An economic and standard study of potato production in Nineveh Governorate for the spring planting season of 2025

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Abstract

Potatoes are one of the most important main vegetable crops and are considered among the modern vegetable crops introduced to Iraq. They are also a source of cheap energy due to their nutritional content, which contributes to achieving food security. This research aimed to estimate the Cobb-Douglas production function for potatoes in Nineveh Governorate for the spring season of 2025, as it is one of the most important governorates contributing to potato cultivation in Iraq. The study relied on cross-sectional data from a random sample of (82) farms. Among the most important findings of the research was that the elasticity of production for labor was (0.837) and for capital (0.321), while the total elasticity was (1.158). This indicates the existence of increasing returns to scale and the presence of untapped production capacity, meaning that production can be expanded to achieve high profits. Furthermore, it was found that labor contributed 72.3% to explaining production changes, compared to 27.7% for capital. These percentages illustrate the role of human labor in the production process. The isotropic curves also demonstrated the potential for achieving The same level of production can be achieved through various combinations of labor and capital. In light of these findings, the study recommends providing government support for production inputs at subsidized prices, expanding the use of production factors, establishing specialized research centers, strengthening agricultural extension programs, and implementing a national strategy to bridge the gap between domestic production and actual consumption in order to reduce reliance on imports.

Keywords: Production, Production Elasticity, Indifference Curve, Labor, Capital

Introduction

Agricultural activity is one of the most important productive activities in the economy due to its crucial role in achieving optimal production levels that contribute to maximizing profits and minimizing costs.Potatoes are considered a strategic vegetable crop, belonging to the nightshade family, and rank fourth globally after rice, wheat, and corn in terms of nutritional, economic, production, and consumption value. In Iraq, potatoes are cultivated in two seasons (spring and autumn).Nineveh Governorate is one of the most suitable areas for potato cultivation. Spring planting begins between December and January, and the yield per dunam of potatoes in Iraq for the spring season ranges between 6 and 9 tons/dunam, while for the autumn season it ranges between 3.5 and 7.5 tons/dunam. Potato farmers face several obstacles, including high prices for seeds, fertilizers, and pesticides, which have led to increased production costs and consequently lower

ISSN 2072-3857

farmers' profits.Therefore, the government must provide farmers with support in the form of production inputs to enhance local production and reduce imports.It provides income, but it faces many challenges related to price fluctuations, high production input costs, and climatic conditions.This study is one of the most important studies that have addressed the study of this crop.

Research Problem

Despite the widespread cultivation of potatoes in Iraq in general and Nineveh Governorate in particular, and given its significant nutritional and economic importance, production still suffers from a substantial shortfall. Furthermore, potato yield per dunam remains low compared to many other countries. This is compounded by the high costs of production inputs, especially seeds and fertilizers, as well as the underutilization of these inputs due to their high prices and limited knowledge of high-yielding potato varieties. These factors are among the most prominent contributors to this production deficit and, consequently, the low profits of farmers.

Research Objectives

This study aims to estimate the Cobb-Douglas production function for potatoes in Nineveh Governorate for the spring planting season of 2025, measure production elasticities and returns to scale, and derive economic indicators to determine the production stage.

Research Hypothesis

Potato production in Iraq in general, and in Nineveh Governorate in particular, did not meet market needs due to the lack of optimal use of available production resources, which affected productivity per dunam. This resulted in a decrease in productivity and the inability of farmers to reach the optimal production volume that would generate a net income that would help increase cultivated areas and adopt the cultivation of this crop.

References and Previous Studies

Given the importance of previous studies and research, we need to highlight some of these studies and research findings to review some of the results and methodologies employed in the quantitative aspect.Al-Akeeli and Nasser,(1) conducted this study which titled "Economics of Potato Production for the Autumn Season 2015-2016 in Baghdad Governorate." The study relied on a random sample of 155 farms and aimed to estimate the production function. It arrived at the most suitable double logarithmic formula for representing the production function. The results of this study also showed that the potato producers in the sample were inefficient in their use of pesticides and irrigation, while they demonstrated efficiency in their use of seeds, labor, and phosphate fertilizers. Furthermore, the study results indicated that the technical, economic, and price efficiencies reached 34.25933%, 34.2937%, and 73.521%, respectively.Al-Jilani Bouzaraf et al.,(2) presented a study titled "Analysis of the Role of Changes in the Potato Production Curve in The Algerian economy using the Cobb-Douglas function: A case study of Mostaganem. The study aimed to analyze potato production as a consumer and strategic commodity. The results showed a strong relationship between the main variables (water quantity, pesticide quantity, fertilizer quantities, seed quantity, and labor), and that there is a correlation between these variables and potato production.Al-Zubaidi,(3) published a study on the economics of potato production for the autumn crop in 2021 in Abu Ghraib district, Baghdad Governorate.The study aimed to examine the production reality of the potato crop in Iraq and Baghdad Governorate for the period (1995-2020), and the accompanying changes in production, productivity, and area. It also aimed to estimate the potato production function according to the planted seed variety, measure its production elasticity using Eviews 10 software, and estimate economic efficiency and its components.The results of the study showed the superiority of the planted Boronia seed variety over other similar varieties, and that the independent variables explain 91% of the changes in the dependent variable. The Rudolph Red variety was found to have the greatest impact on production. The study results showed that the optimal production volume for civil production costs is 5663 kg/dunum, and the optimal farm area is 24 dunums. Therefore, the study recommended the necessity of establishing new research centers to work on producing local seeds, providing guidance seminars for farmers, and directing them to use production inputs in a way that achieves economic efficiency, reduces the need for chemical fertilizers, limits imports, and encourages farmers to expand potato cultivation.Ali et al.,(4) presented a study entitled "Resource Supply and Demand Function for Tomato Production Farms in Nineveh Governorate for the 2023 Agricultural Season." The research aimed to estimate the Cobb-Douglas production function in the long run and identify optimal resource combinations that maximize profits.The study relied on data collected through questionnaires from a random sample of 31 farms, which constituted about 40% of the study population. The results of the research showed that the optimal production volume that maximizes profits reached 15,634 kg/dunum, which exceeds the actual production. (12.799) kg/dunum, which was reflected in the profits, as they increased from (2,269,187) to (3,544,937) dinars/dunum. Therefore, the study recommended that farmers guide tomato crop farmers to use the optimal quantities of production inputs that maximize their profits. In 2023, Giang & Huong presented a study entitled Comparing the Impact of Production Factors on the Environmental and Economic Efficiency of Potato Land Use Type in Vietnam and Russia Based on the Cobb-Douglas Function. The study aimed to identify and compare the impact of production factors on environmental and economic efficiency. The study relied on the Cobb-Douglas function in analyzing its data during for period (2016-2019). The results of the analysis showed that the contribution coefficients of production factors (labor costs, expenditure on agricultural machinery, fertilizers, and pesticides) achieved a higher percentage compared to the Red River Delta. In contrast, the Red River Delta showed an excessive dependence on chemical inputs which generated more severe environmental and economic pressure. The study recommended reconsidering the agricultural policies followed in that region, as it recommended enhancing the positive factors and addressing the negative impacts affecting the economic and environmental efficiency of agricultural land use in the two study areas. Ali et al.,(4) who published a research paper entitled "Optimal Resource Allocation to Maximize Profits for Watermelon Farmers in Rabia District for the 2024 Agricultural Season." The study aimed to determine the optimal quantities of watermelon production resources in Rabia District for the year 2024. The study relied on a sample that included (34) farms with an average area of 6 dunams, and used the Cobb-Douglas function and isoproducible curves as an analytical tool. The research

ISSN 2072-3857

results showed that the optimal production to maximize profit was (37,762) kg with profits of (5,704,102) dinars, while the actual production was (29,040) kg with profits of (2,869,452) dinars, while the profits under the cost reduction strategy amounted to (4,224,380) dinars. Therefore, the study recommended guiding farmers of this crop towards using the optimal quantities of production inputs specified according to standard economic models to maximize their profits.Pham and Huong,(5) published a study entitled "Resource Use Efficiency and Profitability of Potato Production in Sayajna District, Nepal." The study aimed to analyze the factors affecting potato production and the efficiency of production input use in farms of varying sizes. The study relied on the Cobb-Doclas function in its analysis, and its data were collected through a field survey of a sample of 91 farms in 2024. The results reached by the researchers showed that large farmers enjoy 9% lower variable costs compared to small farmers. In addition, the excessive use of production inputs (seeds, labor, and fertilizers) weakened production efficiency. Production increased by (237-293 kg/rubani) using commercial farming systems compared to traditional farming, and the coefficient of return on scale reached (1.40), which indicated the presence of increasing economies of scale. The study recommended the need to provide guidance programs to improve the optimal use of inputs, expand production, and manage the post-harvest stage.

Materials and Methods

The Cobb-Ducklas production function was used to analyze the data and extract the results.Cobb-Ducklas Production Function.The Cobb-Ducklas production function is considered one of the most prominent tools in economic analysis. It has enabled researchers to develop economic models and derive various production functions, thus contributing to advancements in economic analysis (6). The function assumes the constant elasticity of production of resources, regardless of the quantity of inputs used (7). Its general formula which as follows:

Y=A X_1^(b_1) X_2^(b_2)

Where:

Y: Quantity of output, A: A technological variable, b_1 , b_2 : Production elasticity of inputs, X_1 , X_2 : Labor and capital.

Its value ranges from 0 to 1. The Cobb-Ducklas function is characterized by several properties, including the degree of homogeneity (b_1 + b_2), The degree of homogeneity and Returns to Production Capacity are determined through total elasticity (E), which is (b1 + b2) (8). The values of b1 and b2 range from 0 to 1 (7). A change in one of the factors of production (labor and capital) shifts the production curves for each, while the other is calculated continuously. Their parameters are calculated by converting the variables to the logarithmic form to base 10 or the natural logarithm to base ex (e = 2.71828) (9). The equation takes the following form:

Ln Y = Ln A + b1 Ln X1 + b2 Ln X2

The Cobb-Ducklaus function can also take more than two inputs, as in the following form:

Y=AX_1^(b_1) X_2^(b_2)

The double logarithmic form The following formula is used:

Ln Y = Ln A + b1 Ln X1 + b2 Ln X2

Where:

Y: quantity of production, A: technical factor, X1, X2: quantity of factors of production (labor and capital), b1, b2: parameters of factors of production (elasticity of factors of production) (10).

Description of the Model Used

The study relied on data analysis and interpretation of results from a random sample of 82 potato farms in Nineveh Governorate. The Cobb-Douglas production function was estimated using the Ordinary Least Squares (OLS) method and the EViews 10 statistical software. The double logarithmic formula was adopted as it best represents the relationship between the dependent variable (Y), estimated based on the dynamic yield for the 2025 growing season, and the independent (explanatory) variables, which are the production elements affecting the dependent variable. These independent variables are as follows: - Labor (L) (man/day) refers to the total number of human working days, including family and hired labor, estimated for the 2025 production season. It encompasses all agricultural operations necessary for production during the season, such as plowing, fertilization, irrigation, pesticide spraying,etc. (11).

The capital component represents the total capital costs converted into production, including fertilizers, pesticides, fuel, oils, irrigation costs, pumps, equipment maintenance, etc., in dinars during the 2025 production season. This mathematical model was formulated to study the relationship between production and its aforementioned inputs according to the following formula (12) :

$$\text{Ln } Y = \text{Ln } b0 + b1 \text{ Ln}L + b2 \text{ Ln}K$$

Where as :

Y: Production (kg), L: Labor (man/day), K: Capital (dinars), b0: Function constant (technological level), b1, b2: Coefficients (production elasticities of the variables(

Results and Discussion

This equation represents the estimated production function for the farms in the research sample, which was derived from the results in Table (1) using the multiple linear regression method according to the standard OLS method using the Eviews.10 statistical software, as follows:

Table (1) Results of data analysis for large potato farms.

Dependent Variable: LNY

Method: Least Squares

Date: 02/01/2026 Time: 9:15

Sample: 1 82

Included observations: 82

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.7203	0.359400	0.993065	0.356908	C
0.0000	4.394237	0.190519	0.837187	LNL

0.0002	3.849665	0.083445	0.321234	LNK
6.631364		Mean dependent var	0.720064	R-squared
0.440444		S.D. dependent var	0.705382	Adjusted R-squared
0.713996		Akaike info criterion	0.339633	S.E. of regression
0.802046		Schwarz criterion	9.112682	Sum squared resid
0.749347		Hannan-Quinn criter.	-26.27382	Log likelihood
1.769369		Durbin-Watson stat	28.61096	F-statistic
			0.000000	Prob(F-statistic)

Source: Prepared by the researcher based on data from the questionnaire using Eviews.10 software.

Ln Y=0.357 + 0.837 LnL+0.321 Lnk

Statistical Analysis

The results of the t-test, presented in Table 6, showed that the significance of the estimated parameters for the economic variables included in the model was at a significance level of 0.01.The coefficient of determination ($R^2 = 0.721$) of the changes in production (the dependent variable) were attributed to the explanatory (independent) variables, namely L and K, while 27.9% were attributed to other variables not included in the model. The F-test, with a value of 28.611, demonstrates the significance of the function when compared to its critical value at a significance level of 0.01 (13).

Standard Analysis

The results of the D.W. test, which amounted to 1.769, indicate the absence of an autocorrelation problem among random errors at a significance level of 0.05. The critical value of du for two independent variables and 82 observations was 1.54. Therefore, the D.W. value falls within the acceptance region (du) < D.W < 4-du) i.e. (1.541 < 1.769 < 2.46). This confirms the absence of autocorrelation in the model. Furthermore, the Park test analysis revealed the absence of heterogeneity in the model, a problem often observed in cross-sectional data (14). The Park test was applied to test for this problem (15) using the Eviews 10 statistical software as a quadratic logarithmic function Lnei2. The test results are presented in Table (2).

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Table (2) Park Test for Instability of Variance

Independent variables	Test-check box with explanatory variables	R^2	F
Number of employees LnL	$Lnei^2 = -4.485 + 0.1106$ LnL T (-0.609) (0.0856)	0.01	0.007
Capital LnK	$Lnei^2 = 1.44 – 1.5$ LnK T (-1.77) (0.334)	0.01	0.118

Source: Prepared by the researcher based on sample data and Eviews 10 results

Table (2) shows that the parameters of the explanatory variables are not significant according to the t-test at a significance level of (0.05), as their tabulated values are greater than their calculated values.The F-test also showed that the estimated parameters above are not significant because the calculated F-value is less than their tabulated values. This indicates the absence of a heterogeneity problem. Regarding the multiple linear correlation problem, the Klien test was used. Comparing the square root of the coefficient of determination (0.848) with the values of the simple correlation coefficients between the explanatory variables in the simple correlation matrix shown in Table (3) reveals the absence of a multiple linear correlation problem.

Table (3): Correlation Matrix Between Explanatory Variables

Degree of correlation		
LnL	LnK	
0.405058	1.000000	LnK
1.000000	0.405058	LnL

Source: Prepared by the researcher based on sample data and results from Eviews.10

Economic Analysis of the Production Function

Logarithmic Formula: LnY = 0.357 + 0.837 LnL + 0.321 LnK

Exponential Formula: Y = 1.429 L0.837 K0.321

The results of the statistical analysis of the potato production function data indicate a direct correlation between the explanatory variables (labor and capital) and the dependent variable Y, which represents total production. This aligns with the logic of economic theory, given the reliance on a double logarithmic function. Therefore, the

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coefficients of the variables represent the elasticities of production. This means that production quantities can increase by the coefficient of each of (L, K) if their utilization increases by 1%. Since the value of the elasticities of the variables ranges between zero and one, the resources operate within the second stage of production. It is evident that the sum of the production elasticities for each of (L, K) reached (1.158), which is greater than one. This indicates that the potato production function reflects a state of returns Increasing capacity. This indicates that production is increasing in an increasing way. This means that farmers continue to produce until they reach the second stage, meaning that the productive resources used have not yet exhausted all their properties. Therefore, production continues to expand. The percentage of contribution of each resource of production is calculated by dividing the elasticity of each resource by the total elasticities and multiplying it by 100. Through this, it was found that the labor resource occupies the first rank, followed by capital resources, with percentages of (72.3%, 27.7%) respectively.

Derivation of the Potato Production **Function for the Research Sample**

The most important economic derivatives of the production function, derived from the Cobb-Ducklaus function (marginal product, average product, and production elasticity), are crucial tools used by producers to make decisions about increasing or decreasing resource utilization and determining resource efficiency. The exponential formula of the production function is used to calculate these derivatives, as follows:

$$Y = 1.429L^{0.837}K^{0.321} \text{ (Exponential Formula)}$$

The production functions for each resource involved in the production process are derived separately by fixing one element at its arithmetic mean and the other element at different levels.Derivation of the average product, marginal product, and production elasticity for the labor resource is as follows:

The derivative is achieved by fixing the capital resource at its arithmetic mean (122.86 million dinars) to find the relationship between production and labor, as follows:

$$Y = 1.429\,L^{0.837}\,(122.86)^{0.321}$$

$$Y = 1.429\,L^{0.837}\,(4.6849) \rightarrow Y = 6.6947\,L^{0.837}$$

$$AP_L=(1.429\,L^{0.837}\,K^{0.321})/L \rightarrow APL = 1.429\,L^{-0.163}\,K^{0.321}$$

$$MPL = 1.429\,(0.837)^{-0.163}\,K^{0.321} \rightarrow MPL = 1.196\,L^{-0.163}\,K^{0.321}$$

$$EL = MP_L/AP_L = (1.196\,L^{(-0.163)}\,K^{0.321})/(1.429\,L^{(-0.163)}\,K^{0.321})=0.8369$$

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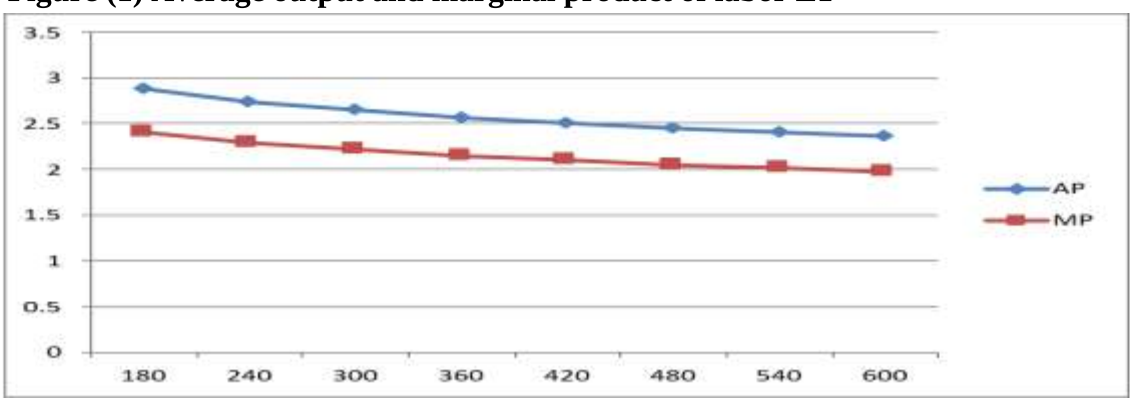
Table (4) Economic derivatives of the production function when K is held at its arithmetic mean and L is changed

L	K	Y	AP_L	MP_L	E_L
180	122.86	516.89	2.8716	2.4034	0.8369
240	122.86	657.61	2.7401	2.2933	0.8369
300	122.86	792.65	2.6422	2.2114	0.8369
360	122.86	923.33	2.5648	2.1466	0.8369
420	122.86	1050.49	2.5012	2.0934	0.8369
480	122.86	1174.71	2.4473	2.0483	0.8369
540	122.86	1296.42	2.4008	2.0093	0.8369
600	122.86	1415.94	2.3599	1.9751	0.8369

Source: Prepared by the researcher based on the estimated production function and questionnaire data.

Figure (1) Average output and marginal product of labor L1



Source: Prepared by the researcher based on the data in Table (4).

The results in Table (4) and Figure (1) show that the values of both marginal product and average product are positive, but they decrease with the expansion of production, which increases at a decreasing rate. Furthermore, neither value reaches zero. The partial elasticity of labor is a constant value, representing the quotient of marginal product divided by average product, and it is approximately (0.8369).The average product, marginal product, and elasticity of production for capital are derived as follows:

The derivation is achieved by fixing the labor resource at its arithmetic mean of (303) man/day to find the relationship between production and capital, as follows:

$Y = 1.429 (303)^{0.837} K^{0.321}$

$Y = 1.429 (119.39) K^{0.321} \rightarrow Y = 170.61 K^{0.321}$

$AP_K=(1.429L^{0.837} K^{0.321})/K \rightarrow APK = 1.429 L^{0.837} K^{-0.679}$

$MPK = 1.429 (0.321)L^{0.837} K^{-0.679} \rightarrow MPK = 0.4587 L^{0.837} K^{-0.679}$

$E_L= MP_K/AP_K \rightarrow (0.4587 L^{0.837} K^{(-0.679)})/(1.429 L^{0.837} K^{(-0.679)}) = 0.32099$

Table (5) Economic derivatives of the production function when K changes, and L is held constant at its arithmetic mean 2.

L	K	Y	AP_K	MP_K	E_K
303	40	556.35	13.9380	4.4740	0.32099
303	60	633.69	10.5836	3.3973	0.32099
303	80	694.99	8.7057	2.7945	0.32099
303	100	746.60	7.4817	2.4016	0.32099
303	120	791.60	6.6105	2.1219	0.32099
303	140	831.75	5.9536	1.9111	0.32099
303	160	868.18	5.4375	1.7454	0.32099
303	180	901.63	5.0196	1.6113	0.32099

Source: Prepared by the researcher based on the estimated production function and questionnaire data.

ISSN 2072-3857

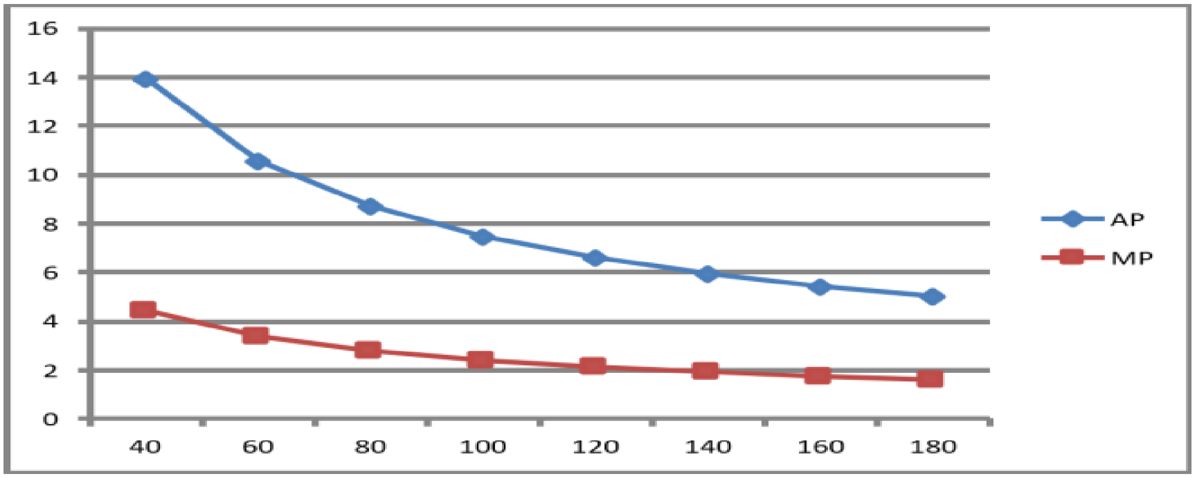


Figure (2) Average Production and Marginal Product of Labor k2

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

The results in Table (5) and Figure (2) show that the values of both marginal product and average product are positive, but they decrease with the expansion of production, which increases at a decreasing rate. Furthermore, neither value reaches zero. The partial elasticity of capital, which is the quotient of marginal product divided by average product of labor, is a constant value and is approximately (0.32099).

Isotope Curves

Isotope curves are defined as the locus of different combinations of the two inputs used in a production process. They yield a single, constant level of output when other productive resources are held constant (Debertion, 2012, p. 86). The equation for the isotope curve of the estimated production function for potatoes can be derived from three or four production levels, as follows:

Y = 1.429 L0.837 K0.321

Isotope curves between labor (L) and capital (K) can be estimated when labor is held at its mean and capital is varied at different production levels (500, 600, 700, 800 tons). At a production level of 500 tons and capital of 40 million dinars, and with labor held at its mean of 303 men/day, we obtain 266 workers. Repeating this process at different levels of capital and production yields corresponding labor quantities for each case, as shown in Table 6 and Figure 3. This allows us to plot the inequality curves between labor Capital is maintained through stable operations as follows:

ISSN 2072-3857

$L^{0.837}=Y/(1.429K^{0.321})\rightarrow L=(500/(1.429K^{0.321}))1.1947$

$L=(500/(1.429\llbracket(40)\rrbracket^{0.321}))1.1947 \rightarrow L=(500/4.6697)1.1947$

$L=266$ Factor

Table (6) The isotropic curve between L and K, with L held at its average for a number of production levels.

Production levels (kg/dunum)		500	600	700	800
Capital K (million dinars)	Labor L	Labor L (worker)			
40	303	266	331	398	466
60	303	228	283	340	399
80	303	204	254	305	357
100	303	187	233	280	328
120	303	175	217	261	306
140	303	165	205	246	288
160	303	156	194	234	274
180	303	149	186	223	262

Source: Prepared by the researcher based on the results of the production function and the questionnaire form

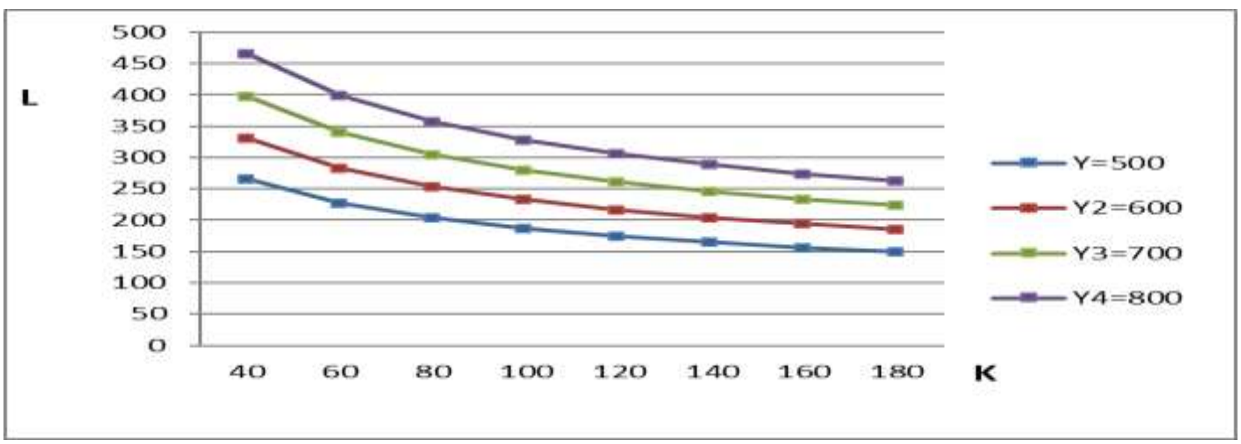


Figure (3) shows the equal output curves between the factors of production for different levels of production

Source: Prepared by the researcher based on the data in Table (6).

ISSN 2072-3857

If the previous mathematical operations for the relationship between L and K were repeated, and capital were fixed at its arithmetic mean (122.86) million dinars, we would obtain the data in Table (7), as follows:

$Y = 1.429 L^{0.837} K^{0.321}$

$K^{0.321}=Y/(1.429 L^{0.837}) \rightarrow K=(500/(1.429L^{0.837}))^{3.11526}$

$K=(500/(1.429 (180)^{0.837}))^{3.11526} \rightarrow K=(500/110.33)^{3.11526}$

K=111 million dinars

Table (7) The isoproducible curve between L and K, with K held at its average for a number of production levels.

Production levels (kg)		500	600	700	800
Labor L	Capital K	)Capital K (million dinars			
180	122.86	111	195	316	479
240	122.86	52	92	149	226
300	122.86	29	52	83	126
360	122.86	18	32	52	79
420	122.86	12	21	35	53
480	122.86	9	15	24	37
540	122.86	6	11	18	27
600	122.86	5	8	14	21

Source: Prepared by the researcher based on the results of the production function and the questionnaire form.

ISSN 2072-3857

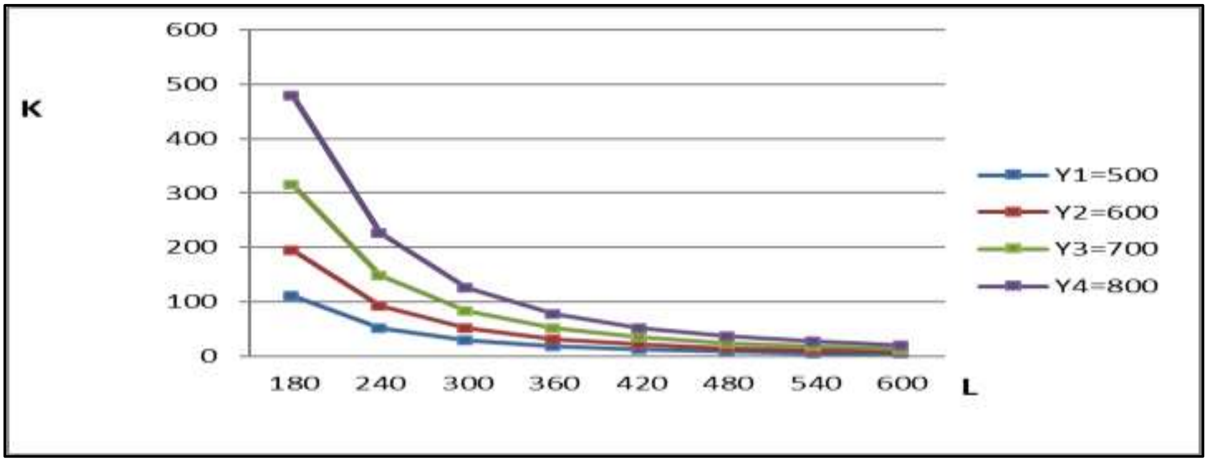


Figure (4) Isohytograms for Factors of Production at Different Production Levels

Source: Prepared by the researcher based on data from Table (7).

Conclusions

This research has demonstrated the statistical significance of the estimated econometric model and its lack of econometric problems, resulting in highly

reliable statistical results. It also shows that labor constitutes the largest share of the production process compared to capital, highlighting its significant contribution to total output. Furthermore, the function operates under increasing returns on capacity, indicating that productive capacity is not yet exhausted and that production can continue to expand. This plays a major role in increasing production and reducing costs, thus maximizing farmers' profits. The analysis of the isohytograms also demonstrates the possibility of achieving the same production level through various combinations of labor and capital. This gives farmers the freedom to make production decisions based on prevailing factor prices.

Recommendations

Based on the preceding findings, the researcher recommended the necessity of providing government support to farmers with production inputs at subsidized prices to reduce production costs. This includes expanding the use of production factors in light of the increased returns on scale demonstrated by the study's results. Furthermore, agricultural workers should be trained and qualified through agricultural extension programs, as they represent the largest segment in explaining production changes. Specialized research centers should also be established to raise awareness of modern production methods. Additionally, farmers should be encouraged to adopt optimal production combinations derived from isotropic curves to make sound production decisions. Finally, the study recommends adopting a comprehensive national strategy aimed at narrowing the gap between local production and actual consumption of potatoes by encouraging farmers to expand cultivated areas and adopt modern agricultural methods to reduce imports and enhance national food security.

ISSN 2072-3857

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