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Economics of Production and Costs of Tomato Crop in Sharkia Governorate

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ABSTRACT

This research aims, in general, at studying the estimation of production cost functions that reflect the relationship between total costs and actual production, through which can derive the most important economic indicators that reflect the extent to which agricultural production units achieve economic efficiency in their use of productive resources participating in the production process, as well as the extent to which these Units are a means of maximizing profits for the agricultural product. studying the production costs and associated indicators are also important, whether at the level of the production unit or at the national level, as they can be used in drawing and analyzing price policies and assisting agricultural producers in making their own production decisions, which motivate producers to continue and expand the production process or to stop production, in addition to determining the volume of production that achieves the most profits, and then achieving economic efficiency from the use of productive elements**.**

It is shown that the optimal production volume, which minimize costs of tomato production in the total sample of the study, amounted to about 35 tons, and that the actual total production volume of the farm amounted to about 54.3 tons, which is greater than the optimal production volume. As for the economic production volume that maximizes profit, it amounted to about 49.9 tons. Marginal costs amounted to about 3265.8 pounds, while average costs amounted to about 4512.5 pounds, and the elasticity of production costs was estimated at about 0.72, which indicates that the production of tomatoes at the level of the total study sample achieves economic efficiency, as it takes place in the stage of diminishing returns to capacity.

INTRODUCTION

The marketing of agricultural commodities is considered one of the main determinants of economic and agricultural development. Marketing is complementary and integral to the production process. The existence of an effective marketing system is necessary and vital to meet the requirements of the economic development process, ensuring the achievement of incentives for farmers, and the provision of information, services and systems that facilitate the arrival of commodities to the consumer in the form desired, suitable place, at the time needed, and at the lowest possible costs, as the development of agricultural products marketing systems is one of the priorities of the requirements for the progress.

The tomato crop is considered one of the most important vegetable crops in Egypt. Sharkia governorate is considered one of the important agricultural governorates in Egypt because of the cultivated and crop area it occupies, in addition to the diversity of agricultural exploitation patterns. The governorate is characterized by the cultivation of many vegetable crops. Country has taken care of the reclamation and cultivation of new areas of vegetables in Egypt, where the weather conditions are suitable for their cultivation. It is also one of the main areas of agricultural development in Egypt.

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Research problem:
The problem is summarized in the existence of a difference in the cultivated area of the tomato crop, many studies have recently tended towards trying to determine the optimal size of tomato production areas, especially in light of the agricultural development strategy's tendency towards increasing the agricultural area is about 3.5 million acres until 2030, The average value of Egypt's exports to European Union countries for agricultural products amounted to 923.28 million dollars during the period (2002-2021).

Search objective:
The research aims, in general, at studying economics of the production and costs for the tomato crop in the Sharkia Governorate, through achieving sub-objectives represented in estimating the production functions, identifying the most important specific production inputs for tomato production, as well as estimating the production elasticity of these inputs, and calculating the total elasticity specified to the nature of the production stage, while cost functions are used to measure the optimal size of tomato farms in new and old lands and to determine the economics of scale and returns according to the difference in the cultivated area, by studying the physical quantities and monetary values of agricultural inputs according to the different size of the farm and estimating the relative importance of the contribution of each input to the total costs, as well as estimating economic efficiency for the production elements, in a way that enables maximum use of the available production inputs.

Research methodology and data sources:To achieve its objectives, the research relied on the primary data obtained by a questionnaire that was prepared and collected through a purposed sample from Sharkia Governorate. The data analysis process included the use of some qualitative and quantitative statistical methods represented by the arithmetic mean and relative importance, in addition to estimating the production and cost functions to estimate as mentioned previously of scale, as well as calculating economic efficiency. Ismailia governorate and its districts were chosen according to the relative importance of the area and production of tomatoes, and the sample of farmers was selected in the study sample within the villages using purposed sample.

Results

Firstly: The statistical estimate for the production functions of the tomato crop in the field study sample:

<u>Estimation of the production functions for tomato crop in the study sample</u>:

Parameters of the productive function for tomato crop were estimated from the data of the study sample according to the model estimated in the (Cobb-Douglas) form converted to the double logarithmic form to simplify the estimation of the derivatives of the function and ease of interpretation, by entering all the productive inputs affecting the total output of an acre from tomato crop through the following form:

$$\ln Q = \ln \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ... + \beta_8 \ln X_8$$

where:

Q = the total yield per feddan of the tomato crop (tons / feddan).

X1 = the amount of seeds needed for cultivation (kg / acre).

X2 = the number of human labor units of the crop (hour / acre).

X3 = the number of mechanized labor units of the crop (hour/acre).

X4 = the amount of municipal fertilizer used (cubic meter / acre).

X5 = amount of nitrogen fertilizer (kg / acre).

X6 = amount of phosphate fertilizer (kg / acre).

X7 = amount of urea fertilizer (kg / acre).

X8 = amount of pesticides (liters / acre).

X9 = season production (winter - summer - indigo) of tomatoes (tons / acre).

B = production elasticity for each production element in the function.

A = constant amount of total output per feddan.
2.3Ln = log base 10.

(1) Production functions of the tomato crop at the total level of study sample:

The production elements that have a significant positive effect on the production of tomato crop for the total sample of study were determined through the estimated model of the total acre production function of the tomato crop using the phased multiple regression (stepwise) in the double logarithmic form, which is explained by the following equation:, The value of α fades in the long run

Ln Q = 0.46 Ln X_1+0.05 Ln X_2 + 0.06 Ln X_3 +0.39 Ln X_6

(3.1) (2.2)** (4.6)** (5.8)****

$\bar{R}^2$ = 0.77 F = 121.1 **

** Significant at the level of significance 5%.

Source: Collected and calculated from the results of the study questionnaire.

It was shown from the total output equation (Q) that the most important productive elements that have a significant impact on the total output per acre of the tomato crop are: the amount of seeds, human labor, mechanical work, and phosphate fertilizer, by estimating the different partial production elasticity for these elements, it was shown that the production elasticity of the amount of seeds, human labor, mechanical labor, and phosphate fertilizer amounted to about 0.46, 0.05, 0.06, 0.39, respectively, This indicates that the increase of the used amount from elements by 10% leads to an increase in the production of an acre of tomatoes by 4.6%, 0.5%, 0.6%, and 3.9%, respectively. The significance of these results has been statistically proven at a significant level of (0.05).

The total productivity elasticity (E.P.) of the function was estimated at about 0.96, and this means that increasing these production elements at the estimated equation by 10% leads to an increase in the total output of an acre of tomatoes by about 9.6%. This indicates that the production takes place in the second stage of production (the economic stage), whereas The increase percentage in the amount of total output per acre is greater than increase percentage in the quantity of production elements used, which means a decrease in the return to scale because the elasticity of production is less than one.

The modified coefficient of determination ($\bar{R}^2$) was about 0.77, which indicates that those independent variables explained by the estimated function are responsible for about 77% of the total changes occurring in the total output of an acre of tomato crop, and the value of (F) indicates the statistical significance of the estimated function at a significant level (0.05).

The marginal product and the average product were estimated for each productive element in the estimated total product function of the tomato crop in the total study sample. It was shown from Table (1) that the marginal product (M.P.) of the tomato crop in relation to both the amount of seeds, human labor, mechanical labor and phosphate fertilizers was estimated at about 0.005, 0.003, 0.19, 0.12 tons / acre for these production elements, respectively, and the value of The marginal product (V.M.P) of these production elements is about 11.1, 6.6, 418, and 264 pounds/acre, respectively.

Table 1. Indicators of economic efficiency for using production elements used in the tomato production function, in the total sample of the study for season (2021-2022)

Statement	The production factors (inputs) in the aggregate product function			
	Quantity of seeds X1	Human labor X2	mechanical labor X3	phosphate fertilizer X6
The average quantity of the production factor $\bar{X}$	5100	814.2	17.2	170.3
Average of total product (tons)			54.3	
Production Elasticity of production factor (E.X)	0.46	0.05	0.06	0.39
Total Elasticity of production (E.P)			0.96	
Average product (A.P.) (ton/acre)	0.011	0.07	3.16	0.32
Marginal Product (M.P.) (ton/acre)	0.005	0.003	0.19	0.12
Value of marginal Product (V.M.P.) (EGP)	11.1	6.6	418	264
Price of production factor unit (PX) ((EGP)	11	20	125	8.9
Economic Efficiency (E.E)	1	0.33	3.34	29.6

Where :
Price of the main product unit (the price of a ton from tomatoes) = 2200 pounds.
Average output (A.P.) = total production per acre ÷ total amount of production input per acre.
Marginal Product (M.P.) = Elasticity of the Production input(E.X.) * Average Product (A.P).
Marginal Product Value (V.M.P.) = Marginal Product (M.P.) x the price of main product unit (PQ)
Economic efficiency (E.E.) = value of marginal product (V.M.P.) ÷ the price of production input unit (PX)
Source: collected and calculated from the results of the questionnaire for studying the production season (2021-2022).

While the average of unit price for the quantity of seeds was about 11 pounds/kg, the average wage for a unit of human labor was about 20 pounds/hour, the average wage for a mechanical labor unit was about 125 pounds/hour, and the average of unit price of phosphate fertilizer was about 8.9 pounds/effective unit.

It was also shown from Table (1) that the average yield (A.P.) of the tomato crop in relation to both the amount of seeds, human labor, mechanical labor and phosphate fertilizer was estimated at about 0.011, 0.07, 3.16, 0.32 tons/acre for those production elements, respectively.

The economic efficiency of using the productive factors was estimated in the estimated total product function. The economic efficiency index is calculated by dividing the value of marginal product (V.M.P) for each productive element by (÷) the unit price of this productive element (PX). Table (1) shows that the value of The index of economic efficiency for each of the quantity of seeds, mechanical work and phosphate fertilizer was found to be greater than the correct one, which reflects a rise in the level of economic efficiency for the use of these production elements, as it was found that the value of the marginal product of the production element was higher than the unit price of the production elements.

The economic efficiency of using the production factors was estimated by the estimated total product function. The economic efficiency parameter is calculated by dividing the value of marginal product (V.M.P) for each production factor by (÷) the unit price of this production factor (PX). Table (1) shows that the value of the economic efficiency parameter for each of the quantity of seeds, mechanical labor and phosphate fertilizer was found to be greater than one, which reflects a rise in the level of economic efficiency for the use of these production factors, as it was found that the value of the marginal product of the production factor was higher than the price of the production factor unit.

while human labor, it was found to be less than the one, which reflects the low level of economic efficiency for using of this production factor, as it was found that the value of the marginal product of the production factor was lower than the price of its unit. It is advised to minimize the used quantities of this production factor, until the value of its marginal product equals with the price of its unit.

(**2) Function of Tomato production for the first tenure category (1 acre to less than 3 acres):**

The production factors that have a significant positive effect on the production of the tomato crop in the short term for the first tenure category in the study sample were determined through the estimated model of the total acre production function of the tomato crop using the phased multiple regression (stepwise) in the double logarithmic form, which is explained by the following equation:

$$\text{Ln } Q = 0.08 + 0.59 \text{ Ln } X1 + 0.12 \text{ Ln } X2 + 0.26 \text{ Ln } X6$$
$$(0.12) \quad (1.9)^{**} \quad (2.01)^{**} \quad (2.5)^{**}$$
$$\bar{R}^2 = 0.8 \qquad F = 85.9$$

**Significant at the level of significance 5%.

Source: Collected and calculated from the results of the study questionnaire.

Whereas it was shown from the estimated total output function that the most important production factors that have a significant impact on the total output per acre of the tomato crop are represented in the amount of seeds, human labor and phosphate fertilizer, and by estimating the different partial production elasticity of these factors, it was shown that the production elasticity of the amount of seeds, human labor and phosphate fertilizer amounted to about 0.59, 0.12, 0.26 for each of them respectively, This indicates that increasing the used amount of factors by 10% leads to an increase in the production of an acre of tomatoes by 5.9%, 1.2%, and 2.6%, respectively. The significance of these results was statistically proven at the level of significance (0.05). The total production elasticity (E.P.) of the function was estimated at about 0.97, and this means that increasing these production factors in the estimated function by 10% leads to an increase in the total output of an acre of tomatoes by about 9.7%, and this indicates that production locates at the beginning of the second stage of production (the economic stage). As the rate of increase in the amount of total output per acre is greater than the rate of increase in the amount of production factors used, which means an increase in the return of scale.

The modified coefficient of determination ($\bar{R}^2$) was about 0.80, which indicates that those independent variables explained by the estimated function are responsible for about 80% of the total changes occurring in the total output of an acre of tomato crop, and the value of (F) indicates the statistical significance of the estimated function at a significant level (0.05).

Both marginal product and average product were estimated for each production factor in the estimated total product function of the tomato crop in the first tenure category at the study sample, as it was shown from Table (2) that the marginal product (M.P.) of the tomato crop in relation to both the amount of seeds, human labor and phosphate fertilizer was estimated at about 0.02, 0.008, and 0.08 tons/acre for those production factors, respectively, and the value of the marginal product (V.M.P) for those production factors was estimated in about 44, 18.48, and 184.3 pounds/acre, respectively. While the average unit price of the quantity of seeds was 11 pounds/kg, the average unit price of human labor was about 20 pounds/hour, and the average unit price of phosphate fertilizer was 8.9 pounds/effective unit, As shown in Table (2), the average product (A.P.) of the tomato crop in relation to both the amount of seeds, human labor and phosphate fertilizers, was

estimated at about 0.03, 0.07, 0.32 tons/acre for these productive elements, respectively.

The economic efficiency of using the production factors was estimated by the estimated total product function. The economic efficiency parameter is calculated by dividing the value of the marginal product (V.M.P) for each production factor by (÷) the unit price of this production factor (PX). Table (2) shows that the value the economic efficiency parameter for both the amount of seeds and phosphate fertilizer is greater than one, which indicates a high level of economic efficiency for the use of these elements, as it shows that the value of the marginal product of the production factor is higher than its unit price, it is recommended to use additional quantities of these factors, but for human labor, it was found to be less than the one, which reflects the low level of economic efficiency for the use of this production factor, as it was shown that the value of the marginal product of the production factor was lower than its unit price, and it is advised to minimize the used quantities of this production factor, until the value of its marginal product equals to its unit price.

Table 2. Indicators of economic efficiency for using the production factors used in the tomato production function in the first tenure category in the study sample for season (2021-2022)

Statement	The production factors (inputs) in the aggregate product function		
	Quantity of seeds	**Human labor**	**phosphate fertilizer**
	X_1	X_2	X_6
The average quantity of the production factor $\bar{X}$	1690	671.9	140.3
Average of total product (tons)			
Production Elasticity of production Factor (E.X)	0.59	0.12	0.26
Total Elasticity of production (E.P)			
Average product (A.P.) (ton/acre)	0.03	0.07	0.32
Marginal Product (M.P.) (ton/acre)	0.02	0.008	0.08
Value of marginal Product (V.M.P.) (EGP)	44	18.48	184.3
Price of production factor unit (PX) ((EGP)	11	20	8.9
Economic Efficiency (E.E)	4	0.92	20.7

Where :

Price of the main product unit (the price of a ton from tomatoes) = 2200 pounds.

Average output (A.P.) = total production per acre ÷ total amount of production input per acre.

Marginal Product (M.P.) = Elasticity of the Production input(E.X.) * Average Product (A.P).

Marginal Product Value (V.M.P.) = Marginal Product (M.P.) x the price of main product unit (PQ)

Economic efficiency (E.E.) = value of marginal product (V.M.P.) ÷ the price of production input unit (PX)

Source: collected and calculated from the results of the questionnaire for studying the production season (2021-2022).

(3) Function of the tomato production for the second tenure category (from 3 acres to less than 6 acres):

The production factors that have a significant positive effect on the production of the tomato crop in the short term for the second tenure category in the study sample were determined through the estimated model of the total acre production function of the tomato crop using the phased multiple regression (stepwise) in the double logarithmic form, which is explained by the following equation:

$$\text{Ln } Q = 1.6 + 0.45 \text{ Ln } X_2 + 0.54 \text{ Ln } X_3 + 0.2 \text{ Ln } X_6$$
$$(0.5) \quad (2.1)^{**} \quad (2.3)^{**} \quad (3.2)^{**}$$
$$\bar{R}^2 = 0.86 \qquad F = 124.5$$

**Significant at the level of significance 5%.

Source: Collected and calculated from the results of the study questionnaire

Where it was shown from the estimated total production function that the most important production elements that have a significant impact on the total output per acre of the tomato crop are human labor, mechanical work, and the amount of phosphate fertilizer, by estimating the different partial production elasticity of these elements, it was found that the production elasticity of human labor, mechanical labor, and the amount of phosphate fertilizer amounted to about 0.45, 0.54, and 0.2, respectively, which indicates that increasing the used quantity of elements by 10% leads to an increase in the production of an acre of tomatoes by 4.5%, 5.4%, 2%, respectively, and the significance of these results was statistically proven at the level of significance (0.05).

The total production elasticity (E.P.) of the function was estimated at about 1.19, and this means that an increase of these production factors by 10% leads to an increase in the total product of an acre of tomatoes by about 11.9%, this means that the rate of increase in the quantity of the total output of an acre is greater than the rate of increase in the quantity of factors used in the production and this means an increase in the return on scale because the elasticity of production is greater than one.

The modified coefficient of determination ($\bar{R}^2$) was about 0.86, which indicates that those independent variables explained by the estimated function are responsible for about 86% of the total changes occurring in the total output of an acre of tomato crop, and the value of (F) indicates the statistical significance of the estimated function at a significant level (0.05).

Both marginal product and average product were estimated for each production factor in the estimated total product function of the tomato crop in the second tenure category at the study sample, as it was shown from Table (3) that the marginal product (M.P.) of the tomato crop in relation to both the human labor, mechanical labor and phosphate fertilizer was estimated at about 0.03, 1.69, and 0.06 tons/acre for those production factors, respectively, and value of the marginal product (V.M.P) for those production factors was estimated in about 66, 3683, and 132 pounds/acre, respectively. While the average unit price of the human labor amounted to about 20 pounds/hour, the average unit price of human labor was about 20 pounds/hour, the average unit price of mechanical labor was about 125 pounds/hour and the average unit price of phosphate fertilizer was 8.9 pounds/effective unit. As it was shown in Table (3), the average product (A.P.) of the tomato crop in relation to both the human labor, mechanical labor and phosphate fertilizers, was estimated at about 0.07, 0.31, 0.32 tons/acre for these productive factors, respectively.

The economic efficiency of using the production factors was estimated through the estimated total product function. The economic efficiency parameter is calculated by dividing the value of the marginal product (V.M.P) for each production factor by (÷) the unit price of this production factor (PX). Table (3) shows that the value of The economic efficiency parameter for human labor, mechanized labor, and the quantity of phosphate fertilizer is greater than one, which indicates a high level of economic efficiency for using these elements, as it shows that the value of the marginal product of the production factor is higher than its unit price .

Table 3. Indicators of economic efficiency for using the production factors used in the tomato production function in the second tenure category, in the study sample for season (2021-2022)

Statement	The production factors (inputs) in the aggregate product function		
	Human labor	**mechanical labor**	**phosphate fertilizer**
	X_2	X_3	X_6
The average quantity of the production factor $\bar{X}$	1024.7	21.4	214.6
Average of total product (tons)		67.9	
Production Elasticity of production Factor (E.X)	0.45	0.54	0.2
Total Elasticity of production (E.P)		1.19	
Average product (A.P.) (ton/acre)	0.07	3.1	0.32
Marginal Product (M.P.) (ton/acre)	0.03	1.69	0.06
Value of marginal Product (V.M.P.) (EGP)	66	3683	132
Price of production factor unit (PX) ((EGP)	20	125	8.6
Economic Efficiency (E.E)	3.3	29.4	15.3

where:

Price of the main product unit (the price of a ton from tomatoes) = 2200 pounds.

Average output (A.P.) = total production per acre ÷ total amount of production input per acre.

Marginal Product (M.P.) = Elasticity of the Production input(E.X.) * Average Product (A.P).

Marginal Product Value (V.M.P.) = Marginal Product (M.P.) x the price of main product unit (PQ)

Economic efficiency (E.E.) = value of marginal product (V.M.P.) ÷ the price of production input unit (PX)

Source: collected and calculated from the results of the questionnaire for studying the production season (2021-2022).

(4) Function of the tomato production for the third tenure category (6 acres or more):

The production factors that have a significant positive effect on the production of the tomato crop in the short term for the third tenure category in the study sample were determined through the estimated model of the total acre production function of the tomato crop using the phased multiple regression (stepwise) in the double logarithmic form, which is explained by the following equation:

Ln Q = 0.18 **+** 0.16 **Ln X_2 +** 0.2.7 **Ln X_3 +**0.37 **Ln X_7**

$(6.4)^{**}$ $(2.1)^{**}$ $(4.5)^{**}$ $(3.3)^{**}$

$\bar{R}^2$ **= 0.91 F = 212.5****

**Significant at the level of significance 5%.

Source: Collected and calculated from the results

It was shown from the estimated total output function that the most important productive elements that have a significant impact on the total output per acre of the tomato crop are represented in human labor, mechanized labor, and the amount of urea fertilizer. Urea fertilizer amounted to about 0.16, 0.27, 0.37, respectively, which indicates that increasing the used amount of elements by 10% leads to an increase in the production of tomatoes per acre by 1.6%, 2.7%, and 3.7%, respectively. The significance of these results was statistically proven when Significance level (0.05).

Elasticity of The total production (E.P.) function was estimated at about 0.80, and this means that increasing these production factors 10% leads to an increase in the total output of an acre from tomatoes by about 8%, and this indicates that the production lies in the second stage of production (the economic stage)

The modified coefficient of determination ($\bar{R}^2$) was about 0.91, which indicates that those independent variables explained in the estimated function are responsible for about

91% of the total changes occurring in the total output of an acre of tomato crop.

Data of table (4) showed that the average product (A.P.) of the tomato crop for both human labor, mechanical labor and the amount of urea fertilizer was estimated at about 0.09, 0.52, and 0.27 tons/ acre for these production elements, respectively.

Table 4. Indicators of economic efficiency for using the production factors, used in the tomato production function in the third tenure category, in the study sample for the season (2021-2022)

Statement	The production factors (inputs) in the aggregate product function		
	Human labor	**mechanical labor**	**phosphate fertilizer**
	X_2	X_3	X_7
The average quantity of the production factor $\bar{X}$	1154	210	398
Average of total product (tons)		109.6	
Production Elasticity of production Factor (E.X)	0.16	0.27	0.37
Average product (A.P.) (ton/acre)	0.09	0.52	0.27
Marginal Product (M.P.) (ton/acre)	0.0144	0.14	0.099
Value of marginal Product (V.M.P.) (EGP)	31.68	308	217.8
Price of production factor unit (PX) ((EGP)	20	125	7.2
Economic Efficiency (E.E)	1.6	2.5	30.2

where:

Price of the main product unit (the price of a ton from tomatoes) = 2200 pounds.

Average output (A.P.) = total production per acre ÷ total amount of production input per acre.

Marginal Product (M.P.) = Elasticity of the Production input(E.X.) * Average Product (A.P).

Marginal Product Value (V.M.P.) = Marginal Product (M.P.) x the price of main product unit (PQ)

Economic efficiency (E.E.) = value of marginal product (V.M.P.) ÷ the price of production input unit (PX)

Source: collected and calculated from the results of the questionnaire for studying the production season (2021-2022).

The marginal product and the average product were estimated for each production factor in the estimated total product function of the tomato crop in the second tenure category in the study sample, as it was shown from table (4) that the marginal product (M.P.) of the tomato crop in relation to both human labor, mechanical labor and the amount of urea fertilizer was estimated at about 0.0144, 0.14, and 0.099 tons/acre for those each of them, respectively, and the value of marginal product (V.M.P) for those factors was estimated at about 31.68, 308, and 217.8 pounds/acre, respectively. Whereas, the average wage for a unit of human labor was about 20 pounds/hour, the price of a unit of mechanical labor was about 125 pounds/hour, and the average unit price of a unit of urea fertilizer was about 7.2 pounds/effective unit.

The indicators of economic efficiency for using the three production factors were estimated in the estimated total product function, by dividing the value of the marginal product (V.M.P) for each production factor by (÷) the unit price of this production factor (PX). Table (4) shows that the value of the economic efficiency parameter for each of Human labor, mechanized labor, and urea fertilizer are greater than one, which indicates a high level of economic efficiency for the use of these three elements, as it was shown that the value of the marginal product of the production factor increased more than the unit price of the production factor for the three elements.

Second: the statistical estimate for the cost functions of the tomato crop.

This part includes a detailed view of the economic indicators of the costs for producing the tomato crop at the level of the different tenure categories based on the data of the field study sample, as well as estimating the functions of production costs for each holding category (short term) and the total sample (long term).

(1)The function of tomato production costs at the level of the total sample (the long run):

By estimating the parameters of the total costs function (T.C) for producing the tomato crop in the long run at the level of the total study sample in the quadratic and cubic form using the data of the study sample, it was found that the best estimated form is the function in the quadratic form, which is explained by the following equation:

$T.C = 5759.2\ Q - 35.62\ Q^2$ ……..... (1)

(2. 3)** (5.3)**

$R^2 = 0.91$ F = 378**

where:

T.C = total production costs (LE) for tomato production at the level of the total study sample.

Q = actual total output (tons.(

** Significant at the level of significance 1%.

The total costs function (T.C) for the production of the tomato crop in the total sample of the study shows that the total output (Q) is responsible for about 91% of the total changes occurring in the total costs of the tomato crop. The average cost function (A.C) in the long run was estimated by the following equation (2):

A.C = 5759.2 – 35.62Q …….. (2)

The marginal cost function (M.C) was also estimated in the long run by conducting the first derivative of the derived total cost function (T.C) referred to in equation (2) and obtaining the marginal cost function described in equation (3):

M.C = 5759.2 – 71.24Q …….. (3)

It is shown that the optimal production volume that minimizes costs for tomato production in the total sample of the study amounted to about 35 tons, which is achieved at the lower limit of average costs in the long run or achieved when marginal costs (MC) are equal to average costs (A.C), and the volume of actual total output of the farm amounted to about 54.3 tons, which is greater than the optimal volume of production. As for the volume of economic production that maximizes profit amounted to about 49.9 tons, which is achieved when marginal costs (M.C) are equal to marginal revenue (M.R), and it is equal to the unit price of final product (PQ) in the market of perfect competition, and to find the elasticity of production costs (E.C.), the marginal costs (M.C) are divided by the average costs (A.C), where the marginal costs amounted to about 3265.8 pounds, and the average costs amounted to about 4512.5 pounds, then the elasticity of production costs was estimated at about 0.72, which indicates that the production of tomatoes on the level of the total study sample achieves economic efficiency, as it lies in the stage of diminishing returns to scale as shown in Table (5).

(2) The function of the costs for producing the tomato crop for the first category in the study sample:

By estimating the parameters of the total costs function (T.C) for producing the tomato crop in the short term on the level of the first tenure category in the quadratic and cubic form using the data of the study sample, it was found that the best estimated form is the function in the quadratic form, which is explained by the equation (1)

$T.C = 11960.1 + 577.5\ Q - 10.9\ Q^2$ …….. (1)

(5.1)** (3.5)** (-2.2)*

$R^2 = 0.89$ F = 168**

Where

T.C = Total production costs (EGP) for producing tomatoes on the level of the first tenure category.
Q = actual total output (tons).

The total cost function (T.C) for producing the tomato crop in the first holding category shows that the total output per acre (Q) is responsible for about 89% of the total changes occurring in the total costs of the tomato crop. The average cost function (A.C) in the short run is calculated by dividing the total cost function (T.C) by the volume of production (Q), thus obtaining equation (2):

A.C = 11960.1/ Q + 577.5 - 10.9 Q ……..…. (2)

The marginal cost function (M.C) was also estimated in the short run by performing the first derivative of the total cost function (T.C) referred to in equation (2) and obtaining the marginal cost function explained in equation (3):

M.C = 577.5 **–** 21.8 **Q…… (3)**

It turns out that the optimal production volume, which lowers the costs of tomato production in the first holding category, amounted to about 33.1 tons, which is achieved at the lower end of the average costs in the short run, or achieved when the marginal costs (M.C) are equal to the average costs (A.C).

……The actual total production volume amounted to about 45.2 tons, which is greater than the optimal production volume. The volume of economic production that maximizes profit, amounted to about 56.1 tons, which is achieved when marginal costs (M.C) are equal to marginal revenue (M.R), and it is equal to the unit price of final product (PQ) in a perfect competition market, to find the elasticity of production costs (E.C.), the marginal costs (M.C) are divided by the average costs (A.C), where the marginal costs amounted to about 144.08 pounds, and the average costs amounted to about 577.8 pounds. The elasticity of production costs was estimated at about 0.24, which indicates that tomato production is on the level of first tenure category in the study sample achieves economic efficiency, given that production is located in the stage of diminishing returns to scale, as shown in Table (5).

(3) The function of the costs for producing the tomato crop, the second category, in the study sample:

By estimating the parameters of the total costs function (T.C) for producing the tomato crop in the short term on the level of the second tenure category in the quadratic and cubic form using the data of the study sample, it was found that the best estimated form is the function in the quadratic form, which is explained by equation (1):

$T.C = 71547.5 + 2636.7\ Q - 16.99\ Q^2$ …….…… (1)

$(3.2)^{**}$ $(4.7)^{**}$ $(-3.01)^{**}$

$R^2 = 0.88$ $F = 380^{**}$

Where:

T.C = Total production costs (EGP) for producing tomatoes on the level of the second tenure category.
Q = actual total output (tons).

The function of the total costs (T.C) for producing the tomato crop in the second tenure category shows that the total output per acre (Q) is responsible for about 88% of the total changes occurring in the total costs of the tomato crop, and the significance of the function and its parameters were statistically proven at a significant level of 1%, The average cost function (A.C) in the short run is calculated by dividing the total cost function (T.C) by the volume of production (Q), thus obtaining equation (2):

A.C = = 71547.5 / Q + 2636.7 - 16.99 Q …….. (2)

The marginal cost function (M.C) was also estimated in the short run by conducting the first derivative of the total cost function (T.C) with respect to the production quantity Q referred to in equation (2) and obtaining the marginal cost function explained in equation (3):

M.C = 2636.7 - 33.98 Q …….. (3)

It shown that the optimal production volume, which minimizes the costs of tomato production in the second tenure category, amounted to about 64 tons, which is achieved at the lower end of the average costs in the short term, or achieved when the marginal costs (MC) are equal to the average costs (A.C), and the actual total output volume amounted to about 67.9 tons, which is greater than the optimum production volume. As for the volume of economic production that maximizes profit amounted to about 71.7 tons, which is achieved when marginal costs (M.C) are equal to marginal revenue (M.R), which is equal to the unit price of final product (PQ) in the perfect competition market. The elasticity of production costs (E.C.) through is estimated through dividing the marginal costs (M.C) on the average costs (A.C), where the marginal costs amounted to about 462 pounds and the average costs amounted to about 2667.2 pounds, and then the elasticity of production costs was estimated at about 0.17, which indicates that the production of tomatoes on the level of the second tenure category in the study sample achieves economic efficiency because of the production is located in a stage of diminishing returns to scale, as shown in Table (5).

Table 5. Indicators of the results of the cost function for the study sample

Statement	The total sample	The first tenure category	The second tenure category	The third tenure category
1- Average production $\bar{Q}$	54.3	45.2	67.9	109.6
2- cost-minimizing Production Volume	35	33.1	64	64.7
3-profit-maximizing Production Volume	49.9	56.1	71.7	107.9
4- Cost elasticity	0.72	0.24	0.17	0.39

1- cost-minimizing Production Volume: Achieved when marginal costs (M.C) are equal to average costs (A.C).

2- profit-maximizing Production Volume: Achieved when marginal costs (M.C) are equal to marginal revenue (M.R), which is equal to the unit price of final output.

3- 3) Elasticity of production costs (E.C.): The value of marginal costs (M.C) is divided by the value of average costs (A.C).

(4) The function of the costs of producing the tomato crop in the third category for the study sample:

By estimating the parameters of the total costs function (T.C) for producing the tomato crop in the short term at the level of the third tenure category in the quadratic and cubic form using the data of the study sample, it was found that the best estimated form is the function in the quadratic form, which is explained by equation (1):

$$T.C = 93420.5 + 7012.8\ Q - 22.3\ Q^2 \quad \ldots\ldots (1)$$

$$(2.1)^{*} \qquad (6.7)^{**} \qquad (-2.6)^{*}$$

$$R^2 = 0. \qquad F = 165.4^{**}$$

Where:

T.C = Total production costs (EGP) for producing tomatoes on the level of the third tenure category.

Q = actual total output (tons).

The total cost function (T.C) for producing the tomato crop in the third holding category shows that the estimated total output of an acre is responsible for about 84% of the total changes occurring in the total costs of the tomato crop, and the significance of the function and its parameters were statistically proven at a significant level of 1%, and the average cost function (A.C) was estimated in the short run by dividing the total cost function (T.C) by the estimated production volume, thus obtaining equation (2):

A.C = 93420.5 / **Q** + 7012.8 **–** 22.3 **Q** **……..…… (2)**

The marginal cost function (M.C) was also estimated in the short run by conducting the first derivative of the total cost function (T.C) with respect to the production variable Q referred to in equation (2) and obtaining the marginal cost function explained in equation (3):

M.C = 7012.8 **–** 44.6 **Q** **……..……. (3)**

It is shown that the optimal production volume, which minimizes the costs of tomato production in the third tenure category, amounted to about 64.7 tons, which is achieved at the lower limit of the average costs in the short term, or achieved when the marginal costs (MC) are equal to the average costs (A.C). The actual total output volume amounted to about 109.6 tons, more than the optimum production volume. As for the volume of economic production that maximizes profit, it amounted to about 107.9 tons, which is achieved when marginal costs (M.C) are equal to marginal revenue (M.R), which is equal to the unit price of final product (PQ) in the perfect competition market. The elasticity of production costs (E.C.) is calculated through dividing the marginal costs (M.C) by the average costs (A.C), where the marginal costs amounted to about 2124.6 pounds, the average costs amounted to about 5421.02 pounds, and the elasticity of costs was 0.39, which indicates that the costs of tomato production at the level of the third tenure category in the study sample achieve economic efficiency because the elasticity of Costs are less than one, meaning that total costs increase at a lower rate than the rate of increase in production, as shown in Table (5).

Recommendations

1- Attempting to take care of the human element and add appropriate amounts of organic fertilizer to increase the production and level of economic efficiency of tomatoes in farms from 3 acres to less than 6 acres in the second tenure category (from 3 acres to less than 6 acres):

2- Increasing the quantities of potassium fertilizers and pesticides for controlling pests and weeds to the extent that allows maximizing the production in the second category whose area ranges from 3-6 acres.

3- Trying to use modern agricultural mechanization in agricultural operations, as well as paying attention to human labor and adding appropriate amounts of phosphate fertilizer in order to achieve the best production of tomatoes in large-scale farms, whose area exceeds 6 acres.

4- Encouraging producers to direct part of their production for foreign export, in a way that achieves suitable prices for farmers that achieve appropriate profit and the possibility of continuing production, due to the presence of a surplus in the local market of tomatoes.

5- The presence of specialized banks that give the farmer credits with simple interest so that he can work and continue in the market, such as using the liquidity available in the Egyptian Agricultural Bank, which is better than commercial banks, and also with the aim of restricting speculators' finance of the sector in these farms.

6- Purchasing all farm needs of production requirements at the beginning of the season to ensure their availability throughout the year.

7- Vertical expansion of the cultivated area by to small farms.

REFERENCES

Abdel-Mawly, D. A. M. (2021). Economic Possibilities and Implications for Reducing Loss and Damage of Some Egyptian Crops. Master Thesis, Department of Agricultural Economics, Faculty of Agriculture, Ain Shams University, Cairo, Epypt.

Directorate of Agriculture in Sharkia, (2022). Records of the Vegetable Department.

Doss, B. D. H. (2017). An Economic Study of Losses from the Winter Tomato Crop in Assiut Governorate. The Egyptian Journal of Agricultural Economics, 27(4), 2063-2082. doi: 10.21608/meae.2017.111832

El-Santresi, M. A. (2021). Agricultural Cost Analysis [Lecture]. Department of Agricultural Economics, Faculty of Agriculture, Ain Shams University.

Mazroua, Y. S. A. and Al-Adawy, R. S. (2020). The Economic and Marketing Efficiency of the Tomato Crop in Kafr El-Sheikh Governorate. Journal of Agricultural Economics and Social Sciences, 11(3), 187-194. doi: 10.21608/jaess.2020.91104

Wahdan, E. Y.; Gado, E. H.; Afify, M. F.M. and Ibrahem, S. M. (2020). An economic study and marketing of tomato economies in Egypt, Moshtohor Journal of Agricultural Sciences, 58(1), 205-212. doi: 10.21608/assjm.2020.111388