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AN ECONOMIC ANALYSIS OF THE TOMATO GROWING INDUSTRY IN THE BAGHDAD GOVERNORATE FOR 2022

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Abstract

This study on the economics of tomato production for the 2022 harvesting season was conducted in the Baghdad governorate. Actual output, manufacturing costs, and production inputs together with labor and capital costs were included in the analysis. Annual capital expenditures and labor costs, including both family and hired labor, were estimated. Fifty-seven percent of the workers in the study were direct relatives of the participants while 39% were professional workers. The estimated labor, capital, and total production elasticities were 0.249, 0.501, and 0.75, respectively. The optimal amounts of labor and capital required to produce the optimal volume of the crop were 12.9 workers per day and 479,113 dinars per year. The lowest possible production costs were achieved within the K and L parameters of 4,677 and 658,497 dinars, respectively. They are, in fact, interchangeable, just as in the economic theory.

Keywords: Economics of production, Production elasticity, Optimum size of production.

دراسه تحليله لاقتصاديات انتاج محصول الطماطة في محافظة بغداد للعام 2022

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الخلاصة

تم في هذا البحث دارسه تحليله لاقتصاديات انتاج محصول الطماطة في محافظة بغداد للموسم الانتاجي 2020. بعد ان تم اعداد استمارة استبانة لمنتجي محصول الطماطة. وتضمنت الدراسة الإحصائية تكاليف الإنتاج ومدخلات الانتاج (العمل، راس المال) بعد تقدير تكاليف راس المال والعمل بشقيه (العائلي، المؤجر). وشكلت نسبه عمل الاجير 39% اما العمل العائلي فقد شكل 61% وقدرت مرونة العمل 0.249، بينما كانت مرونة راس المال 0.501 اما المرونة الكلية للإنتاج 0.75. تم احتساب الكميات المثلى من العمل وراس المال عند حجم الإنتاج الأمثل من المحصول حيث كانت تساوي 12.9 ساعة/ يوم، 479.113 دينار/ يوم من راس المال. وبلغ الحجم الأمثل للإنتاج عند التوليفات المثلى من (العمل، راس المال) كانت تساوي 4577 اما التكاليف الإنتاجية الكلية 658.497 ألف دينار وهي متطابقة مع النظرية الاقتصادية.

كلمات مفتاحية: اقتصاديات الإنتاج، مرونة الإنتاج، حجم الأمثل للإنتاج.

Introduction

The tomato is an important agricultural crop with a short production cycle. There is a possibility of generating abundant profits for farmers, because it is a daily food for humans as it contains many nutrients necessary for the body such as vitamins, starches, proteins, and carbohydrates. It is an autoinoculation vegetable crop of important economic value because it is widely consumed by humans or enters into many industries to produce other commodities. Despite the increase in the cultivated areas of this crop, the amounts supplied to Iraqi markets fluctuate. In most cases, local production is inadequate for the needs of the Iraqi consumers, so the deficit in demand for this crop is met through imports (8).

The importance of this research lies in the economic and nutritional importance of the tomato crop, which is the most consumed crop. Therefore, this study is based on determining the optimal quantities of production elements (labor and capital) for achieving optimal production levels of this crop. Various challenges in the production of this crop prevents the achievement of an optimal production level, thereby impacting the incomes of producers and consumers. The increased demand for this crop and its limited supply is due to various production constraints and the failure to use resources optimally, leading to high production costs, which negatively affected the income of the producer and consumer.

Therefore, this research aimed to determine the optimal labor and capital inputs to achieve optimal production amounts and costs by estimating the production function for the tomato crop, as well as determining the value of capacity returns by estimating its total production elasticity.

Materials and Methods

Descriptive analysis, statistical, and econometric analysis methods are used in this study to estimate the production functions and their economic derivatives using ratios and equations. Farmers in the Baghdad province were provided a questionnaire to be completed. Altogether, 92 out of a total of 900 farmers in Baghdad Governorate were surveyed on various aspects such as cultivated areas, labor and capital production factors employed, and estimations of fixed and variable costs. Production and marketing data was also collected.

Results and Discussion

Estimating the Production Function of the Tomato Crop: Various models were adopted for estimating the production function through the use of three formulas, i.e., linear function, double logarithmic, and inverse logarithmic. The double logarithmic function model was found to be the most suitable for the relationship adopted in the study due to its consistency with statistical, econometric, and economic tests. Based on economic theories, the following mathematical model was identified in estimating and analyzing the production function in its linear logarithmic form:

$$lnY = b_0 + (b_1 * lnL) + (b_2 * lnK)$$

Converting it to the exponential form:

$$Y = b_0 * L^{b1} * K^{b2}$$

The details are as follows:

Dependent Variable *(Y)*: represents the volume of production of the tomato crop in tons.

Independent Variables: They are represented by each of the following variables:

- Labor (L): The total number of hours expended by family and hired workers.
- Capital (K): Total variable capital expenditures on seeds, tillage, fertilizer, fuel, pesticides, lubricants, maintenance of machines, and agricultural pumps for producing the tomato crop in the same productive season. The best estimation function was the double logarithmic function which passed the statistical tests (t, R^2, F) and econometric test (Durbin-Watson) at the 5% significance level, and its coefficients agree with the logic of economic theory (see Table 1).

Table 1: Estimated parameters of the tomato crop production function according to the double logarithmic formula for the production function (Cobb-Douglas).

Independent Variables	Estimated Parameters #
Constant (lnB_0)	2.753
Labor (L*) in hours	0.249
Capital (K) in thousand dinars	0.501
R	956.0
Coefficient of determination (R^2)	0.910
R adjusted (R^2)	0.912
D-W test	1.902
F test	433.517

The results of the estimated parameters of the productivity function are all positive and consistent with the logic of economic theories. The analysis shows that the capital variable is the most influential in the production of the tomato crop, followed by the human element. This is because the crop depends on input resources such as the type of seeds and fertilizers and the process of seeding, fertilizing, and irrigation The latter requires experience and practice especially since modern development and technological means are not used particularly in family-run farms. As seen in Table 1, the t-test is significant for all parameters of the independent variables, as it is higher than its critical value at the levels of significance (0.05, 0.01). Also, the overall function is significant, as the F-test reached 433.517 at the level of significance (5%, 1%) to show the importance of the independent variables within the model and the quality of reconciling the regression line. The coefficient determination (R^2) indicates that 91.0% of the variance and fluctuations in the total output of the tomato crop (dependent variable) are caused by the independent variables (labor and capital), while 9.0% are due to other variables and factors not included in the estimated model.

Econometric Analysis: In conducting econometric tests, the estimated mathematical model must be acceptable and approved to explain the phenomenon under study, including the autocorrelation as detected by the Durbin-Waston test (adopted in this study) based on a test schedule. The results show the absence of autocorrelation according to the D-W test for the estimated model. As such, the value of d* extracted as seen in Table 1 is 1.902, which is greater than du and smaller than 4-du, and therefore within the varying limits.

$$du < D.W < 4\text{-}du \quad 0.83 < 1.902 < 2.$$

A level of significance of 5%.

The decision is to accept the null hypothesis which states that the estimated function exceeded autocorrelation by a significant level (5%), meaning that the estimated model is confident of the independence of stochastic variables (Ui) values from each other. Therefore, it can be concluded that there is no positive or negative stochastic variable of the first degree between the residuals.

Economic Derivatives of the Tomato Production Function (Cobb-Douglas): In order to study the production function of the tomato crop, it is necessary to determine its economic derivatives in order to convert the production function from the linear logarithmic formula:

$$lnY = 2.753 + (0.249 * lnL) + 0.501 * \ lnK$$

To the exponential form (Cobb-Douglas formula), it becomes:

$$Y = 11.047 * L^{0.249} * \ K^{0.501}$$

Economic derivatives include the average product function AP, the marginal product function MP, and the productivity elasticity E of the two factors of production (labor and capital). It is possible to derive some economic indicators for the factors used in the production process by deriving the marginal product (MP) functions, the average product AP, and for each of them, by fixing one of the factors at their arithmetic mean and changing the other factor (13).

The functions of average production and the marginal product of the factors of production can be extracted using the fixed results, to note the type of relationship between marginal and average productivity in that it is constant and does not change. So, average productivity (AP) is constantly declining with the productive factors used, with marginal productivity (MP) being less than average productivity (4). This indicates that the surveyed farmers work within the second stage of production, called the rational stage of production (11).

Average Product: Average product refers to the productivity of a single unit of a factor of production. It is total production divided by the number of units used by the productive factor. It can be described as the ratio of output to input (5).

The first is AP per unit labor and it is given by:

$$AP_L = 11.047L^{-0.751}K^{0.501}$$

The second is AP per unit capital and given by:

$$AP_K = 11.047 \ L^{0.249}K^{-0.449}$$

Marginal Product: The term that designates a unit of output that results from the addition of one unit of a variable factor of production is known as the marginal product. It represents the amount by which an increase in overall production is neutralized by an increase in the amount of the productive factor that is utilized while the other factor remains constant. When calculating the marginal product, the change in the number of units of the variable input factor is divided by the total number of units.

Elasticity of Productivity: Productivity elasticity is derived by dividing the marginal product by the average product of the two factors of production (L, K), and represents the ratio of the change in production to the relative change in the productive factor involved in the production process, *ceteris paribus*. The elasticity of production of labor (EL) is extracted by the following equation:

$$E_K = 0.501 \ (11.047L^{0.249}K^{-0.499})/11.047 \ (L^{0.249}K^{-0.499})$$

Economic Analysis of the Tomato Crop Production Function with Changes in Labor and Constant Capital Inputs: As shown in Table 2, an increase in the number of units of the variable productive factor leads to an increase in the level of production, and that the values of average production (AP) are positive and gradually decrease as the level of production rises. These findings were arrived at through an examination of the data. As for the marginal product (MP) values, they are also positive for all levels of utilization; they begin decreasing with an increase in the level of production, but do not reach zero. This indicates that the variable productive factor has not lost all of its properties or, put alternatively, that there is the possibility of increasing the amount of resource being used due to the absence of complete exploitation of its properties, both in terms of capital and labor (6). The elasticity values for each level of productivity are very close to being the same, and the elasticity of the variable production factor (labor L), which is equal to its elasticity in the estimated function with a value of 0.249, was determined to validate the findings obtained.

This indicates that the elasticity of the response to the factors used is less than one, showing that the results obtained are reliable. This places it in the second stage of production because it implies an increase in production at decreasing rates. The capacity returns totaled less than one 0.75, indicating that an increase in factors by a certain percentage is offset by a smaller percentage increase in production, which falls within the realm of diminishing returns. Total production elasticity, which represents the sum of the response to the factors used, was the capacity returns. These findings are in line with conventional economic theory (18).

Table 2: Average labor and capital, elasticities, and tomato crop production function with change in labor and constant capital inputs.

No.	L	K	Y	MPL	APL	EL
1	10	250,175	3474.122	73.331	347.455	0.249
2	15	250,175	3784.428	53.234	252.295	0.249
3	18	250,175	3932.851	46.104	218.515	0.249
4	20	250,175	4021.262	42.426	201.072	0.249
5	25	250,175	4215.124	35.377	168.615	0.249
6	35	250,175	4525.258	27.282	129.299	0.249
7	40	250,175	4654.571	24.553	116.367	0.249
8	45	250,175	4771.697	22.374	106.038	0.249
9	55	250,175	4978.076	19.098	90.513	0.249

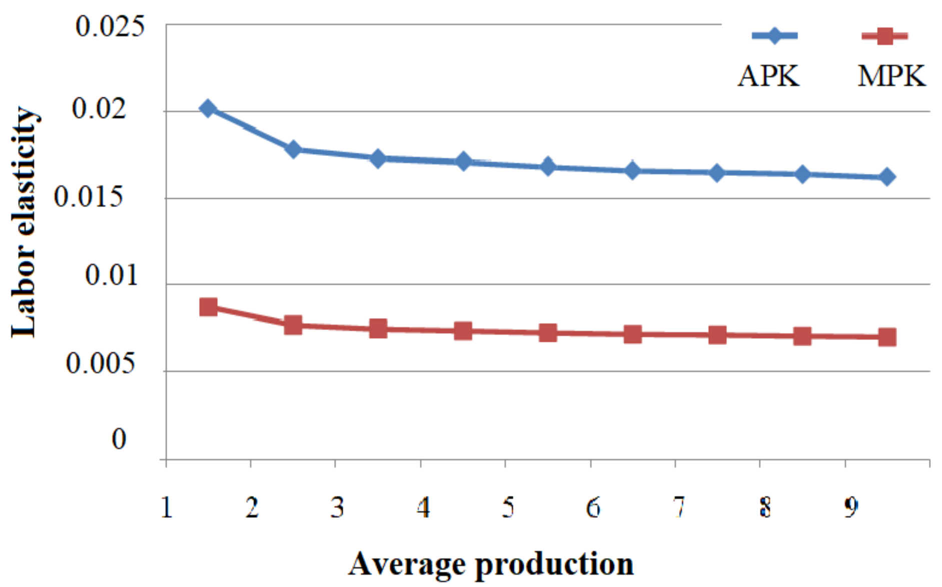

Figure 1: Average and marginal production curves of the tomato crop function when capital is constant and labor input changes.

Economic Analysis of the Tomato Crop Production Function with Changes in Capital and Constant Labor inputs: Table 3 shows that the level of production increases with higher unit inputs of the variable production factor and that average production (AP) is positive but begins to decrease gradually with increased production levels. Marginal product (MP) is also positive for all unit levels used and begin declining with higher production levels, but do not reach zero. Meaning that variable capital has approached the stage of depletion of its properties, in other words, begins losing its potential because of the higher value of production (10). The limit is very close to zero. The elasticity values for all levels of productivity are almost constant, and the elasticity of the variable productive factor (capital K) is equal to its elasticity in the function estimated at a value of 0.501. To confirm the accuracy of the results obtained, this means that the elasticity of response to the factors used is less than one, indicating an increase in production at decreasing rates, so it declines in the second stage of production (3). Total production elasticity, which represents the sum of the elasticity of response to the factors used, refers to the returns to capacity, which totaled less than one (0.75), indicating that the increase in factors by a certain percentage is offset by an increase in production by a smaller percentage, which falls within the diminishing returns (14). These results are consistent with operative theories of economics (17).

Table 3: Averages of labor and capital, elasticities, and tomato crop production function with changes in capital and constant labor inputs.

No.	L	K	Y	MPK	APK	EL
1	25	180,570	3662.532	0.00874	0.0202	0.501
2	25	225,661	4031.874	0.0077	0.0178	0.501
3	25	237,111	4118.807	0.00748	0.0173	0.501
4	25	243,215	4164.176	0.00737	0.0171	0.501
5	25	250,175	4215.124	0.00726	0.0168	0.501
6	25	255,432	4253.074	0.00717	0.0166	0.501
7	25	257,614	4268.695	0.00714	0.0165	0.501
8	25	262,125	4300.752	0.00707	0.0164	0.501
9	25	266,381	4330.71	0.007	0.0162	0.501

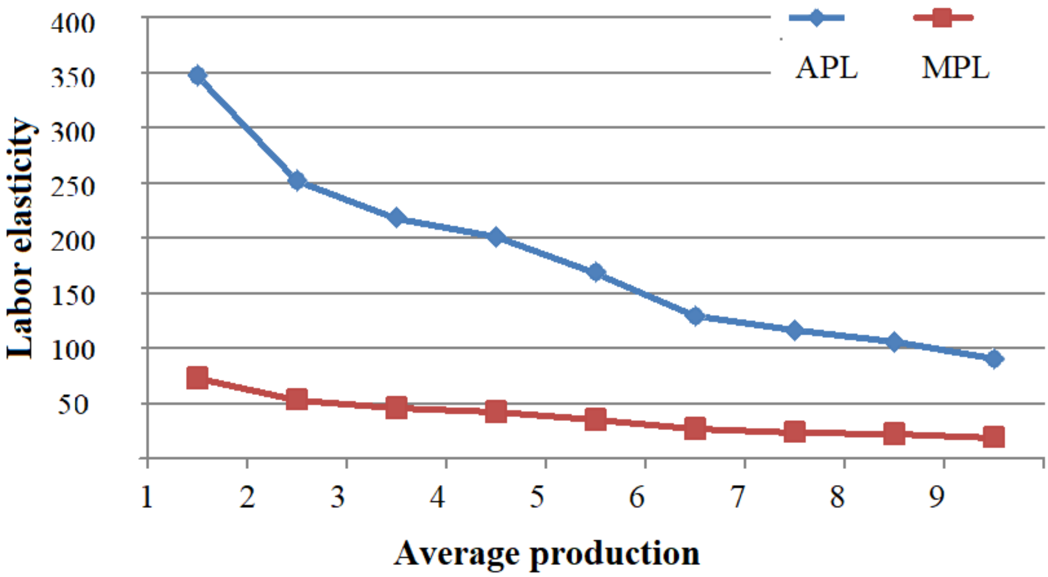

Figure 2: Average production and marginal production curves of the tomato crop function with constant labor and changes in capital inputs.

Optimum Labor and Capital for Optimum Production: It is necessary to extract the optimum quantities of labor and capital at the optimum production level to bring production costs to their minimum level (21). This is achieved by equalizing the marginal substitution rate for the factors of production (labor and capital) in regard to their inverse prices, and the stability of the factors in their arithmetic mean (20).

Substituting in the capital required for a dunum of 250175, we get:

RTS =b2L⁄b1K = r⁄w

0.501L⁄0.249(250175) = 1.1⁄10000 = L = 58065.617⁄4310

L = 12.9 man/days, the labor necessary to achieve the optimum volume of production for the tomato crop.

Substituting for the labor needed for a dunum of 27 days/man, we get the capital as follows:

RTS = b2L⁄b1K = r⁄w

0.249K = 1.1⁄10000 / (27) 0.501 = K = 107750⁄0.2321

K = 479113 Dinar

The capital is required to grow one dunum of the tomato crop.

To find the optimum volume of production, the optimal values of labor (L) and capital (K) are substituted into the production function (Cobb-Douglas) (12).

Y = 11.047 K0.501 L0.249

Y =11.047 (479113)0.501 (12.9)0.249

Y = 4677 Kg/dun

The optimum production at optimum combinations of L and K. To extract the total production costs for the tomato crop, the cost equation is applied, as follows (19):

$$C = wL + rK$$

$$C = (479113)\ 1.1 + (12.9)\ 100000$$

$$C = 658497 \text{ Dinar}$$

Where C represents the total production costs per dunum of the tomato crop.

Table 4: Optimal quantities of capital and labor, optimal production, total revenue, and net profit for the tomato crop.

Labor hours/day	Capital (Dinars)	Optimum Production (Kg/ Dunum)	Output Price (Dinars)	Total Revenue (Dinars)	Total Production Costs	Net Profit
12.9	479,113	4677	300	1,457,559	658,497	805,432

Economic interpretation: As seen in Table 4, optimal production reached 4677 kg/dunum, optimal quantities for the two production factors (labor and capital) is 12.9 hours/day and 479133 dinars, respectively. Total revenue for the tomato crop reached 1457559 dinars at an average price of 300 dinars, while estimated net profit was 805432 dinars, and total production costs were 658497. This is in line with economic theory (16).

Table 5 indicates labor, capital, and production in the surveyed tomato crop producers according to data from the questionnaire, offset by the results of analyzing the data achieved for the optimal quantities of the three factors. It shows the optimal results (15) if the tomato crop producers in Baghdad follow the recommended reduction in costs to obtain optimal production (7).

Table 5: Labor, capital, and production of the samples and results achieved.

Production Resources	Samples	Results Achieved
Labor hours/day	27	12.9
Capital (Dinars)	907,115	658,497
Production (Kg)	4798	4677

The findings in this study provide crucial insights into the tomato cultivation industry, highlighting various aspects that influence productivity, profitability, and the challenges faced by farmers. The optimal annual output of 4677 kg, achieved with an optimal daily workforce size of 12.9 and a recommended capital investment of 479113 dinars, serves as a valuable reference point for farmers looking to optimize their crop yields and financial returns.

The economic theory's prediction that the tomato harvest will yield 14557559 dinars, the highest income among all crops studied, underscores the economic significance of tomato cultivation. However, the study also uncovers a concerning aspect—the high production costs associated with tomato farming. This signals possible inefficiencies in the utilization of productive resources, which warrant closer examination and remedial action.

A primary contributor to the high production costs appears to be the inefficient utilization of labor resources. The study identifies a possible lack of proper workforce management and productivity enhancement strategies as factors that contribute to increased expenses. Addressing these inefficiencies through targeted training programs and better workforce planning could have a positive impact on reducing costs and improving overall productivity (9).

Moreover, the study sheds light on the elevated prices of essential inputs such as fuel, seeds, and fertilizer. The lack of state support in providing these inputs at more reasonable prices adds to the financial burdens faced by tomato farmers. Policymakers need to consider interventions that offer subsidies or incentives to farmers, ensuring access to affordable inputs, which would help mitigate production costs and enhance profitability (2).

Additionally, the study highlights the role of education and technology adoption in influencing productivity and expenses. The lack of agricultural education among farmers and resistance to adopting modern farming practices hinder progress in the sector (1). Encouraging the dissemination of knowledge, promoting agricultural training initiatives, and advocating the adoption of modern technologies can lead to higher levels of productivity and lower overall expenses.

Conclusions

This comprehensive study on tomato cultivation yielded several significant findings that warrant attention from farmers, policymakers, and agricultural stakeholders. The optimal annual output of 4677 kg, achieved with an optimal daily workforce size of 12.9 and a recommended capital investment of 479113 dinars, provides a valuable blueprint for enhancing productivity and financial returns in tomato farming.

The economic theory's prediction of the tomato harvest bringing in 1457559 dinars, the highest income compared to other crops studied, highlights the economic potential of tomato cultivation. However, the study has also brought to light the presence of high production costs, indicating the existence of inefficiencies in resource allocation and utilization.

The inefficient use of labor resources, coupled with the inflated prices of inputs like fuel, seeds, and fertilizer, poses significant challenges to tomato cultivation. The lack of state support in providing these inputs at more reasonable prices further hampers the sector's growth and profitability. Addressing these issues through targeted interventions, such as workforce training and providing affordable inputs, is essential for sustainable growth and improved economic outcomes.

Furthermore, the research underscores the importance of education and technology adoption in enhancing productivity and reducing production expenses. The lack of agricultural knowledge among farmers and resistance to adopting modern farming practices hinder progress in the industry. Encouraging knowledge dissemination and advocating the adoption of modern technologies can significantly boost productivity and overall efficiency.

To realize the full potential of tomato cultivation, stakeholders must collaborate to address these challenges and implement solutions. By doing so, the tomato farming sector can not only achieve optimal production levels and profitability but also contribute substantially to the agricultural and economic development of the region. Continued research and practical implementation of insights gleaned from this study will play a pivotal role in the sustainable growth and prosperity of tomato cultivation in the future.

Supplementary Materials:

No Supplementary Materials.

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Raad Idan Obaid: methodology, writing—original draft preparation; Majid Abed Hamza and Firas Ibrahim Rahim: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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