1} equipment rent and 164.08 \$ ha^{-1} fuel.

Table 1: Descriptive statistics of the variables used in the efficiency analysis

Data envelopment model	Average	Standard deviation	Minimum	Maximum
Gross production value ($\$$ ha^{-1})	2373.29	876.79	551.47	4047.06
Labor costs ($\$$ ha^{-1})	348.95	204.65	29.41	845.59
Fertilizer costs ($\$$ ha^{-1})	307.28	123.83	137.87	597.43
Pesticide costs ($\$$ ha^{-1})	159.91	82.20	18.38	367.65
Seed costs ($\$$ ha^{-1})	76.75	17.11	36.76	119.08
Equipment rent costs ($\$$ ha^{-1})	255.48	168.37	3.68	551.47
Fuel costs ($\$$ ha^{-1})	164.08	97.90	39.22	459.56

Descriptive statistics of the efficiency scores are given in Table 2. Technical efficiency score with variable return to scale changed between 0.552 and 1 and it was found as 0.907 on average. This value indicated that the inefficient enterprises could decrease the inputs in the ratio of 9.3% by not decreasing the outputs. Technical efficiency with constant return to scale and scale efficiency were found as 0.822 and 0.908, respectively.

In the study conducted in Söke Plain of Turkey (Aktürk and Kıral, 1997), average technical efficiency, pure technical efficiency and scale efficiency in cotton production were found as 0.839, 0.864 and 0.971, respectively. In another study conducted in Çukurova Region (Gul et al. 2009), average technical efficiency, pure technical efficiency and scale efficiency in cotton production were found as 0.720, 0.890 and 0.809, respectively. Adzawla et al. (2013) determined that technical efficiency in cotton production between 0.70 and 0.99 and it was 0.88 on average. In the study conducted in Aegean Region by Çobanoğlu (2013), average technical and pure technical efficiency were found as 0.25 and 0.77, respectively. In the study carried out by Hameed and Salam (2014), technical efficiency in cotton production was found as 0.94 on average. Sarker and Alam (2016) found average technical efficiency, pure technical efficiency and scale efficiency in cotton production as 0.836, 0.891 and 0.939, respectively. In the study carried out by Kumar et al. (2019), technical efficiency and scale efficiency were found as 0.973 and 0.937, respectively. In the study conducted by Örük (2020) in Diyarbakır province of Turkey, average technical efficiency, pure technical efficiency and scale efficiency in cotton production were found as 0.87, 0.97 and 0.89, respectively. Wei et al. (2020) found the technical efficiency in cotton production as 0.90 on average.

Allocative efficiency changed between 0.312 and 1 and it was found as 0.682 on average. This value indicated that the enterprises made expenses in the ratio of 31.8% than the minimum costly input combination. In cotton production, allocative efficiency values were found as 0.57 (Hameed and Salam, 2014), 0.781 (Sarker and Alam, 2016), 0.876 (Kumar et al., 2019), 0.59 (Wei et al., 2020).

In the research area, economic efficiency changed between 0.312 and 1 and it was found as 0.616 on average. This value showed that the economically ineffective enterprises should decrease the expenses in the ratio of 38.4% in order to reach the level of the economically efficient enterprises (Table 2). In cotton production, economic efficiency values were found as 0.54 by Hameed and Salam (2014), 0.697 by Sarker and Alam (2016), 0.852 by Kumar et al. (2019), 0.53 by Wei et al. (2020).

Table 2: Descriptive statistics of the efficiency scores

Efficiency measurements	Average	Standard deviation	Minimum	Maximum
Technical efficiency (CRS)	0.822	0.180	0.453	1.00
Pure technical efficiency (VRS)	0.907	0.140	0.552	1.00
Scale efficiency	0.908	0.137	0.489	1.00
Allocative efficiency	0.682	0.202	0.312	1.00
Economic efficiency	0.616	0.213	0.312	1.00

It was determined that 34.33% of the enterprises had constant return to scale, 46.27% of the enterprises had decreasing return to scale and 19.40% of the enterprises had increasing return to scale (Table 3). In the study carried out by Sarker and Alam (2016), it was determined that 75.51%, 10.20% and 14.29% of the cotton enterprises had increasing return to scale, decreasing return to scale and constant return to scale, respectively.

Table 3: Scale efficiency analysis results

Return to scale	Number	%
Constant return to scale	23	34.33
Decreasing return to scale	13	19.40
Increasing return to scale	31	46.27
Total	67	100.00

It was determined that the gross production value of the enterprises which had increasing return to scale was lower than the enterprises which had decreasing return to scale and constant return to scale. Besides, the fertilizer, pesticide, seed, equipment rent and fuel costs of the enterprises which had decreasing return to scale were lower than the enterprises which had increasing return to scale and constant return to scale, respectively. According to the variance analysis results, it was determined that gross production value (F=35.434, p=0.000), fertilizer costs (F=8.352, p=0.001), pesticide costs (F=4.379, p=0.017), seed costs (F=4.086, p=0.021), equipment rent (F=4.451, p=0.015), fuel costs (F=2.829, p=0.066) changed according to the return to scale groups whereas the labor costs did not.

Table 4: Comparison of the enterprises in terms of return to scale

Return to scale	**GPV ($ ha^{-1})**	**Labor ($ ha^{-1})**	**Fertilizer ($ ha^{-1})**	**Pesticide ($ ha^{-1})**	**Seed ($ ha^{-1})**	**Rent ($ ha^{-1})**	**Fuel ($ ha^{-1})**
Constant return to scale	2573.57a	410.85	281.08a	143.22a	70.67a	180.79a	156.39a
Decreasing return to scale	3438.55b	308.44	421.23b	217.42b	86.85b	336.85b	219.80b
Increasing return to scale	1777.97c	320.00	278.93a	148.18a	77.01a	276.76b	146.43a

*Values within a column with different letters differ significantly at P<0.05.

The classification of the enterprises according to technical efficiency is given in Table 5. It was determined that 58.21% of the enterprises operated fully technically efficient. Besides, it was found that 7.46% of the enterprises operated efficient, 4.48% of the enterprises operated less efficient and 53.73% of the enterprises were not technically efficient. It was determined that 34.33% of the enterprises operated in optimal scale and 23.88% of the enterprises operated approximately in optimal scale.

Table 5: Classification of the enterprises according to technical efficiency

Efficiency status	**Technical efficiency (CRS)**		**Pure technical efficiency (VRS)**		**Scale efficiency**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Full efficient (TE=1)	23	34.33	39	58.21	23	34.33
Efficient (0.95≤TE<1)	5	7.46	5	7.46	16	23.88
Less efficient (0.90≤TE≤0.949)	3	4.48	2	2.99	9	13.43
Inefficient (TE≤0.899)	36	53.73	21	31.34	19	28.36
Total	67	100.00	67	100.00	67	100.00

The classification of the enterprises according to allocative and economic efficiency was done (Table 6). According to the results, it was determined that 7.46% of the enterprises was fully efficient, 2.98% of the enterprises operated efficient, 8.96% of the enterprises operated less efficient in terms of resource allocation. Besides, it was determined that 80.60% of the enterprises were not efficient, in other words made production with incorrect input combination.

It was determined that 7.46% of the enterprises operated fully economic efficient, in other words made production with minimum costly input combination. When 2.98% of the enterprises were determined to operate efficient and less efficient, 86.57% of the enterprises was found as economically inefficient.

Table 6: Classification of the enterprises according to allocative and economic efficiency

Efficiency status	**Allocative efficiency**		**Economic efficiency**	
	Number	**%**	**Number**	**%**
Full efficient	5	7.46	5	7.46
Efficient	2	2.98	2	2.98
Less efficient	6	8.96	2	2.98
Inefficient	54	80.60	58	86.57
Total	67	100.00	67	100.00

Descriptive statistics of the variables used in Tobit model are given in Table 7. It was determined that average producer's age was 52.31, education period and agricultural experience were 6.46 and 33.22 years, respectively. Average family size was 5.24 and average land size was 279.16 da. It was determined that 51% of the producers was affiliated to any agricultural organization, 13% of the producers was occupied in stock farming and 73% of the producers used credit.

Table 7: Descriptive statistics of the variables used in Tobit model

Tobit model	**Average**	**Standard deviation**	**Minimum**	**Maximum**
Producer's age (year)	52.31	9.89	33.00	76.00
Education period (year)	6.46	2.49	0.00	11.11
Agricultural experience (year)	33.22	10.87	8.00	50.00
Family size (person)	5.24	2.30	1.00	11.00
Land size (da)	279.16	266.19	30.00	1050.00
Cooperative membership[1]	1.00			
Stock farming[2]	0.00			
Credit use[3]	1.00			

* Arithmetic mean was used in distance and ratio data as measure of central tendency, median in ordered data, mode in classified data, [1, 2, 3] No: 0, Yes: 1

The results of the Tobit model, performed in order to determine the factors effective on economic efficiency, are given in Table 8. It was determined that producer's age affected the economic efficiency positively whereas family size, agricultural experience and cooperative membership affected negatively. These variables were statistically insignificant (p>0.10).

It was determined that the education period affected the economic efficiency positively (p=0.0452). As the education period increased, the economic efficiency increased. This indicated that the more educated producers took more accurately decisions on the application of the production techniques and input usage level.

Land size affected the economic efficiency positively, in other words as the land size increased, economic efficiency increased (p=0.0917). This indicated that the producers who had more agricultural lands obtained more yield and consequently more income.

Stock farming activity affected the economic efficiency negatively (p=0.0202). This can be interpreted as the producers who were occupied in stock farming could not spare enough time to plant production according to the producers who were occupied in only farming. Credit use affected the economic efficiency negatively (p=0.0121). As the credit use increased, economic efficiency decreased.

In the study conducted by Gül et al. (2009), it was determined that the education level and cotton production area were effective on economic efficiency. Besides, in the study conducted by Örük (2020), it was determined that the effect of land size was negative on efficiency and in the study carried out by Wei et al. (2020), the education level of the producers had positive effect on the efficiency.

Table 8: Tobit analysis results: Factors affecting economic efficiency

Variable	Coefficient	Standard deviation	P
Producer's age	0.001596	0.004363	0.7145
Education period	0.025082**	0.012523	0.0452
Agricultural experience	-0.002678	0.003409	0.4322
Family size	-0.003879	0.010175	0.7030
Land size	0.000130*	0.000007	0.0917
Cooperative membership	-0.010829	0.043155	0.8019
Stock farming	-0.111261**	0.047915	0.0202
Credit use	-0.134011**	0.053380	0.0121
Likelihood ratio	11.57586***		

* Significant at %10 significance level, ** significant at %5 significance level, *** significant at %1 significance level

The regression analysis results, which was done in order to determine the effects of the inputs on cotton production, are given in Table 9. The equation related with the production function is given as exponential form below.

$Y = 2.531 * X_1^{0.087} * X_2^{0.606} * X_3\text{-}^{0.063} * X_4^{0.065} * X_5^{0.016} * X_6^{0.271}$

Determination coefficient of the production function (R^2) was calculated as 0.853. Besides, F statistics, used in order to test the significance of the model, was calculated as 64.872 and it was concluded that the model was statistically significant at 1% significance level. Accordingly, it was determined that 85.3% of the variations in the dependent variable was explained by the independent variables in the model and the selected model was appropriate. TV and VIF values indicated that there was not multicollinearity problem between the independent variables and Durbin-Watson d statistics value indicated that there was not autocorrelation between the error terms.

β coefficients in Cobb-Douglas production function indicated the elasticity. The total of the production elasticity was found as 0.982 and this indicated decreasing return to scale. In other words, by the increase of the variables in the function in the ratio of 1%, a decrease in the ratio of 1.8% would occur in the income. In the study carried out by Semerci and Çelik (2018), the total of the production elasticity was found as 0.976 and this result was similar to this research result.

The fertilizer costs and fuel costs variables were determined as statistically significant whereas labor, pesticide, seed and equipment rent costs variables were statistically insignificant. When the coefficients of the independent variables were examined, it was seen that pesticide costs (X3) input had negative signed production elasticity and the other factors had positive signed production elasticity.

The sign of fertilizer costs production factor coefficient was positive and statistically significant at 1% significance level. When the other variables were constant, the increase of the fertilizer costs in the ratio of 1% would increase the income in the ratio of 0.606%.

The sign of fuel costs production factor coefficient was positive and statistically significant at 1% significance level. When the other variables were constant, the increase of the fuel costs in the ratio of 1% would increase the income in the ratio of 0.271%. But, this should not be interpreted as the increase of the costs of the inputs will provide an increase in cotton income. This can be interpreted as the use of more qualified input will cause a particular increase in production value.

Table 9: Regression analysis results

	Coefficient	Standard deviation	T value	P value	TV	VIF
Constant	2.531	0.631	4.008	0.000***		
Labor costs	0.087	0.066	1.325	0.190	0.456	2.195
Fertilizer costs	0.606	0.116	5.247	0.000***	0.165	6.045
Pesticide costs	-0.063	0.057	-1.092	0.279	0.381	2.623
Seed costs	0.065	0.050	1.302	0.198	0.779	1.283
Equipment rent costs	0.016	0.012	1.342	0.185	0.781	1.280
Fuel costs	0.271	0.085	3.190	0.002***	0.255	3.927
R^2	0.853					
F test	64.872***					
Durbin-Watson d	2.339 ***					

*** p<0.01, ** p<0.05, * p<0.10

In the study conducted by Semerci and Çelik (2018), the increase of seed, fertilizer, energy, pesticide, harvest and land interest inputs in the ratio of 1% would increase the cotton income in the ratios of 0.29%, 0.26%, 0.20%, 0.04%, 0.12% and 0.16%, respectively.

Marginal incomes and efficiency coefficients of the factors were determined (Table 10). The geometric means of the factors were calculated by dividing the total to the sample size by taking the logarithm of the data. It was utilized from geometric means on the calculation of marginal yield values. Fertilizer (X2) input had the highest marginal yield value with 48.19 and fuel (X6) input followed this with 23.08. As the sign of pesticide (X3) input had negative sign, it had negative marginal yield (-48.05). The negative sign of the pesticide input showed that this input was used excessively. In the study conducted by Bayramoğlu and Çelik (2007), the insecticide use in cotton production was much, the irrigation number was low and labor and machinery were used efficiently.

When the marginal incomes of the production factors were examined, as in marginal yield values, it was seen that fertilizer input had the highest marginal income and fuel, labor, seed and equipment rent followed this.

The efficiency coefficients were calculated as 0.18 for labor (X1), 1.38 for fertilizer (X2), -0.20 for pesticide (X3), 0.72 for seed (X4), 0.07 for equipment rent (X5) and 1.24 for fuel (X6). The use of the factors which had efficiency coefficient higher than 1 should be increased and lower than 1 should be decreased. The negative sign of the efficiency coefficient of the pesticide input indicated that this input was used excessively. The efficiency coefficients of fertilizer and fuel inputs were higher than 1 and this indicated that these inputs were used under economic optimum. The fuel (X6), the efficiency coefficient of which was 1.24, was the input used closest to economic optimum.

Table 10: Marginal values and efficiency coefficients of the factors

Y = 871.79	**Labor (X1)**	**Fertilizer (X2)**	**Pesticide (X3)**	**Seed (X4)**	**Equipment rent (X5)**	**Fuel (X6)**
Geometric mean	10.87	10.96	10.08	9.11	6.78	10.24
Marginal yield	6.98	48.19	-5.45	6.22	2.06	23.08
Marginal income	61.58	425.22	-48.05	54.88	18.16	203.64
Marginal cost (factor prices)	348.95	307.28	159.91	76.75	255.48	164.08
Marginal efficiency coefficient	0.18	1.38	-0.30	0.72	0.07	1.24

5. Conclusion

In this study, the efficiency analysis of cotton production in Kahramanmaraş province of Turkey was done and besides, the factors affecting the income of cotton production were determined. Technical efficiency coefficient was found as 0.907 and it was determined that the producers were technically at good level. Technical efficiency and scale efficiency scores were found almost the same and it was concluded that the technical inefficiency resulted from the inefficiency in input use and scale inefficiency.

Allocative efficiency and economic efficiency in cotton production were found as 0.682 and 0.616, respectively. It was concluded that the enterprises made expenses in the ratio of 31.8% than the minimum costly input combination and the economically ineffective enterprises should decrease the expenses in the ratio of 38.4% in order to reach the level of the economically efficient enterprises

The factors affecting cotton production was econometrically analyzed. It was determined that the effects of the fertilizer and fuel costs on the cotton income were statistically significant. Besides, it was determined that there was decreasing return to scale in the enterprises.

The increase of the fertilizer and fuel costs were determined as two criteria affecting the income positively. Besides, when the marginal efficiency coefficients of these inputs were examined, it was seen that these inputs were used under economic optimum point. This state can be interpreted as by the effect of the increase of the input prices, the input use could be decreased. In agricultural production activities, increase of fertilizer subsidies would prevent the input use under economic optimum point and will remove the negative effect on profitability.

The results of this study indicated that the inputs used in cotton production should be used in economic optimum level. The efficient use of these factors will contribute to the reduction of the input costs and increment of the profit margin. The necessary regulations should be done for accounting records of the enterprises and the studies should be increased on the efficient use of the production inputs.

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