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Estimation of Technical Efficiency (TE) for Watermelon Crop in Karma District Using Stochastic Frontier Approach

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Abstract. Agricultural production, in both parts of the plant and animal, is the main nerve of the national economy, as the economics of plant production is an important tributary to achieving the economic surplus that the world seeks, regardless of the different systems and inputs to achieve economic growth. Targeting the research: Estimating Technical Efficiency for Watermelon in Anbar province, Karma district, the random sample consisting of (67) farmers of the study population of 381 farmers for the productive year 2020, the results of estimating technical efficiency using the method of random boundaries analysis and using the trans-logarithmic function (Trans Loge), The average efficiency is about 81%, so it is required that these farms use only 81% or less of the inputs to produce the same quantity or more of the cereal crop in order to be described as technically efficient. It gave a modest estimate for the intercept part B0, as it reached a value of 8.95 it is less than the estimated values according to the corrected least squares method (COLS) and the method of Maximum Likelihood (ML), as it reached 9.12, 9.24. The estimations of the function parameters by the OLS showed a positive relationship between the quantity of the crop produced and the inputs (Seeds, pesticides, size of holding) while the relationship was negative with inputs (labor, fertilizer).

1. Introduction

Watermelon is considered one of the most important summer vegetables in Iraq and most Arab countries. From the marketing point of view, it is considered one of the highly marketable crops, as it takes a large share in terms of exportation, especially in the Arab markets, as its fruits bear shipping and storage, and it is also considered one of the strategic crops due to the high economic return for the farmer and for a short period, as it is the period from the date of cultivation until a period ranging from 75 - 90 days. It's cultivated in large areas in Iraq, exceeding 80 thousand dunums annually distributed over the various parts of the country. However, agriculture is concentrated in the governorates of Baghdad and Mosul. The original home of watermelon is tropical [**1**].

1.1. The Study Problem

We note that in light of the current situation, global and local changes, the Iraqi agricultural sector has suffered from many problems, including institutional and other economic problems, to achieve economic efficiency in the use of economic resources, many economic studies must be conducted, whether in agriculture or other than agriculture. In order for the economic departments and sectors to be implemented in a way that helps to achieve the desired economic growth, there is another problem that is measuring efficiency and determining its size, because this is one of the most important means of diagnosing defects in order to achieve rationality. Use of economic resources. The problem with systematic research is that, like other producers in agriculture, Watermelon farmers often lack the optimum use of economic resources. They work hard to achieve economic efficiency, its components, technical capabilities and allocation, which may deviate from the optimum use of resources.

1.2. The Study Objectives

The research aims to:

1.Estimation of the logarithmic transcendent production function of the paper yield of the research sample.

2.Estimation of Technical Proficiency (TE) by Stochastic Frontier Approach.
3.Estimating technical proficiency using the Trans Loge function.

1.3. Study Hypotheses

Although the cultivation of the watermelon crop is economically feasible, there is a variation in the optimal use of resources, which is reflected in the achievement of technical efficiency (TE).

1.4. The Importance of the Study
The importance of the study is that it is one of the important economic studies that dealt with the quantitative analysis of the most important factors affecting the estimation of the Stochastic Frontier Production Function (SAF), from which the technical efficiency of the watermelon crop farmers was obtained.

1.5. Study Method
1. The Secondary Data**:** It is reflected in reviewing books, studies and researches that have dealt with the study variables.
2. The Primary Data**:** we obtained it through the personal interview of the farmers according the questionnaire form prepared for this purpose

2. The Theoretical Framework

2.1. Production
Production is an activity that is carried out by transforming inputs into service or commodity outputs that have greater values, in order to create or increase benefits and work to increase levels of satisfaction of human desires, so production results in the following:
1- The benefits that are from production are essential benefits and are represented in the form of output compared with inputs, or it is a kind benefit such as training and education or a spatial benefit represented by the transfer of goods from one place to another or a time benefit represented by the storage process
2- Increasing the inputs value, meaning that it gives an added value for production inputs [**2**].

2.2. Production function
Production function is a mathematical expression between the amount of output obtained and the amount of production resources used to produce a particular commodity [3]. It is a table or mathematical equation or a graph that has large quantities of production per unit of the productive element during a certain period of time when using the best available production techniques [**4**]. To facilitate the study of these functions, some of the concepts used in this field to be studied: -
1. Average Product
Average Product (AP) is the amount of total output divided by the amount of resources used:
$AP = q / Xi$
2. Marginal Product
Marginal production (MP) is the change in total output as a result of changing resources per unit as other resources stabilize
$MP = \partial q / \partial Xi$

2.3. Cobb-Douglas production function
Cobb- Douglas function can be expressed in the following mathematical way:
y=AX1aX2b
b1 and b2 refer to the regression coefficients, it measures the marginal effect of production resources (X1, X2) on output (y), it also represents the partial elasticity of resources, sum of both refer (b1 + b2) to the nature of return to scale. If their sum is greater than one (b1 + b2> 1) then this corresponds to the case of increasing returns to scale. Whereas if their sum is equal to one (b1 + b2 = 1), then this indicates the constant of the return to scale, but if their sum is less than one (b1 + b2 <1) it indicates the decreasing of the return to scale. Since if the return to scale is constant, the case is simple to show in the Cobb- Douglas function that the substitution elasticity between resources is equal to one (Es = 1), that is, the elasticity of substitution between resources is constant, this fact may lead researchers to use the function as a general description of all production relationships ,the function was also chosen in many applications because of the ease of converting it to linear form, to puts the function in its logarithmic form [1], as it takes the following form:
Lny=LnA+b1LnX1+b1LnX2
There are some mathematical characteristics of the function [**5**].
1- homogeneous function of degree (a + b).
2- There is linear homogeneity when a + b = 1 (in a special case)
(That is, the homogeneous function of the first degree), characterized by constant returns to scale.

3- The isoquant curve has a negative slope and is convex towards the origin with respect to the values positive for the two production elements.

3. Previous studies

[**6**] study "Estimating the technical efficiency of wheat farms under supplementary irrigation using SFA, Telekif district," where sharp seasonal fluctuations were observed during the last three decades in the production of wheat for demilitarized agriculture due to the fluctuation of climatic conditions that affected the yield, especially the rains are due to the fluctuation of their quantities, the timing of their fall, and their spatial distribution, as the amounts of rainfall in the Takleh district amounted to about 186.5 mm for the agricultural season, the aim of the research is to estimate the technical efficiency of wheat farms using the method of (SFPF) using the superior logarithmic production function. Where he depended on field data for a random sample of 53 farms, the researcher concluded that the technical efficiency reached an average of 62%,this is that the effect of inefficiency represented by ui was equal to the one, it is the responsibility of this sample to produce the same amount of wheat using only 62% or less from the inputs to reach the optimum efficiency, a positive relationship was observed between mechanical technology, seeds, area and output of wheat, while this output was related to an inverse relationship with agricultural work and the amount of irrigation water, as the amount of irrigation increased in a way that exceeded the water crop requirement by 1% it will lead to a decrease in production by 0.808%, this led to a waste of resources and thus a decrease in technical efficiency below the optimal level. [**7**] studying "Estimating the technical, allocative and economic efficiency of the cultivated potato varieties using the DEA data envelope analysis method in Iraq for the spring cycle 2018, the importance of the research emerged from the importance of the potato crop, which occupies a prominent nutritional and economic position in food security at the local and global level. Despite of the expansion of the potato crop cultivation generally in Iraq in and in the Amiriya district in particular, the potato productivity is still below the required level, and this may be due to the lack of knowledge of the most efficient varieties and the failure to use production resources at levels at which technical, allocative and economic efficiency is achieved. The aim of the research is to determine the technical efficiency, allocative and economics according to the variety of seeds. researcher use the data enveloped analysis method (DEA) to estimate the technical, allocative and economics efficiency, assuming the constant and change of return to scale, the results of the study that the Safran type has achieved the highest average technical efficiency according to the constant of return to scale and the efficiency of scale in addition to that it achieved the highest technical efficiency average assuming the change of return to scale. It is evident from previous studies and research that the technical competency was estimated using the (SFPF) method using the superior production function logarithmic and the data envelope analysis method (DEA). This research adopted Stochastic Frontier Approach in estimating technical efficiency.

4. Work materials and methods

The primary data was obtained from its field sources, relying on the questionnaire form prepared for this purpose, data were collected through a personal interview for a sample of the watermelon farmers in the Karma district, their number reached (67) farmers, the total inputs of the production are:
X1: Work
X2: compost
X3: seeds
X4: Pesticides
X5: The size of the holding

Characterization of the Stochastic Frontier Approach

It is assumed in estimating and measuring the technical efficiency of each farm and knowing the stochastic frontier production function, which is a suitable function to study the productive efficiency of the sectors that suffer from problems and large variances in the data [8] as is the case in the agricultural sector, the stochastic frontier function includes an error, it takes the formula the following:

$\ln y_i = b_0 + \ln x_i + (v_i - uj)$..................1

whereas:
yi = the total quantities produced from the watermelon crop (kg) annually.
Vi = random error, normally distributed, mean equal to zero and constant variance, it includes measurement error and conditions outside the control of agriculture.
ui = random variable technical inefficiency.
on the basis of the model in Equation (1), the technical efficiency is calculated from dividing the actual

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production by the expected production in each farm and as follows:
TEi = yi / yi * …………… 2
Yi = Actual production
Yi * = expected production

To estimate the model parameters and measure the technical efficiency, we adopted the frontier statistical program. The function parameters were estimated in three different formulas, namely:
1- Estimation by the ordinary Least square method (OLS), which is the Best Linear Unbiased Estimator of the model parameters except for the intercept of the Y (B0 which is biased).
2- in order to make the estimation of the parameters B0 so that all the parameters are of good estimation unbiased, by using the ordinary Least square Corrected methods.
3- Re-estimating the function parameters by Maximum Likelihood (ML), from which the Technical Proficiency (TE) is calculated.

to measure this efficiency using Stochastic Frontier Approach, the stochastic function in equation (1) is transformed into the transcendent logarithmic function, which is called Trans Loge, so the model used to measure technical efficiency using the Stochastic Frontier Approach and in TL formula takes the following formula:

Lnyi = B0 +B1 Lnx1 + B2 Lnx2 + B3 Lnx3 + B4 Lnx4 + B5 Lnx5 +B6 (LnX1)2 + B7 (LnX2)2+ B8 (LnX3)2+ B9 (LnX4)2 +B10 (LnX5)2 +(vi-ui)**+**B11(lnx1 lnx2 lnx3 lnx4 lnx5)……3
whereas:
Y1 = the total quantities produced from the annual (kg)
X1 = Labor (hours)
X2 = amount of fertilizer (kg)
X3 = seed (kg)
X4 = pesticides (liter)
X5 = Size of the holding (dunams)

5. Results of the TE Stochastic Frontier Approach

The technical efficiency TE was estimated by the Stochastic Frontier Approach SFA according to the log-transloge (superior) production function TL by focusing on the basic inputs used in all sample farms, which included in addition to the dependent variable and independent variables (work, amount of fertilizer, amount of pesticides, quantity of seeds, The size of the farm), the estimates of the parameters of the explanatory variables mentioned for the logarithmic translog production function were obtained in three ways, namely, the normal least squares (OLS), the corrected least squares (COLS), the Maximum Likelihood(ML), and the estimation results are shown in the following table:

Table1. Estimation of production function

parameters	OLS	COLS	ML
B0	8.95	9.12	9.24
B1	-1.42	-1.42	-1.43
B2	-1.22	-1.22	-1.24
B3	1.14	1.14	1.20
B4	0.37	0.37	0.28
B5	3.63	3.63	3.80
B6	0.13	0.13	0.13
B7	0.12	0.12	0.11

B8	0.17	0.17	0.13
B9	-0.03	-0.03	-0.02
B10	-0.56	-0.56	-0.59
B11	-0.000085	-0.000085	0.000079

log likelihood function = -4.44

From the table it clear that the least squares method gave a modest estimate of the intercept B0 as it reached a value of 8.95, it was less than the values estimated according to the corrected least squares method (COLS) and the method of Maximum Likelihood (ML) as it reached 9.12, 9.24 in the two methods. The table also shows the value of the parameters of the Translog production function by the OLS method and after Correction to its value by the ML method that will be relied upon the values of its parameters interpret the relationship between the independent variables and the dependent variable. It should be noted that the parameters obtained by the ML and OLS method and were not identical, as the number of observations increases and the greater the size the sample, OLS and ML estimators, are unbiased, including random variance (Gujrati, 2004). Below is a general description of the numerical values of these parameters and their compatibility with economic logic.

1- Labor hours X1.

The reference of the agricultural work parameter to the inverse relationship between labor and production, where if labor increases by a one unit, production will decrease by (1.43).

2- The amount of fertilizer X2

The sign of elasticity of the variable was negative and conforming to the logic of economic theory, confirming the negative impact of this variable on the quantity of production in the sense that if the fertilizer exceeds the recommended limit in fertilizer by 10% leads to a decrease in the quantity of production by 12.4% , this means that the amount of fertilizer used by farmers exceeds the required level, which confirms the presence of waste in the use of Resources, especially in some crops that have root nodes that fix nitrogen in the soil m the use of fertilizers, especially urea, in such crops increases the group of vegetables without fruits.

3- seeds X3.

Through the t-test, the significance of the variable becomes clear, the variable parameter value in the production function TL represents the production elasticity of the resource, it's reached 1.20, as increasing the resource used by 1% leads to an increase in production by 1.20%, this indicates that there is no waste in the use of the resource by farmers because of the use of the resource according to scientific recommendations and reliance on reliable varieties. It is also noted that farmers do not use recycled seeds from last year, as germination and productivity of the type is guaranteed.

4-Quantity of pesticides X4

The signal of the pesticide variable of 0.28 corresponds to the economic logic, indicating the positive relationship between the quantity of pesticides and the output, meaning that an increase in the use of pesticides by 10% leads to an increase in the output by 2.8%.

5- The size of the holding X5.

The elasticity value of this variable showed the direct relationship between area and production, this means that production increases with the increase of the cultivated area and therefore it will increase by 3.80% if the area increased by 10%, this result is consistent with the economic theory logic.

Table2. The technical efficiency according to Stochastic Frontier Approach

Technical efficiency	farm	Technical efficiency	farm	Technical efficiency	farm
0.798	47	0.911	24	0.805	1
0.806	48	0.829	25	0.879	2
0.737	49	0.933	26	0.769	3
0.807	50	0.874	27	0.938	4
0.674	51	0.867	28	0.856	5
0.879	52	0.801	29	0.569	6
0.839	53	0.801	30	0.538	7
0.818	54	0.930	31	0.859	8
0.913	55	0.750	32	0.859	9

0.800	56	0.795	33	0.658	10
0.833	57	0.870	34	0.880	11
0.899	58	0.852	35	0.827	12
0.727	59	0.610	36	0.896	13
0.885	60	0.937	37	0.903	14
0.854	61	0.853	38	0.863	15
0.737	62	0.920	39	0.716	16
0.826	63	0.782	40	0.798	17
0.861	64	0.944	41	0.896	18
0.891	65	0.894	42	0.919	19
0.889	66	0.946	43	0.929	20
0.838	67	0.856	44	0.735	21
		0.753	45	0.791	22
		0.723	46	0.895	23
		0.946	Max. value		
		0.831	Average value		
		0.538	Min. value		

from the table that the highest value of technical efficiency reached 94% at the farm, sequence 43 in the above table, meaning that this farm has approached the level of full efficiency as it was able to achieve the highest output among the sample farms with a limited number of inputs, meaning that this farm should produce this amount of production. With only 94% of inputs or less, while the lowest level of efficiency reached 53% when the farm is sequence 7, as the farm that realizes this value in order to reach the efficiency stage must produce the current amount of output or more by using only 53% or less of the current inputs.

As for the average technical efficiency at the sample, it reached 83%, this result indicates that farmers can increase their production by 17% without increasing any amount of economic resources used in the production process. This means that the sample loses some economic resources, therefore incurs additional costs 17% of resource costs and also means that the farmer can produce the same previous product with less resources, which is approximately 17% of the resources used, average efficiency indicates that there is a deviation in the actual production at optimum production by 17%, the farmers can achieve it if the available economic resources are used optimally. It should be noted here that the sample farms did not achieve 100% full economic efficiency. Consequently, all farms did not produce on the productive potential curve and move away from it in different proportions, this means that these farms have the opportunity to reduce the amounts of economic resources used to obtain the same level of output or to use the amounts of resources used to obtain a higher level of production.

When dividing the levels of technical efficiency into different levels, it was found that 7.46% of farmers have limited technical efficiency between 50-70%, this is due to the great waste of some resources, especially labor and the amount of fertilizer, compared with other farms, while 20 farms achieved an efficiency that was limited to between 71-80%, it constituted 84.29% of the sample farmers, only 62.43% of the total sample had achieved technical proficiency levels above 83%. The results were obtained are comparable to the results of [**9,10**].

Table 3. Efficiency levels and numbers of farmers at each level.

Percentage %	Number	Technical Efficiency levels
2.98	2	60-50
4.47	3	61-70
29.84	20	71-80
62.45	42	81 and more

Source: From the researcher's work based on the technical competency results obtained using SFA method.

6. Conclusions

1- It is not necessary for farms to be technically efficient and volumetric; some farms may work well. The reason for the inefficiency because the bad conditions around the production unit.
2- The results of the study showed that primary education is the predominant among the sample farmers, where their percentage is (31.34%), while the percentage of illiteracy is (29.85%) of the total number of farmers, followed by graduates of university education at a rate of (17.91%), then after several intermediate and middle school graduates with a percentage (13.43%) and (7.46%).
3- The most common ownership class between (11-20) dunams, as this class constitutes more than (31%) of the total cultivated area.
4- The reference to the labor component came with a negative sign, which is contrary to the logic of economic theory. It is due to the use of many of the sample farmers to intensive family work and thus is reflected in the increase in costs.

5- The average technical efficiency estimated by the Stochastic Frontier Analysis (SFA) method according to the translog production function was about (79%), this means that there is a waste in the use of resources amounting to (21%) of the total quantities used, noting that one third of the farmer achieved technical efficiency more (78%).
6- It is not necessary for farms to be technically and volumetrically efficient, because some farms may work well, but the reason for inefficiency results from the bad conditions surrounding the production unit.

7. Recommendations

1- Using the agricultural production inputs in the scientifically recommended quantity
2- The work contributed to the deterioration of the technical efficiency ratio at the farm level, as it recommended that it be used according to the best needs.
3- From the average levels of efficiency achieved in most farms, there is an indication of the need to expand the size of the farms to accommodate the surplus inputs that caused the decrease in technical efficiency.
4- Study the reasons that led to the achievement of complete efficiency in some farms and try to take them as practical models to be emulated by inefficient units in order to reach full efficiency.

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