Technical efficiency and its determinants in watermelon production in Adana Province, Turkey

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Abstract

This study explores the technical efficiency of watermelon farms and their determinants, using the stochastic production frontier function, in the province of Adana in Turkey. The purpose of this analysis was to determine the cost of production and the technical efficiency of watermelon farms. Data of this study were collected from 69 randomly selected watermelon farmers. The results found that the unit production cost of watermelon was \$0.10 kg^{-1} and that labor costs accounted for the greatest share of the total cost. The findings show that technical efficiency coefficients varied from 0.45 to 1.00 in watermelon farms and the average was 0.82. As for the average farm, the intake of inputs at the same value may be 18% lower. Farm inefficiencies are usually triggered rather than spontaneous by preventable technological causes. There have been findings of farmers expanding their farming size, not only reducing input use but regulating off-farm influences, to enjoy the economy of production. In addition to the government's agriculture insurance programs and policies, their technical efficiencies in the study field should be increased.

Keywords: Watermelon, Stochastic frontier analysis, Inefficiency, Adana.

1. Introduction

Watermelon (*Citrullus lanatus*) is a plant species in the family Cucurbitaceae (Schippers, 2000), a vine-like flowering plant that scrambles and trails. It is originally from

West Africa. A total of 103.9 million tons of watermelons are produced on a total area of 3.2 million hectares in the world. Turkey is in the 7th rank in terms of production area, and 3rd rank in terms of production volume (FAOSTAT, 2018). In Turkey, 3.9 million tons of watermelon are produced in 83 thousand hectares, and the average yield is 46.43 tons/ha. Adana province is in the first place in terms of production area, and production volume with 15%, and 22%, respectively (TURKSTAT, 2020).

It is one of the important sources of income for watermelon producers in the cultivated regions. However, as in many products, producers are faced with risks and uncertainties in the watermelon production process. Since watermelon production is mostly carried out by small-scale enterprises, it is often not possible for producers to come together to determine the amount of production, to turn the prices in their favour and to make a production plan for the next year. This situation negatively affects the effective operation of the enterprises. In this study, the factors affecting the technical efficiency, and parameters which causes of the ineffectiveness with various variables in watermelon production.

Efficiency searches will decide whether or not the inputs are used at the desired stage. Any steps can be taken by recognizing the cause of inefficiency based on the findings of efficiency analyses so as to ensure more productive production, minimize costs and increase profits.

The main objective of this study was therefore to approximate, by using Stochastic Frontier Analysis (SFA) and evaluating factors that impact on technical production failures, the technical performance of watermelon farmers in Adana. In order to evaluate the input usage returns on scale (hereinafter RTS), the output elasticity was determined. By calculating the model and by evaluating technological productivity certain policy consequences for watermelon farms are proposed.

2. Literature Review

Measuring technical efficiency is to maximize production output using the available resources (Farrell, 1957). The use of frontier models for the investigation of farm technical efficiency has attracted substantial attention from researchers around the world (Battese, 1992; Bravo-Ureta et al., 2007; Latruffe et al., 2016). Since the technical efficiency aspect can be conveniently integrated, stochastic frontier functions are ideally favoured. The stochastic production frontier gives the highest amount of output that can be generated by inputs, technology and the production environment (Kumbhakar, 1987). The aim is to determine the potential increase in the amount of watermelon production without any improvement in inputs.

Some studies on technical efficiency in watermelon production, Otunaiya and Adedeji (2014) measured the level of technical efficiency, its determinants in production and the constraints in the production system in Nigeria. They used quantity of inorganic fertilizer, the quantity of seed(s), number of labor, total land area, herbicides usage, and other intermediate costs for efficiency, age of the farmer, sex of the farmer, marital status, off-farm income, number of farmers having, membership orientation on borrowing, experience, and educational level of farmers for inefficiency model.

Also, another study conducted in Nigeria, Ada-Okugbowa and Egbodion (2017) determine technical efficiency analysis among small scale watermelon farmers used farm size, planting material, family labor, hired labor, the /or quantity of fertilizer used, and quantity of pesticides used for efficiency, age, education level, experience, household size, gender, and contact with extension agent for inefficiency model.

Sarker et al. (2017) conducted a study of technological efficiencies, inefficiencies found and expectations of farmers on the main risk sources for watermelon production in Bangladesh. Seed usage, total labor input by family and hired, pesticide cost, tillage cost, irrigation cost, manure, and fertilizer variables used for efficiency, age, education level, the experience of farmers, watching and/or listening agriculture-related program, contact with extension agent, micro-credit usage, profession, and participation to training on watermelon production for inefficiency model. Adedeji *et al*. (2017) examined the technical efficiency and its determinants in watermelon farming in Nigeria by using farm size, labor, seeds, fertilizer, agrochemicals for efficiency, and age, education level, the experience of farmers, and household size for the inefficiency model.

Makuya *et al*. (2018) determined the cost efficiency level of watermelon farms, determining variation in cost efficiency between farms of different sizes and capital and examined sources of cost inefficiency. The parameters, pesticide, fertilizer, seed, land rent, and labor costs for efficiency model, and experience, sex, education level of farmers, logistic services, capital size, and firm size for inefficiency. Adeoye et al. (2020) have been employed to analyze factors affecting watermelon production among farmers in the study region and the technical efficiency of capital. They used seed, chemical, and fertilizer quantities, farm size and labor for the efficiency, and age, experience, education level of the farmers, household size, and extension visits for inefficiency model. In this study, to estimate the efficiency, watermelon production land, labor, fertilizer, seedling, and pesticide usage use were used.

They all contact with extension agent and have a habit of taking out agricultural insurance. That's why parameters such as age, education, experience, and off-farm income variables were used to estimate the factor affecting the inefficiency. Despite the huge production of watermelon in Turkey, there is a lack of study on watermelon production efficiency.

3. Materials and Methods

3.1. Analytical methodology

In research, the technique of watermelon production was tested using the Stochastic Frontier Analysis (SFA) method. The SFA approach establishes an interplay between dependent variables like prices, profits, output and explanatory variables like input variables and environmental variables (Berger and Humprey, 1997). The SFA also provides a model error term. Stochastic efficiency frontier approach, a parametric method, was developed by Aigner *et al*., (1977), Meeusen and Broeck (1977) and Battese and Corra (1977) to estimate production efficiency using $Y_i = x_j\beta + \varepsilon_i$ production function. Aigner *et al*., (1977) and Meeusen and Broeck (1977) reported that error term (ε_i) consisted of two separate components and the manufacturing function was formulated as follows:

$$Y_i = x_j\beta + v_i - u_i \quad (i = 1,2, \ldots., n) \tag{1}$$

$$v_i - u_i = \varepsilon_i \tag{2}$$

Y_i, Production function of i^{th} farm; x_i, input vector of i^{th} farm; β, coefficient. v_i, a random variable that cannot be controlled, has normal distribution $N\,(0, \sigma_v^2)$ and is independent of u_i. u_i is an independent random variable that is not negative, can be tested in part and thus contribute to technical inefficiency. Depending on the use of the function, u_i may be partially regular, truncated normal or exponential distributed. Battese and Coelli (1995) created the following model to describe changes in u_i that reflect technical inefficiency.

$$u_i = z_i\delta \tag{3}$$

In Eq.3, z_i reflects distinctive properties affecting technical inefficiency (e.g., educational standard, age, administrative approach) while representing coefficients. For a stochastic efficiency frontier method, the efficiency of the enterprise could be calculated by using Eq.1 as the ratio of the measured output to the predicted output (Coelli et al., 2005). Technical efficiency formulated as follows:

$$TE_i = e^{x_i\beta + v_i - u_i} / e^{x_i\beta + v_i} = e^{-u_i} \qquad (4)$$

where TE_i has a value ranged from 0 to 1, and if $u_i = 0$, means ith the farm is full technically efficient. Coelli (1995) claimed that the maximum-likelihood method is more suitable than the lowest square method to approximate production functions.

In the study, the technical efficiency of watermelon farmers was calculated using the Translog production function by the maximum-likelihood method. Translog production is an easy to estimate and highly tolerant form of variable elasticity production function (Christensen et al., 1973). The translog functional can be formulated as follows:

$$nY = \beta_0 + \sum_j \beta_j lnX_{ij}{}_{1} + \frac{1}{2}\sum_j\sum_k \beta_{jk} lnX_{ij}\, lnX_{ik}{}_{2} + v_i - u_i \qquad (5)$$

where, Ln is the natural logarithm, Y_i is output if i^{th} farm, x_i's are input variables presented in Table 1 and β's are estimated parameters

For the model specification, diagnostic tests were estimated using likelihood ratio test (LR) and variance parameters $Gamma\ (\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2))$, and *sigma square*$(\sigma^2 = \sigma_v^2 + \sigma_u^2)$. The disparity between real and expected quantities is solely induced by statistic noise when the value of γ is equal to zero. On the other hand, γ value closer to 1 shows technical inefficiency (Coelli *et al.*, 2005).

In the research, to calculate the efficiency of watermelon farmers, one output and four input variables were used. In the model, Output (Y_i) was watermelon yield, and inputs (x_i) were watermelon production land (WLi), labor (Li), fertilizer (Fi), seedling (Si), and pesticides (Pi). Thus, the translog function was formed as follows.

$$LNY = \beta_0 + \beta_1 ln_1WL_i + \beta_2 lnL_i + \beta_3 lnF_i + \beta_4 lnS_i + + \beta_5 lnP_i + ½\, \beta_6 lnWL_i^2 + ½\, \beta_7 lnL_i^2 + ½\, \beta_8 lnF_i^2 + ½\, \beta_9 lnS_i^2 + ½\, \beta_{10} lnP_i^2 + \beta_{11} lnWL_{i1}\, lnL_{i2} + \beta_{12} LnWL_{i1}\, lnF_{i3} + \beta_{13} LnWL_{i1}\, lnS_{i4} + \beta_{14} lnWL_{i1}\, lnP_{i5} + \beta_{15} lnL_{i2}\, lnF_{i3} + \beta_{16} lnL_{i2}\, lnS_{i4} + \beta_{17} lnL_{i2}\, lnP_{i5} + \beta_{18} lnF_{i3}\, lnS_{i4} + \beta_{19} lnF_{i3}\, lnP_{i5} + \beta_{20} lnS_{i4}\, lnP_{i5} + V_i - U_i \qquad (6)$$

The total output elasticity (RTS) is $eH_i + eHC_i + eFC_i + eL_i$ (Yang *et al*., 2020).

Where, e shows elasticity term. It was seen that the elasticity of each input (x_i) needs to be calculated, separately. To calculate each elasticity (RTS), the following formulas were used (Yang *et al*., 2020).

Output elasticity of watermelon land was shown to be an example below;

$$eH_i = \frac{dY_i/Y_i}{dWL_i/WL_i} = \beta_1 + \beta_6 lnWL_i + \beta_{11} lnL_i + \beta_{12} lnF_i + \beta_{13} lnS_i + \beta_{14} lnP_i \quad (7)$$

Considering the formula, the elasticity of the other inputs can be calculated. The elasticity of inputs refers to how many percentage points the output will increase when an input increases by 1% under the condition that other inputs remain unchanged in the same period.

In the research, to determinants of inefficiency effects, six non-random variables were used.

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \quad (8)$$

Variables such as the age of watermelon farmers, education level, experience, and off-farm income were used to explain technical inefficiency (u_i).

Table 1 presented descriptive data on the variables used in the model. In the analysis of economic efficiency, FRONTIER 4.1 software program was used. The analyses give the Maximum likelihood estimates of the parameters (Coelli, 1995).

3.2. Research data

The research was conducted in Adana province, which is one of the most significant agricultural and industrial centres in the south-central part of Turkey. The area is peculiar for fruits, vegetables and field crops production, and a large percentage of the inhabitants are farmers. Data in the study were collected through questionnaires with 69 watermelon farmers selected by random sampling method. Data belongs to the 2018-2019 production period. The sampling criteria was the size of the land reserved for the processing of watermelon, the sampling error margin of 10% and the confidence level of 90%. The sample size was determined by using the formula below;

$$n = \frac{N * s^2 * t^2}{(N-1) * d^2 + s^2 + t^2} \tag{9}$$

3.3. Method of data analysis

The cost of producing watermelon will vary depending on the location. Costs such as water and soil at least differ depending on the place, but the quantity of inputs, such as fertilizer, pesticide, etc., depends on the weather and soil (Rhodes and Zhang., 1999). The theory of opportunity cost was used for the calculation of the unit cost of production. The total cost of production was analysed under two variable and fixed headings. Seedling, fertilizers, pesticides, labour, diesel, machinery rentals, water, machinery repairs and maintenance, miscellaneous cost, and interest of variable costs were all part of the variable costs. Depreciation, rent of farmland, taxes, repairs and maintenance for buildings, interest on fixed costs and general operating costs are fixed costs (Kiral et al., 1999).

Production costs for watermelon is calculated as amounts used per hectare. Work duration and labour costs were included for the estimation of labor costs, including family and temporary labor. The fee charged for irrigation water by farmers was used as water for the cost of irrigation. Repair and maintenance costs for machinery is the share of watermelon production within the farm's total annual repair and maintenance costs. 4% interest rate was used for the interest of variable costs (ZB, 2019). 5.25% of the variable costs have been taken into account for miscellaneous costs in the production process. The overhead rate was usually measured as 3% of the total cost. In the case of building and machinery interest rates, the share of watermelon production multiplied by the existing interest rate of 10.50% (CBRT, 2019). The unit cost of production of watermelon was determined by dividing the total cost of production by the total volume of production (Kiral et al., 1999).

The output of the model was watermelon yield (ton ha^{-1}), and inputs were watermelon land (ha), labor (manpower $ha\text{-}^{1}$), fertilizer (kg ha^{-1}), seedling (number ha^{-1}) and pesticides ($ $ha\text{-}^{1}$). On the other hand, variables used to explain technical inefficiency (u_i), was the age of producer (year), education of producer (year), the experience of producer (year), and off-farm income (dummy).

4. Findings and Discussion

Farmers produced an average of 76.01 tons of watermelon with the largest producer producing 110 tons in the planting season. The average watermelon farm size was 12.12 hectares 3,170 seedlings were used per hectares. The use of the fertilizer was minimal with an average of 1,021 kg of fertilizers, and $ 3,714 valued pesticides being used per farm against a mean land area of 12.14 hectares. Farmers used an average of 32 manpower to produce and harvest the watermelon, although there was a wide variation, ranging from 18 to 55 manpower (Table 1).

Table 1: Descriptive statistics of the variables used in the SFA model

Variable	Description	Minimum	Maximum	Mean	Std. Dev.
Y_i	Watermelon yield (ton ha^{-1})	50.00	110.00	76.01	14.50
WL_i	Watermelon land (ha)	1.30	45.00	12.14	9.46
L_i	Labor (manpower ha^{-1})	17.50	55.00	31.59	8.29
F_i	Fertilizer (kg ha^{-1})	400.00	3,000.00	1,021.01	450.39
S_i	Seedling (number ha^{-1})	2,200.00	4,000.00	3,169.86	432.91
P_i	Pesticides ($ ha^{-1})	2,681.52	5,024.66	3,713.86	525.33
Z_1	Age of producer (year)	20.00	74.00	46.58	11.28
Z_2	Education of producer (year)	5.00	13.00	8.52	2.95
Z_3	Experience of producer (year)	2.00	42.00	21.91	11.45
Z_4	Off-farm income (If yes 1, otherwise 0)	0.00	1.00	0.33	0.47

All of the farmers are male and the average age is 47. The age of the farmer is a significant factor in deciding whether the household benefits from the expertise of older farmers or the risk-taking behavior of younger farmers. In formal schooling, the total number of years is 9 years. The experience of the farmers in watermelon production is 22, and 67% of farmers have off-farm income. The production cost of watermelon in the region has been calculated and shown in Table 2. In this basis, the total cost of production was $ 7 804.90 h^{-1}. It is estimated that 71.72% of the total cost of production was for variable costs and 28.28% for fixed costs.

Labor costs accounted for the largest share of the total costs, followed by land rent and pesticide costs.

Table 2: The calculation of watermelon production cost*

Cost items	$ h^{-1}	%
Variable costs (A)	**5,597.62**	**71.72**
Seedling	698.82	8.95
Fertilizers	755.44	9.68
Pesticides	818.75	10.49
Labor	1,883.29	24.13
Diesel	244.48	3.13
Machinery rent	399.86	5.12
Water for irrigation	85.31	1.09
Repairs and maintenance for machinery	237.73	3.05
Miscellaneous cost (A*5.25%)	268.99	3.45
The interest of variable costs (A*2.8%)	204.95	2.63
Fixed costs (B)	**2,207.28**	**28.28**
Depreciation	237.61	3.04
Land rent	1,466.05	18.78
Tax	43.59	0.56
Repairs and maintenance for farm buildings	83.34	1.07
Interest	149.36	1.91
General overhead (A+B)*0.03	227.33	2.91
Total production cost (C) = (A+B)	**7,804.90**	**100.00**
Watermelon yield (kg h^{-1}) (D)	76,010.00	
Unit cost ($ kg^{-1}) (C/D)	0.10	
The selling price of producer ($ kg^{-1})	0.16	

* $1= 5.67 Turkish Lira in 2019 (CBRT, 2020)

Details on the costs and returns, as well as the technical efficiency of the production of watermelons, would be of great benefit. Technical efficiency here refers to the capacity to achieve the maximum production amount with a given resource (Onyenweaku and Nwaru, 2005). According to Dung *et al*. (2010), the calculation of technical efficiency using the stochastic boundary production function makes it possible to decide if the divergence of technical efficiency from frontier output is due to specific agricultural factors or external random factors. The unit cost of watermelon was calculated to be $0.10 kg^{-1} and the average income was $0.16 kg^{-1}.

Table 3 represents the parameters of the stochastic production frontier model and the technical inefficiency model.

Despite the lack of a direct interpretation of the translog production frontier parameters, the stochastic production frontier parameter estimation Equation (9) summarized and explained in terms of output elasticities concerning various inputs. The γ parameter correlated with variances at the stochastic production frontier is calculated to be close to 1 (Table 3). Since the γ- parameter cannot be viewed as a proportion of the total variance described by the technical inefficiency effects, the findings show that the technical inefficiency effects do make a substantial contribution to the level and variation of watermelon production in the province of Adana. The result showed that the estimated coefficient of watermelon land input was positive and significant at 5% level. This means that the output will increase as the level of these independent variables increases. This conforms to the findings of Ada-Okugbowa and Egbodion (2017), Adedeji *et al*. (2017) and Adeoye *et al*. (2020). The estimated coefficient of labour input was negative and significant at 1% level. This means that the output decreased as the level of these independent variables increased. The estimated coefficient for fertilizer was positive and statistically significant at 5%. That means fertilizer usage increases watermelon production.

The estimated coefficient of seedling input was negative and significant at 1% level. The negative sign on the estimate for a seedling variable indicates that a decrease in seedling usage in watermelon production increases technical inefficiency.

For technical inefficiency effect, the coefficient of the education level of producer showed a positive relationship with the predicted technical inefficiency effect and was significant at 1% level. This suggests that an increase in education level may decrease technical inefficiency in the region. These results are consistent with studies by Otunaiya *et al*. (2014), Sarker *et al*. (2017), Adedeji *et al*. (2017).

Only the elasticity of fertilizer coefficient is elastic. Therefore, the output will increase by 0.073, 0.136, 0.018 and 0.262 per cent (on an average) for one percent decrease in watermelon land, labor, seedling and pesticide, respectively holding other factors constant.

The variance parameter of Sigma (σ^2) was 0.078 which is significant at 1% indicating the accuracy and fitness of the distributional assumption for the composite error term. The calculation of Gamma (γ) is an indicator of the degree of inefficiency in the various parameters and it ranges from 0 to 1. From the table, γ is estimated to be 0.999 and is significant at 1% indicating the amount of technical inefficiency of the farmers. This can be interpreted that 100% of random variation in farmers output is due to the difference in technical efficiency.

Table 3: Results of the SFA model for watermelon farms

	Coefficient	Std. error	t-value
Stochastic Production Frontier			
Constant (β_0)	59.883	0.990	60.492***
LnLand (β_1)	1.946	0.953	2.043**
LnLabor (β_2)	-10.339	1.201	-8.611***
LnFert (β_3)	2.564	1.068	2.400**
LnSeed (β_4)	-11.766	0.879	-13.393***
LnPest (β_5)	-0.061	0.804	-0.075
LnLandSQ (β_6)	-0.190	0.048	-3.919***
LnLaborSQ (β_7)	-1.157	0.404	-2.861***
LnFertSQ (β_8)	-1.022	0.175	-5.839***
LnSeedSQ (β_9)	4.376	1.013	4.321***
LnPestSQ (β_{10})	5.110	0.723	7.067***
LnLandLnLabor (β_{11})	-0.034	0.084	-0.407
LnlandLnfert (β_{12})	0.143	0.071	2.001**
LnLandLnSeed (β_{13})	0.674	0.487	1.383
LnLandLnPest (β_{14})	-0.962	0.501	-1.920*
LnLaborLnFert (β_{15})	0.396	0.174	2.269**
LnLaborLnSeed (β_{16})	1.152	0.784	1.469
LnLaborLnPest (β_{17})	0.274	0.747	0.367
LnFertLnSeed (β_{18})	1.130	0.469	2.409**
LnFertLnPest (β_{19})	-0.746	0.515	-1.448
LnSeedLnPest (β_{20})	-4.460	0.730	-6.108***
Elasticity			
eLand		-0.073	
eLabor		-0.136	
eFert		0.207	
eSeed		-0.018	
ePest		-0.262	
Total output elasticity (RTS)		-0.281	
Technical Inefficiency Model			
Constant (δ_0)	-0.182	0.403	-0.452
Age of producer (year) (δ_1)	-0.010	0.010	-1.056
Education of producer (year) (δ_2)	0.055	0.020	2.720***
Experience of producer (year) (δ_3)	0.006	0.009	0.621
Off-farm income (If yes 1, otherwise 0) (δ_4)	-0.081	0.132	-0.612
Variance parameters			
Sigma squared (σ^2)	0.078	0.011	7.116***

Gamma (γ)	0.999	0.000	3,415.284***
Ln (likelihood)		41.502	
LR test (λ^2)		24.757***	

*, **, *** significant at 10%, 5% and 1%, respectively.

Table 4 showed efficiency scores for watermelon farms. Efficiencies were estimated to be from 0.45 to 1.00 with an average of 0.82. As like farm average, 18% less input usage may be done at the same output volume. It can be stated that production costs will decrease as a result of ensuring efficiency in watermelon production. Otunaiya and Adedeji (2014) measured technical efficiency 65%, Ada-Okugbowa and Egbodion (2017) estimated 73%, Sarker *et al*. (2017) estimated 86%, Adedeji *et al*. (2017) estimated 90%. These findings point to major efficiency concerns for watermelon farms and may explain the high cost of the crop's production.

Table 4: Descriptive of technical efficiency in the watermelon farms

	Coefficient
Mean technical efficiency score	0.822 (%82)
Standard deviation	0.137 (%14)
Minimum	0.451
Maximum	0.999

Figure 1 revealed the distribution of the technical efficiency coefficients measured for farms. Twenty-two farms had an efficiency level of over 90%, that were all considered to be efficient. In comparison, 3% had less than 50% efficiency, while 4% had between 50 and 60%, 16% had efficiencies varying from 60 to 70%, 13% had efficiencies varying from 70 to 80%, and 32% had efficiencies varying from 80 to 90% of the remaining farms. Sixty-eight percent of the farms determined technically inefficient. Ada-Okugbowa and Egbodion (2017) found that %97 of the farms were inefficient. Adedeji *et al*. (2017) determined that 43.66% of watermelon farmers in the region were efficiency. Sarker *et al*. (2017) reported that 52.22% of the watermelon farmers in the region were efficient and 47.78% were not.

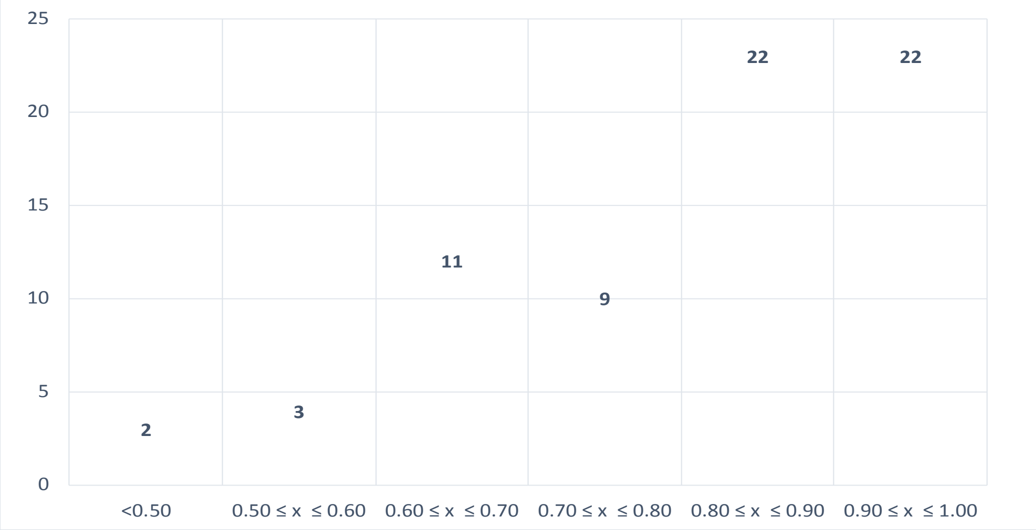

Figure 1: Distribution of the technical efficiency scores

Table 5 showed differences among efficiency and inefficiency of watermelon farms. According to results, there have been variations in some variables between efficient and inefficient watermelon farms. Differences for yield, watermelon growing land, number of seedlings, age, and education level of the producer were significant. Higher yields were granted to efficient farms ($p<0.01$) and these high yields were achieved by using more land growing watermelon ($p<0.05$), seedling usage per hectare ($p<0.05$). Also, technically efficient farmers were older ($p<0.10$), and have a higher education level ($p<0.05$) than inefficient ones.

Table 5: The differences between technically efficient and inefficient watermelon farms

Variables	Inefficient farms (n=47)	Efficient farms (n=22)
Watermelon yield (ton ha^{-1}) (Y)***	72.09	84.41
Watermelon land (ha) (x_1)**	10.41	15.84
Labor (manpower ha^{-1}) (x_2)	31.17	32.50
Fertilizer (kg ha^{-1}) (x_3)	1,029.79	1,002.27
Seedling (number ha^{-1}) (x_4)**	3,107.02	3,304.09
Pesticides ($ ha^{-1}) (x_5)	3,812.66	3,667.61
Age of producer (year) (z_1)*	45.44	49.00
Education of producer (year) (z_2)**	7.41	9.04

*, **, *** significant at 10%, 5% and 1%, respectively.

5. Conclusion

The study revealed that watermelon production was profitable in the production area. The results of the study show that the technical efficiency of watermelon production in Adana

Province is 82% on average, and that means there are still opportunities to improve productivity and profits in the study region by allowing more effective use of production tools. The unit costs of the farms were high due to low yields, weak farming potential and misuse of inputs. Issues in watermelon production may be solved by the introduction of practices that could improve the efficiency of input use. The required quantity and quality of input, using modern growing methods, could help eliminate efficiency problems in watermelon farming.

In the study area, watermelon farmers were not fully efficient. For this reason, the Government should establish policies for the expansion of production by improving cost efficiency and thus supply of watermelon to markets. Also, these policies should encourage farmers to use agricultural inputs efficiently using the minimum cost possible in watermelon production. This would continue to allow farmers to experience economies of scale by lowering the input price per unit and distributing fixed costs over large outputs. Producer prices in the watermelon, as in other agricultural products in Turkey is composed of perfect competition. However, due to factors such as border trade, manufacturers experience problems over time. In this respect, besides the effective input usage level of enterprises, the union of producers, and cooperatives need to be improved. To benefit from economies of scale in production, it appears that farmers should expand their farm sizes and increase watermelon production in the study area if this is solved with effective agricultural policies. To advance development, farmers can extend their production contributes to the economic production area where optimum output can be achieved.

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