Mesopotamia Journal of Agriculture

https://magrj.uomosul.edu.iq

RESOURCE DEMAND AND PRODUCT SUPPLY FUNCTION FOR TOMATO PRODUCTION FARMS IN NINEVEH GOVERNORATE FOR THE 2023 AGRICULTURAL SEASON

Ahmed H. Ali [1], Imad A. Ahmad [2], Waleed I. Sultan [3], Abed Alhameed A. Al-Khararbeh [4]
Department of Agricultural Economics, College of Agriculture and Forestry, University of Mosul, Mosul, Iraq 1,2,3 , Integrated Standards Institution for Research, Studies and Consultations, Jordan 4

Article information
Article history:
Received: 24/6/2025
Accepted: 26/9/2025
Available: 30/9/2025

Keywords:
cobb-douglas, cost, profits, resource.

DOI:
https://doi.org/10.33899/mja.2025.158508.1563

Correspondence
Email: Ahmadhashim1982@uomosul.edu.iq

ABSTRACT

The tomato crop is an important and major vegetable crop on the Iraqi table. His entry into a lot of food industries, like tomato paste and some products, among them, the research aimed to derive the resource demand function and the output supply function of the production function, and identify the optimal resource combinations of tomato farmers in the basin of Al-Alil for the 2023 agricultural season, as one of the cultivation areas of this crop in Nineveh. The production function was estimated as a Cobb-Douglas type, and in the long term, as optimal amounts of maximized profit resources were achieved and compared to actual reality. Among them was derived output display function and resource demand function, through data collected by a questionnaire form prepared for this purpose for a random sample of (31) farms produced, It accounted for 40% of the study community, and one of the most important findings of the research was that the volume of the maximum production of profits was (15,643) kg/dunum. Profits reached (3537567) dinars/dunums compared to the actual production of (12,799) kg/dunums and profits (2269187) dinars/dunums. In light of these findings, the study recommends that tomato farmers use optimal amounts of maximized profit resources to increase their profits.

INTRODUCTION

The tomato crop is one of the vegetable crops that contributes a significant proportion of Iraq's agricultural economy, giving a national income ranging from (25 - 30) million dollars annually, as the possibility of providing the tomato crop to the consumer for days of the year through protected cultivation in greenhouses and plastics, after the tomato crop was seasonal in production. Protected agriculture is an important and sophisticated means of production in terms of the use of scientific methods and technological equipment that secure climatic conditions conducive to the growth and development of the crop outside its production times. Increased demand for the tomato crop requires that the crop be made available in the off-season cultivated large areas in protected agriculture (Jasim and Zanzal, 2022), as well as in open fields, to provide crop over the course of the year The importance of the study comes from the fact that the tomato crop is one of Iraq's major vegetable crops because of its nutritional and economic importance, short life span and abundant profits, giving more revenue than other crops grown in the same area of land in question and over a short period of time, The trend towards growing tomatoes in

Rabia has recently increased, as it is necessary to provide essential supplies, not the product of tomatoes, which hamper many farmers from growing the spaces available to them to grow this crop, which obliges farmers to buy production supplies from local markets. (Plastic lids - fertilizer - seeds - control materials) Production costs are higher at higher prices, and the return on farmers' profits is lower.

Search Problem

Although this crop meets the needs of consumers in Nineveh Governorate, the quantities produced do not cover market demand. The problem lies in the failure of some farmers to adopt the cultivation of this important crop for food, marketing, and export. Furthermore, farmers are reluctant to optimally utilize productive resources due to high production costs resulting from the low or non-existent support for production inputs. This leads to higher prices, which directly impacts the quantities demanded and the produce supply, significantly reflected in the decline in net yield per dunum. This leads some farmers to abandon the production of this crop and shift to other, less expensive and more profitable crops, or to turn to other sources of income and move away from agriculture.

Research Objective

The research aimed to

1. Estimate the long-term production function of the Cobb-Douglas type.
2. Identify and determine the optimal and optimal resource combinations of profits using partial economic theory and mathematical and metric economics to optimize the use of resources and compare them with actual reality.
3. The output supply and quantities offered at different production levels, the demand for resources and the quantities required of productive resources at different levels of prices.

Research hypothesis

The research relied on the premise.

1. The production of tomato crops in Iraq in general and in Nineveh governorate in particular did not meet market needs due to the lack of optimal utilization and better scientific allocation of available economic resources, which affects the productivity of the dunum.
2. These result in a weak adoption by farmers of this crop because they cannot reach the volume of production achieved for the greatest profit, which yields a net rewarding income that helps increase the area cultivated and further adopt the cultivation of this crop.

Search Robbery

The research was based on the first two descriptive methods based on the concepts of economic theory. The reference presentation of the studies that preceded this study The second method is quantitative evidentiary by selecting the model and optimal method that serves the study's objectives, Through the Multiple Regression Analysis Model using the usual OLS micro squares method The production function of Cobb -Douglas is estimated to be long-term in its dual logarithmic linear image and to determine the size of the maximum production of profits, Determine the optimal supplier combinations and the maximum profit as well as the quantities offered of production at different price levels, and the quantities of resources required at different price levels.

Reference review and contemporary studies

Given the importance of previous studies and research, we need to highlight some of these studies and research and the results that have been achieved to see some of the results and working methods of the quantitative aspect. Akamin *et al*., (2017) also presented research on the analysis of the efficiency and productivity of vegetable cultivation within root and tuberculosis-based systems in Cameroon's presented research on the analysis of the efficiency and productivity of vegetable cultivation within root and tuberculosis-based systems in Cameroon's wet tropics. The study aimed to analyses the technical efficiency of vegetable farmers in root and tuberculosis-based agricultural systems in Cameroon's wet tropics. The results showed that the most productive factor was fertilizer, followed by agricultural machinery and employment. The average level of technical efficiency was 67 per cent, revealing a production gap and indicating that production could be significantly improved with current input levels. Females and farmers with higher education were found to be far more productive than their peers. The study also showed that technical efficiency decreases as the size of agricultural households increases. Ibrahim and Ahmed (2020) published research on the efficiency of producing some vegetable crops under Egypt's protected farming system. The study aimed to identify the efficiency of using economic resources according to the protected farming method and the problems faced by the 2015/2016 agricultural season. The study's results indicate an economic efficiency in producing the study's crops. Production flexibility was 1.4, 1.02, and 1.19 for the option in large-sized greenhouses, the option in small-sized greenhouses, and the cantaloupe crop under plastic tunnels, respectively, meaning that production was at a non-economic stage and some factors of production still needed to be strengthened. The cost function was estimated at 118 tons of production with maximum productivity and 88.8 tons with maximum cost and cost flexibility of 0.89 in Dakahlia, the optimal yield production was 166 tons and the civil production cost was 120 tons, In the lake, the optimal yield production was about 345 tons and civil production cost 197 tons and indicating that the challenges facing protected agriculture are the high cost of protected agriculture, low plastics standards and employment problems. A study by Mohamed *et al*. (2021) aimed to estimate the production and economic indicators of mango and orange crops in Ismailia Governorate. The results showed that the optimal production of mango was about 4.9 tons per acre, and orange was 14.8 tons per acre. The economic production was estimated at 8.5 and 17 tons per acre, respectively. The study results also showed that production costs could be reduced by about 8% and 8.6%, respectively, for the study crops, through optimal resource and cost-effective combinations at actual productivity averages. The research recommends the importance of optimal use of production resources. Research on the economics of production and the costs of the tomato crop in Orientale governorate was also conducted by Nasr 2023 and others. The research's objective was to estimate the cost-effectiveness of production that reflects the relationship between total costs and actual production. The optimal production volume that reduces the costs of tomato production in the total study sample was about 35 tons. and that the total actual production volume of the farm was about 54.3 tons, which is greater than the optimal production volume economic production, which maximizes profit, amounted to approximately 49.9 tons; The threshold costs were approximately Pound3,265.8, while the average costs were about Pound4512.5, The flexibility of production costs was estimated at 0.72, indicating that tomato production at the gross sample level is economically profitable. In a study by Ahmed, *et al*., (2023) on measuring the resources achieved for wheat production efficiency in Al-Baaj district in Nineveh Governorate, using the stochastic frontier function derived from the Cobb-Douglas function, a direct relationship was shown for the number of irrigations, quantity of pesticides, area, and wheat productivity, while this production is inversely related to agricultural work, quantity of seeds and fertilizers. The reason for this is the use of these resources at a rate exceeding the factory's need for them, which led to a waste of resources and consequently decreased efficiency to below the optimal level. In a study by Abd *et al*. (2024) on the determinants of the economic efficiency of onion production in Nineveh Governorate for the 2022 season, in Al-Shekhan district, the study focused on the factors that determine onion production and how to calculate their optimal values and compare them with the actual quantities of resources used by crop farmers. The surplus or deficit in the use of resources was also calculated.

MATERIALS AND METHODS

The Cobb-Douglas production function was used to analyze the data and extract the results.

Production Function Cobb-Douglas

It is one of the most important tools of economic analysis that has emerged, enabling economists to build models and derive other production functions, resulting in significant advances in economic analysis (Al-Ruwais, 2009). The function assumes the stability of the productive flexibility of resources regardless of the amount of input used (Debertin, 2012) and its overall formula:

$$Y = A\, x_1^{b1}\, x_2^{b2}$$

Because Y: quantity of production, A is a function or technological variable factor, and both (b_1, b_2) represent the productive flexibility of suppliers X_1 and X_2 (work and capital), and range in value from zero to one. The Cobb-Douglas function has several characteristics, including homogeneous grade ($b_1 + b_2$) as the degree of homogenization and the determination of capacity returns is determined by the total elasticity E is equal to ($b_1 + b_2$). (Lodewijks and Monadjemi, 2016), and the value of b_1 to b_2 ranges from zero to one (Debertin, 2012), production curves for both work and capital elements are also shifted when one increases. The other constantly, as well as the ease of calculating their parameters by converting them to the logarithmic version of the foundation (10) Or the natural logarithm of the base (e^x), as e = (2.71828), takes the following formula:

$$Ln\, Y\ =\ Ln\, A\ +\ b\_1\ Ln\, X\_1\ \ +\ b\_2\ Ln\, X\_2$$

The Cobb-Douglas function can also take more than two inputs, such as the following formula:

$$Y = A\, x_1^{b1}\, x_2^{b2}$$

Its dual logarithmic formula will be:

$$Ln\,Y = Ln\,A + b\_1\ Ln\,X\_1 + b\_2\ Ln\,X\_2$$

If: Y: Quantity of production, A: Technical factor (factor fits function)
X_2, X_1: Quantities of production elements (work and capital)
b_2, b_1: Parameters of production elements (flexibility of production elements, because the logarithmic function is double). (Al-Shammari and Al-Samurai, 2024)

Description of the model used:

Data analyzed and interpreted the results obtained for a random sample of tomato plantations in Hamam al-Ali's district in Nineveh governorate (31) Farm, represented approximately 40% of the sample community, since the production function of Cobb-Douglas type was estimated using the usual micro-squares method Using the statistical program (Eviews.10), the dual logarithmic formula has been adopted because it is the best formula to represent the embedded model of the Y production that was estimated based on the dynamic yield of the 2023 production season as a dependent variable and the production elements on the other hand as influential interpretative variables in the dependent variable:

Work L (man/day) per dunum, represents the element of human work, consisting of family work and rented work and was appreciated for the one dunum for the 2023 productive season such as doing all the agricultural operations the crop needs such as quarrying, weeding, fertilizing, pesticide spraying, watering and reaping... etc. (Farhan, *et al*., 2023)

Capital K represents all capital costs that turn into production (fertilizer, pesticides, electricity wages, fuel, oils, maintenance of equipment, pumps, motor labor wages, irrigation costs, etc.) during the 2023 agricultural season (dinars/dunums)

The mathematical model was formulated to study the relationship between production and its components above, as follows: (Hussein and Salah, 2017)

$$Ln\,Y = Ln\,b\_o + b\_1\ Ln\,L + b\_2\ Ln\,K$$

It is: Y production (kg), L: work (man/day), K: capital (dinar/dunum),
B_0: Constant function (technical level)
b_1, b_2 parameters variables (since the logarithmic function, they represent the production flexibilities of variables)

RESULTS AND DISCUSSION

The equation below represents the farmer's estimated output function obtained from the results of table (1) by using multiple linear regression and according to the usual small square method (OLS) using Eviews 10 program as follows:

Table (1): Data analysis results for tomato farms

Dependent Variable: LNY Method: Least Squares Date: 10/ 03/ 24 Time: 18:27

Sample: 1 – 31 Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.658258	0.792253	5.879757	0.0000
LNL	0.477898	0.194163	2.461324	0.0203
LNK	0.186042	0.036459	5.102727	0.0000
R-squared	0.746217	Mean dependent var	9.438055	
Adjusted R-squared	0.740947	S.D. dependent var	0.160484	
S.E. of regression	0.098806	Akaike info criterion	-1.699560	
Sum squared resid	0.273351	Schwarz criterion	-1.560787	
Log likelihood	29.34319	Hannan-Quinn criter.	-1.654324	
F-statistic	25.57231	Durbin-Watson stat	2.205877	
Prob(F-statistic)	0.000000			

Source: Researcher's preparation based on questionnaire data. Eviews.10

$$Ln\,Y = 4.6582 + 0.478\,L + 0.186\,K$$

Statistical analysis

Test results (t) showed by Table (1) The morale of the estimated parameters of the economic variables entering the model under the morale level of 0.01, as well as the determination factor ($R^2 = 0.746$) explains that 74.6% of changes occur in the affiliate variable (Production) is due to (independent) interpretative variables (K, L) and (25.4%) is attributable to other variables not included in the model, and finally the F test, which is worth (25.57) explaining the morale of the function as a whole when compared to its tabular value at a morale level of 0.01,(Alzobaee and Al-Samurai, 2024).

Standard analysis

The D.W. test value of (2.2) indicated that there was no Autocorrelation problem between random variables (random error) at a morale level of 0.05 since the (1.57) tabular du values for two interpretative variables and (31) views, and therefore the calculated D.W. value would fall in the no-problem acceptance area (du > D.W > 4-du) that is (1.57< 2.2 < 2.43). The park analysis also established no heteroscedasticity problem, which often appears with cross-sectional data (Attia, 2000). To test this problem, Park's test for detection (Gujarati, 2004), using the statistical program (Eviews 10), was tested as a quadratic log Lnei2; the test results are shown in Table 2.

Table (2): Park test for problem of variability instability

Variables	Test box Select error with interpretive	Selection Coefficient R^2	F test

Labor LnL	$Lnei^2 = 16.0106 + 2.357\ Ln\ L$ t (-1.104) (0.709)	0.011	0.503
Capital LnK	$Lnei^2 = 0.3383 - 0.4187\ Ln\ K$ t (0.037) (-0.67)	0.015	0.45

Source: Prepared by the researcher based on sample data and the results and outputs of the (Eviews.10) program.

Table (2) above shows the insignificance of the parameters of the explanatory variables through a t-test at a significance level of 0.05, as their calculated values were less than the table values. The F test also demonstrated the insignificance of the functions estimated above, as the calculated F value was less than the table values. Therefore, the test indicates that there is no problem of heterogeneity of variance.

Regarding the problem of multicollinearity, the Klein test was used. By comparing the square root of the coefficient of determination, which is (0.8637), with the values of the simple correlation coefficient between the explanatory variables in the simple correlation matrix in Table (3), it was found that this problem does not exist.

Table (3): Simple Correlation Matrix

Correlation		
	LNL	LNK
LNL	1.00000	0.41227
LNK	0.41227	1.00000

Source: Prepared by the researcher based on sample data and the results and outputs of the (Eviews.10) program.

Economic analysis of the production function

$\text{Ln}\, Y = 4.6582 + 0.478\, L + 0.186\, K$ Logarithmic formula

$Y = A\, x_1^{b1}\, x_2^{b2}$ Exponential formula

The results of the statistical estimation of the parameters of the olive production function indicate a direct relationship between the explanatory variables (labor L, capital K) and the dependent variable Y. This is consistent with the logic of economic theory. Since the function is a double logarithmic, the variable parameter represents its production elasticity, which means the possibility of increasing the quantity of output by the parameter of each (L, K) if their use increases by 1%. Since the values of the elasticity of the variables are between zero and one, the resources are operating in the second stage of the yield process. From the production function, it is clear that the sum of the production elasticities for (L, K) reached (0.664), which is less than one. This means that the tomato production function reflects the state of diminishing returns to scale, which indicates that production is increasing in a decreasing manner. Each resource's contribution percentage to production is extracted by dividing the resource elasticity by the total production elasticities multiplied by 100. It was found that the resource of the number of workers was in first place, followed by capital, with percentages of (72%, 28%), respectively.

The optimal resource combination for profit-maximizing production

To derive the supply function for production and the demand function for resources, and for comparison, it is necessary to arrive at the optimal resource combination of the two production elements (labor and capital) that achieves profit-maximizing production. This is done using the estimated production function and the cost constraint to obtain the objective function (the normal profit function π) (Awed and Al-Samurai, 2024), as follows:

$$\text{Ln Y} = 4.6582 + 0.478\,\text{L} + 0.186\,\text{K}$$
$$\text{Y} = \text{A}\,x_1^{b1}\,x_2^{b2} \quad - - - -1$$
$$\pi = P_y\,.\,(AL^{b1}K^{b2}) - \lambda(wL + rK - \bar{C}) \quad \text{aim equation for profit}$$
$$\pi = 450(105.45\,L^{0.478}\,K^{0.186}) - \lambda(15000L + 1.08K - 3490363)$$

Where:

π: the normal profit function, Py: the output price (the average price of tomatoes is 450 dinars/kg, it was determined through the questionnaire form).
A: the technical factor, L, K: the factors of production (labor and capital).
w: the wage of labor (since the average wage of workers in tomato farms is 15,000 dinars per man/day).
r: the interest rate of capital (average interest rate is 0.08, so the return on one dinar is 1.08).
b2, b1: the parameters of the function (partial elasticities of the factors of production).
$\bar{C}$: the actual cost (The average cost per dunum in the research sample is 3490363 dinars).
λ: the Lagrange multiplier

By applying the profit maximization condition from the profit function (VMPx = Px), the profit function for the factors must be derived. Production and Landa (L, K, λ) and agencies:

$$\frac{\partial\pi}{\partial L} = (450)(105.45)(0.478)L^{0.478-1}K^{0.186}) - 15000\,\lambda = 0$$
$$= (22682.3\,L^{-0.522}K^{0.186}) = 15000\,\lambda - - - -2$$
$$\frac{\partial\pi}{\partial K} = (450)(105.45)(0.186)L^{0.478}K^{0.186-1}) - 1.08\,\lambda = 0$$
$$= (8826.165\,L^{0.478}K^{-0.814}) = 1.08\,\lambda - - - - - -3$$
$$\frac{\partial\pi}{\partial\lambda} = (15000\,L + 1.08\,K - 3490363) = 0 \quad - - - 4$$

By dividing Equation 2 by Equation 3, we obtain the expansion path equation between L and K

$$= \frac{(22682.3\,L^{-0.522}K^{0.186})}{(8826.165\,L^{0.478}K^{-0.814})} = \frac{15000\,\lambda}{1.08\,\lambda}$$
$$= \frac{(22682.3K)}{(8826.165L\,)} = \frac{15000\,\lambda}{1.08\,\lambda} \Rightarrow 24496.88\,K = 132392475\,L$$ Expansion Path Equation

$$L = 0.000185032\,K - - - - - - - - -5$$

By substituting Equation 5 into Equation 5, we obtain: For the optimal amount of capital:

$$15{,}000\,(0.000185032\,K) + 1.08\,K - 3490864 = 0$$
$$2.77548\,K + 1.08\,K = 3490864 \Rightarrow 3.85548\,K = 3490363$$
$$K = \frac{3490363}{3.85548} = 905299$$ dinars (Optimal profit-maximizing capital)

Substitute the value of the optimal capital (905299) into Equation 5 to find the optimal amount of labor:
$L = 0.000185032\,(905299) = 168$ man/day (Optimal profit-maximizing number of workers)

Substitute the optimal amounts of resources obtained into the estimated production function 1 to obtain the optimal amount of profit-maximizing output as follows:

$Y = 105.45\,(168)^{0.478}\,(905299)^{0.186}$
$Y = 105.45\,(11.57)(12.822) = 15643$ kg/acre (profit-maximizing production volume).

Net Profit for Optimal Profit-Maximizing Resource Combinations

• We can calculate the profits achieved at the profit-maximizing production volume using the profit function by substituting the profit-maximizing resource quantities into the aggregate cost function as follows:

$Y = 105.45\,L^{0.478}\,K^{0.186}$, $PY = 450$ Dinar/kg, $TC = 15000 \times 168 + 1.08 \times 905299$,
$\pi = TR - TC$, $TR = PY \times Y$, $Y = 15634$ kg/dunum
$\therefore \pi = 450\,(15643) - (15000 \times 168 + 1.08 \times 905300)$
$\pi = 7035300 - 3497724 = 3537567$ IQD (Maximum Profit)

• The actual profits for farmers are:
$\pi = (450 * 12799) - (3497724) = 2261826$ dinars

It is clear from Table (4) that the optimal combination of resources at the profit-maximizing production volume amounted to (168) working days and (905299) dinars of capital, giving a production volume of (15643) kg, and a net profit of (3490363) dinars/dunum. From the above, it is clear that the profit achieved at the profit-maximizing production volume is higher than the actual profits, as this requires an increase in the use of the labor element with a decrease in the use of capital due to its importance in increasing the quantity of production. Thus, reaching the maximization of farmers' profits. - The long-run cost function and its economic derivatives.

Table (4): Actual and optimal resource combinations that maximize profits

	Production volume kg/ dunum	Numb Labor man/day	Capital (dinar)	Product price in dinars/Kg	Total revenue (dinar/ dunum)	Total costs (dinar/dun um)	Net revenue or profit (dinars/ Dunum)
Actual sample	12799	79	2135059	450	5759550	3490363	2261826
At profit-maximizing production volume	15643	168	905299	450	7035300	3490363	3544937

Source: The researcher prepared the table based on the estimated profit function for tomato farmers.

The long-run cost function

The long-run cost function must be obtained from the Cobb-Douglas production function using the duality theory to derive the output supply function. This involves deriving the production function and finding the expansion path equation using the partial derivatives of L and K to obtain their marginal product and equate it with their respective price ratios (Debertin, 2012), as follows:

$$C = w L + r K$$
$$C = 15000 L + 1.08 K \quad -------- \; 1$$
$$Y = 105.45 L^{0.478} K^{0.186} \quad -------- \; 2$$

Take the first partial derivative of both L and K from the production function 2

$$\frac{\partial Y}{\partial L} = \left((105.45)(0.478)L^{0.478-1}K^{0.186}\right) = 0 ----3$$
$$\frac{\partial Y}{\partial K} = \left((105.45)(0.186)L^{0.478}K^{0.186-1}\right) = 0 \; ----4$$

Divide Equation 3 by Equation 4 to find the rate of technical substitution MRTSL, K

$$= \frac{\left((105.45)(0.478)L^{0.478-1}K^{0.186}\right)}{\left((105.45)(0.186)L^{0.478}K^{0.186-1}\right)} = \frac{50.405K}{19.614\, L} ----5$$

We equate the prices of production resources (the price ratio) with the marginal rate of technical substitution (MRTS) to obtain the expansion path equation.

$$\frac{50.405\, K}{19.614\, L} = \frac{15000}{1.08} \Rightarrow \; 54.4374\, K = 294210\, L \; --- \; 6$$ Expansion Path Equation

From Equation 6, we find

$$L = \frac{54.4374\;\; K}{294210} \;\Rightarrow L = 0.000185032\, K ----7$$

We substitute Equation 7 into Equation 1.

$$C = 15000\,(0.000185032K) + 1.08K$$
$$C = 2.77548K + 1.08K$$
$$C = 3.85548K \;\Rightarrow\; K = \frac{C}{3.85548} \; --- \; 8$$

Equation 8 represents the value of K in terms of cost. Substitute it into Equation 7 to find the value of L in terms of cost, as follows:

$$L = 0.000185032 \; \frac{C}{3.85548} \;\Rightarrow\; L = 0.000047991\, C ----9$$

Substitute Equations 8 and 9 into Production Function 2 to extract the long-run cost function from the Production Function.

$$Y = 105.45\,(0.000047991C)^{0.478}\,(\frac{C}{3.85548})^{0.186}$$
$$Y = 105.45\,(0.00862181)\, C^{0.478}\,(0.77801757)\, C^{0.186}$$

$Y = 0.70735\, C^{0.664}$ Production function in terms of costs

$$C^{0.664} = \frac{Y}{0.70735} \Rightarrow C = (\frac{Y}{0.70735})^{1.5060241}$$

$C = 1.68443\, Y^{1.5060241}$ Long-run cost function derived from the Cobb-Douglas production function

$$MC = \frac{\partial C}{\partial Y} = (1.68443)\,(1.5060241)\, Y^{0.5060241} = 0$$

$MC = 2.53679\, Y^{0.5060241}$ Long-Run Marginal Cost Function

$AC = \frac{C}{Y} = \frac{\mathbf{1.68443\ Y^{1.5060241}}}{Y}$ ⟹ $\mathbf{AC = 1.68443\ Y^{0.5060241}}$ Long-Run Average Cost Function

$\Psi = \frac{MC}{AC} = \frac{\mathbf{2.53679\ Y^{0.5060241}}}{\mathbf{1.68443\ Y^{0.5060241}}}$ ⟹ $\boldsymbol{\psi = 1.5060241}$ Long-Run Cost Elasticity

From the cost elasticity of (1.5060241), it is clear that it increases with increasing production because it represents the inverse of the total elasticity of production (the coefficient of the function), as the total elasticity of production reached (0.664), which is less than one, indicates that production is decreasing in capacity. Its inverse will be (1/0.664), which equals 1.5060241, which is consistent with the logic of economic theory. If we substitute the profit-maximizing production volume or the cost-minimizing production volume into the cost function, we will obtain the cost per volume of production. We will obtain the cost per production unit added in the marginal cost function. In the average cost function, we will obtain the average cost per production unit, which represents the lowest price the farmer will accept. We will prove this later. If we substitute the profit-maximizing production, we will obtain the following:

$C = 1.68443\ (15634)^{1.5060241} = 3489986$ dinars/dunum
$MC = 2.53679\ (15634)^{0.5060241} = 336$ dinars/kg
$AC = 1.68443\ (15634)^{0.5060241} = 223.23$ dinars/kg

Long-Run Output Supply Function Derived from the Cost Function:

The output supply function can be derived from the long-run cost function by equating the output price with the marginal cost function, or by using the supply function derived from the cost function directly, as follows:

$$MC = Py$$

$$2.53679\ Y^{0.5060241} = Py \Longrightarrow Y^{0.5060241} = \frac{P_y}{2.53679}$$

$\mathbf{Y = (\frac{P_y}{2.53679})^{1.97619}}$ Long-Run Output Supply Function

If we substitute the value of average costs at the profit-maximizing production volume, considering it the lowest price the farmer will accept, we obtain the quantity supplied that the producer is willing to sell at this price. This quantity will increase with price increases, as follows:

$Y = (\frac{223.23}{2.53679})^{1.97619} \Rightarrow Y = 6960$ kg/dunum

or $\mathbf{Y = (\frac{p}{Ze})^{\frac{E}{1-E}}}$ ⟶ $Y = (\frac{223.23}{1.68443 * 1.5060241})^{\frac{0.664}{1-0.664}} = 6960$ kg/dunum

Where the:
z: constant of the cost function, e: is the cost elasticity

The above quantity represents the lowest quantity the farmer is willing to offer his produce at this price (223.23) kg. The quantity offered will increase with the increase in price (Virtual prices), as shown in Table (5) and Figure (1). When this quantity is substituted into the marginal cost function, the value of the marginal cost will be equal to the value of the average costs of (223.23) dinars that we obtained previously, which proves that this price is the lowest price accepted by the farmer, i.e., at the point of intersection of the marginal cost with the average costs, where the amount of revenue obtained from this price at the profit-maximizing production volume of (15,634) kg/dunum is equal to the actual costs of the producer (3,489,978) dinars. With the increase in price, the producer's profits begin to appear, and as the following is true:

$MC = 2.53679\,(6960)^{0.5060241} = 223.23$ dinars/kg (lowest price acceptable to the farmer)

$TR = 15634 * 223.23 = 3489978$ Dinars/dunum (Revenue per dunum equals cost per dunum)

Table (5) Quantity supplied of produce

Product price Py dinars/kg	Quantity offered Y kg/ dunum
223.23	6960
240	8032
260	9408
280	10892
300	12483
320	14182
336	15634
360	17898

Source: Prepared by the researcher based on the output display function.

That is, at a price of (223.23) dinars/kg, the quantity supplied will be (6960) kg/dunum, which represents the supply volume at the lowest price acceptable to the farmer. If the price falls below (223.23) dinars/kg, the farmer will be in a loss and will refrain from offering his produce until the price rises. As the price increases, the quantity supplied will increase, and economic profits will begin to accrue. At a price of (336) dinars/kg, which is equal to the marginal cost of production, the producer will be willing to sell all of his produce. The higher the price, the greater his economic profits.

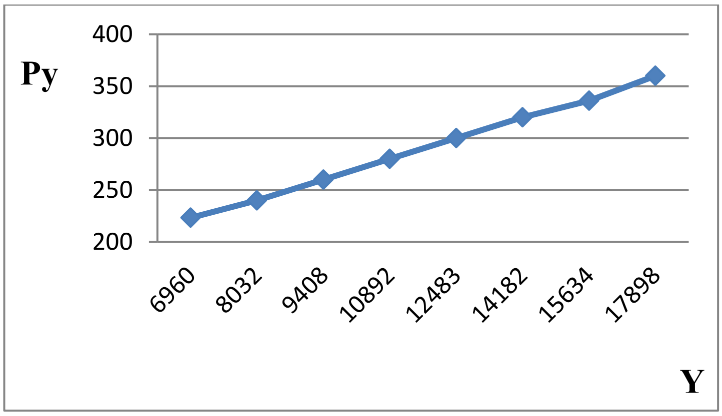

Figure (1): Output supply curve for the first category

Source: Prepared by the researcher based on data from Table (5)

Demand functions for resources

Derivation of demand functions for productive resources

It is well known that all productive factors change in the long run, and the direction of demand for a productive factor depends on the relationship between these factors, whether they are substitutes or complements. This means that the demand for a particular resource does not depend on the value of its marginal product, but rather on the relationship between this resource and other resources, for example, labor and capital. If the price of labor changes, the demand for the capital element will change (Debertin, 2012). The demand function for a resource depends on a number of factors, namely the price of the resource, the price of production, and the prices of other productive resources that complement and substitute the productive resource, as well as the production elasticities of each resource. The demand for production elements is a joint demand (5): This means that the production process does not take place through the availability of a single productive element or resource, but rather requires multiple resources at the same time. Production resources are used by combining them to obtain production, which means that the demand for one of the production resources will affect the demand for the rest of the production resources used in the production of the commodity. This, in turn, means that the price of one of the resources will affect the quantity demanded of the other resources involved in the production process, in addition to its effect on the quantity demanded of the resource itself the demand functions for the production elements (X_1, X_2) can be derived through the normal profit function as follows: Prepared by the researcher based on (Debertin, 2012).

$$\boldsymbol{\pi = P_y . \left(AX_1^{b1}X_2^{b2}\right) - \left(V_1X_1 + V_2X_2\right) - - - - 1}$$

Where π: profit function, Py: product price

A: fixed event (technology level), b1, b2: function parameters (elasticities of production factors)

X_1, X_2: quantities of production factors, V_1, V_2: prices of production factors

By applying the first condition for profit maximization (the necessary condition), we take the first partial derivative of each factor and set it equal to zero:

$$\frac{\partial \pi}{\partial X_1} = \left(P_y . (A)(b_1)X_1^{b1-1}X_2^{b2}\right) - V_1 = 0 \;-\,-\,-\,-2$$

$$\frac{\partial \pi}{\partial X_2} = \left(P_y . (A)(b_2)X_1^{b1}X_2^{b2-1}\right) - V_2 = 0 \;-\,-\,-\,-3$$

To find the demand function for each production element, we solve Equations (2 and 3) for each variable separately. For the demand function for element X_1, we extract it from solving Equation 2 as follows:

$$X_1^{b_1-1} = V_1\,(b_1\,PA)^{-1}X_2^{-b2}$$

$$X_1 = V_1^{\frac{1}{b1-1}}\,(\,b_1\,PA\,)^{\frac{-1}{b1-1}}\,X_2^{\frac{-b2}{b1-1}}$$ Demand function for the first supplier

As for the demand function for element X_2, we extract it from solving Equation 3 as follows:

$$X_2^{b_2-1} = V_2\,(b_2\,PA)^{-1}\,X_1^{-b1}$$

$X_2 = V_2^{\frac{1}{b2-1}} (b_2 \text{ PA})^{\frac{-1}{b2-1}} X_1^{\frac{-b1}{b2-1}}$ The demand function for the second resource.

Since X_1 and X_2 are unknowns, and Equations 2 and 3 are two-unknown equations, we will solve by dividing Equation 2 by Equation 3 to extract the expansion path and then the equation for X_1 and X_2 as follows:

$$\frac{P_Y(A)(b_1)X_1^{b1-1}X_2^{b2}}{P_Y(A)(b_2)X_1^{b1}X_2^{b2-1}} = \frac{V_1}{V_2} \Rightarrow \frac{b1\, X_2}{b2\, X_1} = \frac{V_1}{V_2} \text{ -------- } 4$$

From Equation 4, we extract the expansion path equations 5:

$$b_2 V_1 X_1 = b_1 V_2 X_2 \text{ -------- } 5$$

Equations 5 show the least-cost combinations possible along the expansion path.
Solving the expansion path equation 5, we find the equations for X_1 and X_2:

$$X_1 = b_1 V_2 X_2 b_2^{-1} V_1^{-1} \text{ -------- } 6$$
$$X_2 = b_2 V_1 X_1 b_1^{-1} V_2^{-1} \text{ --------- } 7$$

Substitute the value of X_1 into Equation 3:

$$b_2PA(b_1X_2V_2b_2^{-1}V_1^{-1})^{b1} X_2^{b2-1} = V_2$$
$$X_2^{b1+b2-1} = b_2^{-1}AP^{-1}b_1^{-b1}V_2^{-b1}b_2^{b1}V_1^{b1}$$
$$X_2^{b1+b2-1} = AP^{-1}b_2^{b1-1}b_1^{-b1}V_2^{1-b1}V_1^{b1}$$

Divide both sides of the equation by $(b_1 + b_2 - 1)$

$$\mathbf{X_2} = b_2^{\frac{b1-1}{b1+b2-1}} b_1^{\frac{-b1}{b1+b2-1}} V_2^{\frac{1-b1}{b1+b2-1}} V_1^{\frac{b1}{b1+b2-1}} AP^{\frac{-1}{b1+b2-1}}$$

The above equation can also be written in a simpler mathematical way as follows:

$$X_2 = (\frac{b_2}{V_2})^{\frac{1-b_1}{1-b_1-b_2}} (\frac{b_1}{V_1})^{\frac{b_1}{1-b_1-b_2}} (A)^{\frac{1}{1-b_1-b_2}} (P)^{\frac{1}{1-b_1-b_2}}$$

$$X_2 = A\, V_2^{-e_1}\, V_1^{-e_2}\, P_y^E$$

The above equation represents the demand equation for the second resource affected by the price of the first resource, where V_1, V_2 are the prices of production factors, and its elasticity is negative ($-e_1$) if b_1+b_2 is less than one, explaining the inverse relationship between the price of this resource and the quantity demanded of the resource under study X_2. The relationship between the price of the resource under study and its elasticity is also negative ($-e_2$) (Issa, 2022), explaining the inverse relationship between the resource and its price. Furthermore, the sign of the product price elasticity (E) is positive, explaining the direct relationship between the product price Py and the quantity demanded of the resource under study. (Debertin, 2012)
In the same way, we find the demand equation for X_1. The demand equation is as follows:

$$X_1 = b_1^{\frac{b2-1}{b1+b2-1}} b_2^{\frac{-b2}{b1+b2-1}} V_1^{\frac{1-b2}{b1+b2-1}} V_2^{\frac{b2}{b1+b2-1}} AP^{\frac{-1}{b1+b2-1}}$$

$$X_1 = (\frac{b_1}{V_1})^{\frac{1-b_2}{1-b_1-b_2}} (\frac{b_2}{V_2})^{\frac{b_2}{1-b_1-b_2}} (A)^{\frac{1}{1-b_1-b_2}} (P)^{\frac{1}{1-b_1-b_2}}$$

$$X_1 = A\, V_1^{-e_1}\, V_2^{-e_2}\, P_y^E$$

The above equation represents the demand equation for the first resource X_1

Labor Demand Function: We can find the demand function as follows:

$$L = b_1^{\frac{b2-1}{b1+b2-1}} b_2^{\frac{-b2}{b1+b2-1}} w^{\frac{1-b2}{b1+b2-1}} r^{\frac{b2}{b1+b2-1}} AP^{\frac{-1}{b1+b2-1}}$$

$$L = (0.478)^{\frac{-0.814}{-0.336}} (0.186)^{\frac{-0.186}{-0.336}} w^{\frac{0.814}{-0.336}} r^{\frac{0.186}{-0.336}} (105.45)^{\frac{-1}{-0.336}} P_y^{\frac{-1}{-0.336}}$$

$$L = (0.478)^{2.422619} (0.186)^{0.55357} w^{-2.422619} r^{-0.55357} (1049472.4) P_y^{2.97619}$$

$$L = 69178.525\, w^{-2.422619} r^{-0.55357} P_y^{2.97619}$$ Labor Demand Function

It is clear from the demand function above that the price elasticity of demand for labor reached (-2.422619), which is negative, indicating an inverse relationship between the wage of labor and the number demanded of it. For every 1% decrease in the wage of labor, the number of workers demanded increases. The number demanded of it is (2.422619%), as shown by the cross-price elasticity of demand for capital, which was (-0.55357), explaining the inverse relationship between the price of this resource and the number of workers demanded. For every 1% decrease in the price of this resource, the number of workers demanded increases by the amount of the resource's elasticity. This means that the price relationship between these two resources is a complementary relationship. The price elasticity of production was positive, with a price elasticity of (2.97619), explaining the direct relationship between the price of the product and the quantity demanded of the labor resource. For every 1% increase in the price of the product, the number of workers demanded increases by (2.97619%). If the price of the product is equal to the marginal cost of profit-maximizing production, which is 336 dinars, and the prices of production factors for labor are 15,000 dinars, capital 1.08, we will obtain the optimal number of workers (which represents the required number of workers) ,which is the point that represents the intersection between the marginal cost and the price of the product, which represents the equilibrium point. When the price of the product is fixed at 336 dinars/kg and the prices of the other resource, and we reduce the wage of labor only, we will obtain the demand curve for this resource, as in Table (6) and Figure (2), which is negatively sloped, identical to the curve of the value of the marginal product of labor. We will explain this mathematically as follows:

$$L = 69178.525\, w^{-2.422619} r^{-0.55357} P_y^{2.97619}$$

$$L = 69178.525\, (15000)^{-2.422619} (1.08)^{-0.55357} (336)^{2.97619}$$

$$L = 69178.525\, (0.00000000007637) (0.95829) (33026738.97)$$

$L = 167.5$ man/day per dunum (the required number of workers, which is equal to the optimal number that maximizes profits)

If we keep everything constant and raise the labor wage to 20,000 dinars, the required amount of labor will decrease.

$$L = 69178.525\, (20000)^{-2.422619} (1.08)^{-0.55357} (336)^{2.97619}$$

$$L = 69178.525\, (0.00000000003804) (0.95829) (33026738.97)$$

$L = 83.3$ man/day per dunum (required number of workers)

Demand function for capital

$$K = b_2^{\frac{b1-1}{b1+b2-1}} b_1^{\frac{-b1}{b1+b2-1}} r^{\frac{1-b1}{b1+b2-1}} w^{\frac{b1}{b1+b2-1}} AP^{\frac{-1}{b1+b2-1}}$$

$$K = (0.186)^{\frac{-0.522}{-0.336}} (0.478)^{\frac{-0.478}{-0.336}} r^{\frac{0.522}{-0.336}} w^{\frac{0.478}{-0.336}} (105.45)^{\frac{-1}{-0.336}} P_y^{\frac{-1}{-0.336}}$$

$$K = (0.186)^{1.55357} (0.478)^{1.422619} r^{-1.55357} w^{-1.422619} (1049472.4) P_y^{2.97619}$$

$K = 26926.27 \ r^{-1.55357} w^{-1.422619} \ P_y^{2.97619}$ Capital Demand Function

The price elasticity of demand for capital was (-1.55357), which is negative, indicating the inverse relationship between the interest rate and the value demanded of capital. For every 1% decrease in the interest rate, the value demanded of capital increases by an elasticity of (553571.0%). This is evident from the cross-price elasticity of demand for labor, which was (-1.422619) illustrates the inverse relationship between the price of this resource and the value demanded of capital. For every 1% decrease in the wage of labor, the value demanded of capital increases by the amount of the elasticity of this resource, which means that the price relationship between these two resources is a complementary relationship. As for the price elasticity of production, it was positive with a price elasticity of (2.97619), explaining the direct relationship between the price of the product and the value demanded of the capital resource. For every 1% increase in the price of the product, the capital demanded increases by (2.97619%).

If the product price is equal to the marginal cost of production, which is 336 dinars, and the prices of the factors of production for labor are 15,000 dinars and for capital 1.08 dinars, we will obtain the optimal value of the capital resource (which represents the amount of capital required), which is the point of intersection between the marginal cost and the product price, which represents the equilibrium point. (Alzubaidi, and Waleed, 2023)

If the product price is fixed at 336 dinars/kg and the labor wage, and we reduce the interest rate on capital only, we will obtain the demand curve for this resource, as shown in Table (6) and Figure (2), which is negatively sloped and identical to the marginal product of capital value curve, as follows:

$K = 26926.3 \ r^{-1.55357} w^{-1.422619} \ P_y^{2.97619}$

$K = 26926.3 \ (1.08)^{-1.55357} (15000)^{-1.422619} \ (336)^{2.97619}$

$K = 26926.3 \ (0.88731) (0.000001146) (33026739)$

$K = 904279$ dinars/dunum (the required capital, which is equal to the optimal profit-maximizing value)

If we keep everything constant and lower the interest rate to 0.04%, the demand for capital will increase.

$K = 26926.3 \ (1.04)^{-1.55357} (15000)^{-1.422619} \ (336)^{2.97619}$

$K = 26926.3 \ (0.9401) (0.000001146) (33026739)$

$K = 958078$ dinars/dunum

Table (6): Required quantities of the resources under study at their various prices

P_L	L	P_K	K
23000	59.4	1.1	878862
21000	74.0	1.09	891420
19000	94.3	1.08	904276
17000	123.5	1.07	917439
15000	167.2	1.06	930920
13000	236.5	1.05	944730
11000	354.5	1.04	958881

Source: Prepared by the researcher based on demand functions for each resource.

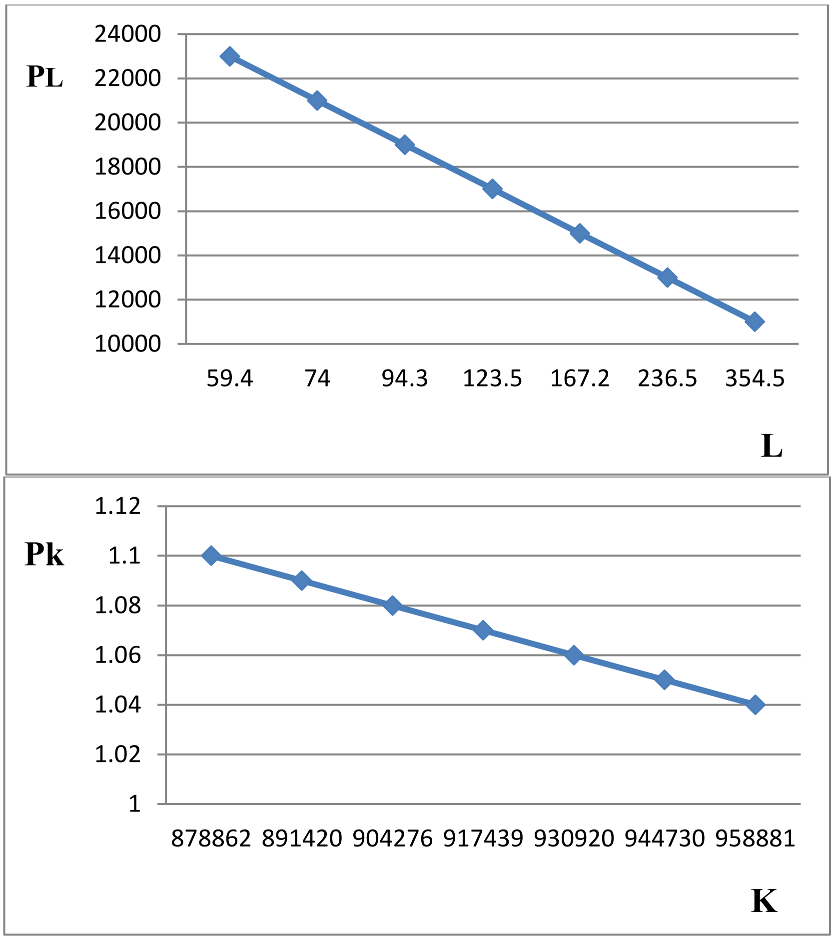

Figure (2): shows the demand curves for labor and capital at different prices.
Source: Prepared by the researcher based on data in Table (6)

CONCLUSIONS

Through the results of the Cobb-Douglas production function and the optimal quantities of labor and capital that the research reached in the case of maximizing production, we conclude that the number of workers can be increased while minimizing the use of capital per unit area, which plays a role in increasing production volume and thus maximizing profits for farmers. This confirms the research hypothesis that farmers are somewhat deviating from the optimal quantities of resources. It also showed that the lowest price that a farmer would accept for his production is (223) dinars/kg, and the higher the price, the greater the quantity offered. Therefore, a price of (450) dinars/kg is economically profitable and encourages production. However, if it falls below this price during peak supply times, farmers' profits will decrease, and they may incur a loss due to the price falling below the lowest price accepted by the farmer. As for the demand function, the negative sign of the price elasticity of demand for labor and capital resources indicates an inverse relationship between the price of these resources and the quantities demanded of them, while the positive sign of the price elasticity of production indicates a direct relationship between the price of output and the quantity demanded of the production resource.

Recommends

Based on the above conclusions, the study recommends increasing the use of labor, especially skilled labor, in production; rationalizing the use of capital and reducing waste in its use, whether in pesticides, fertilizers, or fuel, etc.; adhering to the recommended optimal quantities; assisting farmers in every way possible to achieve optimal resource quantities to maximize their profits; maintaining crop prices during peak production by reducing or prohibiting imports at this time; and subsidizing input prices to increase farmers' interest in cultivating this crop and encouraging those who remain. This, in turn, increases demand for the crop's productive resources, which in turn results in increased production levels.

ACKNOWLEDGMENT

The authors of the Department of Agricultural Economics of Mosul University and the Ministry of agricultural of Iraq have help improve this works quality.

CONFLICT OF INTEREST

Conflict of interest: the author declares that there is no conflict of interest with regard to the publication of this article.

دالة طلب الموارد وعرض المنتج لمزارع انتاج الطماطة في محافظة نينوى للموسم الزراعي 2023

أحمد هاشم علي [1]، عماد عبد العزيز احمد [2]، وليد ابراهيم سلطان [3]، عبد الحميد عبد الكريم الخرابة [4]
قسم الاقتصاد الزراعي / كلية الزراعة والغابات / جامعة الموصل / الموصل / العراق [1،2،3]
مؤسسة المواصفات المتكاملة للأبحاث والدراسات والاستشارات/الاردن[4]

الخلاصة

يعد محصول الطماطة من محاصيل الخضر المهمة والرئيسية على المائدة العراقية, ودخوله في الكثير من الصناعات الغذائية كمعجون الطماطة والصلصة وغيرها, ومنها استهدف البحث اشتقاق دالة الطلب على الموارد ودالة عرض الناتج من دالة الانتاج وتحديد التوليفات الموردية المثلى لمزارعي الطماطة في ناحية حمام العليل للموسم الزراعي 2023 باعتبارها احد مناطق زراعة هذا المحصول في نينوى, تم تقدير دالة الانتاج نوع كوب–دوجلاس وعلى المدى الطويل اذ تم التوصل للكميات المثلى من الموارد المعظمة للأرباح ومقارنتها بالواقع

الفعلي, ومنها تم اشتقاق دالة عرض الناتج ودالة الطلب على الموارد , من خلال بيانات تم جمعها بواسطة استمارة استبيان أعدت لهذا الغرض لعينة عشوائية من المزارع المنتجة مكونة من (31) مزرعة, شكلت 40% من مجتمع الدراسة, ومن أهم النتائج التي توصلت اليها البحث أن حجم الانتاج المعظم للأرباح بلغ (15643) كغم/دونم, وأرباح بلغت (3544937) دينار/دونم مقارنة بالإنتاج الفعلي البالغ (12799) كغم/دونم وارباح مقدارها (2269187) دينار/دونم, على ضوء هذه النتائج توصي الدراسة مزارعي الطماطة باستخدام الكميات المثلى من الموارد المعظمة للأرباح من أجل زيادة ارباحهم.

الكلمات المفتاحية: كوب–دوجلاس، الأرباح، التكلفة، موارد.

REFERENCES

Abd. Z. F., Mahasn M. S., Mohammed H. A., & Aswan A. Z. (2024). Determinants of The Economic Efficiency of White Onion Production (Crystal) in Nineveh Governorate for The Production Season 2022 (a Field Study in Shekhhan District). *Mesopotamia Journal of Agriculture, 52*(2),146- 165. https://doi.org/10.33899/mja.2024.145602.1336

Ahmed, E. A., Mohammed H. A., Osama L. M., & Ahmed H. A. (2023). Estimation of The Technical Efficiency of Wheat Farms Under the Supplementary Irrigation System Using the Stochastic Frontier Approach (Nineveh Governorate- Albaaj District as a Model. *Mesopotamia Journal of Agriculture, 51*(1), 14-23. https://doi.org/10.33899/magrj.2023.136365.1199

Akamin, A, Jean-Claude B., Jules R. M., & Victor A. (2017). Efficiency and productivity analysis of vegetable farming within root and tuber-based systems in the humid tropics of Cameroon. *Journal of Integrative Agriculture*, *16*(8), 1865-1873. https://doi.org/10.1016/S2095-3119(17)61662-9

Al-Shammari, S. T. A. & Al-Samurai, H. T. Z. (2024). Economic Estimation of the Long-Run Cost Function and Economies of Scale for the Date Crop in the Holy Governorate of Karbala-AlHusseiniyah District for the Productive Season (2021). *IOP Conf. Series: Earth and Environmental Science v. 1371*(10), 1-13. https://doi.org/10.1088/1755-1315/1371/10/102004

Alzubaidi, E., M., &., Waleed., A. S., (2023). Macroeconomic Policies and Their Impact on the Agricultural Sector and Economic Growth In Selected Arab Countries for the Period 1990-2020. *Mesopotamia Journal of Agriculture*, *51*(1), 115-131. https://doi.org/10.33899/magrj.2023.137681.1215

Alzobaee, M. M. S. & Al-Samurai, H. T. Z. (2023). Use the Transcendental Function in Estimating Potato Productivity for the Fall Season 2021 (Baghdad Governorate - Abu Ghraib District, an Applied Model), *IOP Conf. Series: Earth and Environmental Science, 1262*(10), 1-10. https://doi.org/10.1088/1755-1315/1262/10/102002

Attia, A. M. (2000). Econometrics between Theory and Practice. *Second Edition, University House*, Alexandria, Egypt, 439. https://www.scribd.com/document/478646624

Awed, S. T. & Al-Samura, H. T. Z. (2024). Optimal Resource Combinations that Maximize the Profits of Date Farmers in AlHusseiniya District in the Holy Karbala Governorate for the Productive Season (2021). *IOP Conf. Series: Earth* *and Environmental Science*, *1371*(10). 1-15. https://doi.org/10.1088/1755-1315/1371/10/102005

Debertin. L. David. (2012). Agricultural Production Economics" *Macmillan Publishing Company*, Pearson Education Corporate Editorial Offices. N. J – USA. Second edition, 174-183. https://core.ac.uk/download/pdf/232567422.pdf

Farhan G. G., Emad A. A., Mohammed H. A. & Waleed I. S. (2023). Estimating the optimal resource mix for breeding and fattening calves in the northern plain - Nineveh Governorate for the year 2021. *4th International Agricultural Conference* (IAC-2023), 1-11. https://doi.org/10.1088/1755-1315/1213/1/012105

Gujarati, D. (2004). Basic Econometrics. *McGraw-Hill Book Co*. New York, 411. https://www.cbpbu.ac.in/userfiles/file/2020/STUDY_MAT/ECO/1.pdf

Hussein, A. S. M., & Salah F. S. (2017). A study of the determinants of olive crop production in Nineveh Governorate, Bashiqa district as a model for the 2010 season. *Mesopotamia Journal of Agriculture*, *45*(1), 25-34. https:/doi.org/10.33899/magrj.2017.161263

Ibrahim, D. E., & Ahmed, M. E. (2020). Production Efficiency of Some Vegetable Crops Under the Protected Agriculture System in Egypt. *Syrian Journal of Agricultural Research.* *7*(1), 107-123. https://agri-research-journal.net/SjarEn/?p=2572

Iraqi Ministry of Planning and Development Cooperation. Central Statistical Organization and Information Technology (CSO). Annual Statistical Abstract. 2021. https:/cosit.gov.iq/central-statistical-organization-and-information

Issa, N. N., & Zanzal, H.T. (2022). Estimation the Cost function in long-run derived from the Cobb Douglas production function and estimating the resources demand function and the output supply function for Calves fattening projects in Baghdad Governorate. *Tikrit Journal for Agricultural Sciences, 22*(3), 20-28. http://dx.doi.org/10.25130/tjas.22.3.3

Jasim, J. N. & Zanzal, H.T. (2022). Estimating the Economic Efficiency of Cucumber Crop the Protected Houses in Diyala Governorate (Baquba an Applied Model) for the 2021 Agricultural Season. *Tikrit Journal for Agricultural Sciences, 22*(3), 12-19. http://dx.doi.org/10.25130/tjas.22.3.2

Lodewijks, J. & M. Monadjemi. (2016). Microeconomic Theory and Contemporary Issues. *1st edition, book boon.com, ISBN* 978-87-403-1535-6, 40. https:/oldmis.kp.ac.rw/microeconomic-theory-and-contemporary-issues.pdf

Mohamed, M. F. E., Mohamed K. E., & Mohamed E. A. (2021). Standard analysis of mango and orange production in Ismailia Governorate. *Journal of Agricultural Economics and Rural Development, Suez Canal University, 7*(1), 231-238. https://dx.doi.org/10.21608/jard.2021.222864