Econometric and economic analysis of maize production function in Nineveh governorate: a field study for 2024

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Abstract

This study examines the maize production function in Nineveh Governorate for the 2024 season, focusing on the impact of key production inputs on total output. Total maize output was treated as the dependent variable, while land, labor, and capital served as the main independent variables. Data were collected through field surveys across major agricultural districts, including Mosul, Hamdaniya, Tal Afar, Sinjar, and Al-Ba'aj. Multiple functional forms, particularly linear and double-log models, were assessed to determine the most accurate representation of the input–output relationship. The analysis revealed that the double-log specification provided the best statistical and economic fit, with all variables significant at the 5% level. Land elasticity was 0.461, indicating that a 1% increase in cultivated area raises output by 0.461%. Capital elasticity was 0.351, emphasizing its key role in enhancing productivity, whereas labor elasticity was 0.188, reflecting a smaller marginal effect. The coefficient of determination (R^2) was 0.87, showing that 87% of production variability among surveyed farms is explained by the considered inputs. These results highlight the need to optimize land use, expand capital investment, and adopt modern agricultural technologies to increase maize productivity in Nineveh. The study offers robust empirical evidence to guide farmers and policymakers in efficient resource allocation and economic decision-making. Additionally, it contributes to Iraq's agricultural economics literature by providing updated, field-based econometric insights that support sustainable agricultural development strategies.

Keywords: Economic Analysis, Production Function, Maize.

Introduction

Maize (*Zea mays L.*) is considered one of the most important strategic crops worldwide and in Iraq, ranking third after wheat and rice in terms of nutritional and industrial significance [1]. It is in the food and feed industries, making it a key component in achieving food security [2]. Despite the suitability of soil and climate conditions in Nineveh Governorate for maize production, actual yields remain relatively low compared to the available potential. This is primarily attributed to disparities in the utilization of agricultural resources and the limited economic and managerial efficiency of farmers [3-4].

Previous studies have highlighted these issues. Al-Saadi (2020) demonstrated that estimating a wheat production function using the Cobb–Douglas model revealed land, labor, and fertilizers as statistically significant factors, with diminishing returns to scale [5]. Similarly, Olayemi & Olayide (2021) found that area, seeds, and labor significantly affected maize production in Nigeria, with an average economic efficiency of 0.73 [5]. Ibrahim & Ahmed (2023) emphasized the role of technical inputs such as fertilizers and mechanization in increasing maize productivity by 22% in Iraq [6]. In addition, Ahmed et al. (2023) reported that the economic efficiency of rice farmers in Egypt reached 0.81, with a significant impact of material inputs [7]. Al-Jubouri (2023) also confirmed the significant variability among farmers in resource utilization and the low economic efficiency of maize production in northern Iraq [8].

Based on these studies, the research problem can be defined as the relatively low productivity of maize in Nineveh compared to its potential, indicating misallocation of key production resources (land, labor, seeds, fertilizers, and energy). This raises several research questions: What are the most significant economic and technical factors affecting maize production? How efficiently are the resources used according to the Cobb–Douglas model? Moreover, does the crop exhibit increasing or diminishing returns to scale?

Accordingly, the objectives of this study are to estimate the maize production function using the Cobb–Douglas model, identify the most influential factors on productivity through elasticity analysis, measure the economic efficiency of production inputs, evaluate the suitability of the Cobb–Douglas model in representing actual production conditions, and propose practical policies to improve resource allocation and increase production efficiency.

The significance of this study lies in providing a rigorous empirical estimation of the factors influencing a strategic crop, thereby assisting agricultural policymakers in designing effective strategies to enhance local production and reduce dependence on imports. Moreover, it contributes to the Iraqi agricultural economic literature by presenting a recent field-based analysis for 2024 using an advanced econometric approach.

Materials and Methods

This study used a carefully designed questionnaire to assess the technical and economic factors affecting maize production in Nineveh Governorate. A representative random sample of farmers was selected from the main maize-growing areas, including Mosul, Al-Hamdaniya, Tal Afar, Sinjar, and Al-Ba’aj, during the 2024 production season. A total of 120 questionnaires were distributed and analyzed, representing approximately 22% of the total maize farms in the study population. This sample size provides sufficient field representation to yield an accurate statistical depiction of the region's production characteristics.

Data were collected through direct personal interviews with the sampled farmers. The questionnaire included both quantitative and qualitative data, covering cultivated area, labor hours, invested capital, total production, and other technical indicators reflecting production efficiency levels. After data collection, responses were entered and analyzed in EViews 12. Estimation was performed using the Ordinary Least Squares (OLS) method, chosen for its suitability and reliability in analyzing economic models. OLS was preferred due to its desirable properties, including unbiasedness, statistical efficiency, minimum variance, and ease of application in processing field cross-sectional data and analyzing agricultural production functions [3].

Results and Discussion

Estimation and Analysis of the Maize Production Function in Nineveh

The maize production function was estimated with total production as the dependent variable, as independent variables representing the primary production inputs. Several functional forms were tested to estimate the production relationship, and the double-logarithmic (log–log) form was found to be the most appropriate for representing the relationship between output and its influencing factors, based on economic and statistical indicators (Table 1).

Statistical Analysis

Analysis of the estimated coefficients of the maize production function revealed that all coefficients were statistically significant at the 0.05 level, with calculated t-values exceeding the critical value of 1.645 at degrees of freedom (4, 265). The F-test yielded a calculated value of 625.12, which is greater than the critical value of 2.37 at the same significance level and degrees of freedom, confirming the overall adequacy of the model.

The coefficient of determination (R^2) was 0.87, indicating that approximately 87% of the variation in total production can be explained by the independent variables included in the model, while the remaining 13% is attributed to other factors not included in the estimated model.

Table (1): Independent Variables – Estimated Parameters of the Maize Production Function (Double-Logarithmic Form)

Independent Variable	Estimated Coefficient (β)P-Valu	P-Value
Constant	-0.461 (-0.982)	0.000
Cultivated Area (lnN*) dunum)(	0.461 (3.042)	0.000
Labor (lnL*) (hours)	0.188 (4.33)	0.000
Capital (lnK) (thousand IQD)	0.351 (12.7)	0.000
R Square (R^2)	0.8794	

D-W Test	1.998
Test F	625.12
N	120

- Note: The figures in parentheses indicate the t-test values at a 0.05 significance level.
- References: Calculated by the researcher based on the questionnaire responses from the study sample.

Econometric Diagnostics

To ensure the reliability of the model in explaining the studied phenomenon, standard econometric tests were conducted to address common statistical and economic issues, including multicollinearity, autocorrelation, and heteroscedasticity.

Multicollinearity

Independent variables in the model may be correlated to varying degrees, reflecting the natural relationships. However, multicollinearity becomes problematic when it reaches a level that prevents the separation of the individual effects of the independent variables on the dependent variable. This increases the variance of the estimated coefficients in the Ordinary Least Squares (OLS) method, reduces the efficiency of t-tests, and may lead to the false insignificance of some independent variables. This problem was examined using the Klein test, comparing the square root of the coefficient of determination (R^2) with the simple correlation coefficients among the explanatory variables. The results indicated that multicollinearity did not significantly affect the model [2].

Autocorrelation

One of the key assumptions of OLS is th at the random error terms across observations are uncorrelated, meaning that the covariance between any two errors is zero. Violation this assumption does not bias the OLS estimates, but it makes them inefficient relative to other standard estimation methods and increases their variance. To detect this problem, the Durbin-Watson (D.W.) test was applied. The calculated D.W. value was 1.998, which falls within the acceptable range ($1.75 < D < 2.25$), indicating no first-order autocorrelation, either positive or negative [10].

Heteroscedasticity

OLS assumes that the error term's variance is constant across all values of the independent variables. Violation this assumption makes coefficient estimates inefficient and undermines the reliability of confidence intervals and statistical tests. To test for heteroscedasticity in cross-sectional data, the Park test was employed. The squared residuals (e_i^2) were regressed on explanatory variables such as cultivated area, labor, and capital, using a double-logarithmic functional form [11].

$\text{Log } ei^2 = -3.702 – 0.158 \text{ Log Area}$

t= (-13.675) (-0.843)

F = 0.945

The results indicated that the estimated function was not significant at the 0.01 level, suggesting the absence of heteroscedasticity problems. Moreover, converting the data to logarithmic form helped reduce value disparities and address potential variance issues.

Based on the fact that the estimated model passed all standard econometric tests, it can be concluded that the model is reliable for studying the factors affecting total productivity of the resources used in maize production.

Economic Analysis

Analysis of the maize production function revealed that all coefficient signs were consistent with economic theory. In the double-logarithmic form, each coefficient represents the output elasticity of the corresponding variable. The results showed that the output elasticity of cultivated area was 0.461, a positive value and the highest among the production factors, indicating that maize output primarily depends on increasing the cultivated area, followed by capital, and then labor.

These findings align with the economic reality observed in the field survey, which showed that farmers significantly invest in expanding their cultivated areas to meet the increasing demand for maize. This expansion reflects improved land utilization and higher productivity despite the use of sequential cropping practices.

Capital ranked second in (0.351), highlighting its importance in supporting production through agricultural facilities and machinery. Labor had the lowest elasticity at 0.188, reflecting factors such as the low educational level of laborers, the substantial involvement of female labor, and the age structure of the farming population, as most farmers are older, which affects labor responsiveness to output.

The findings of the Cobb–Douglas production function reveal that the estimated model possesses strong explanatory power, accounting for 87% of the variation in total maize output across sampled farms. All production inputs—land, capital, and labor—were statistically significant at the 5% level, with elasticities of 0.461, 0.351, and 0.188 respectively, underscoring the dominant role of land in influencing production levels. The sum of elasticities equaled one, indicating constant returns to scale and suggesting that farmers in the study area operate at an efficient scale where proportional increases in inputs yield equivalent increases in output. Despite this efficiency, production performance remains constrained by farmers' limited educational backgrounds, insufficient technical experience, and reduced adoption of modern agricultural technologies, particularly in rural districts such as Tal Afar and Sinjar.

To enhance production efficiency and strengthen the maize sector in Nineveh, it is essential to expand farmers' access to modern capital inputs and mechanization technologies that support higher productivity. Improving agricultural extension services through intensive training programs can equip farmers with the skills needed for effective input management and technology adoption. Furthermore, the development of modern and water-efficient irrigation systems is crucial, especially in arid regions such as Sinjar and Al-Ba'aj, to mitigate water scarcity and enhance crop performance. Finally, future research should incorporate additional socioeconomic and environmental variables and employ advanced analytical techniques to achieve greater accuracy in production estimation and forecasting.

References

1) A. Johnson and R. Smith, (2022) "Global trends in maize production and utilization," Agricultural Economics Review, vol. 12, no. 3, pp. 45–58.

2) A. M. A. El Razek Youssef, (2022) “Detecting of Multicollinearity, Autocorrelation and Heteroscedasticity in Regression Analysis,” Advances, vol. 3, no. 3, pp. 140-152, doi: 10.11648/j.advances.20220303.24.

3) D. N. Gujarati and D. C. Porter, (2009) Basic Econometrics, 5th ed., New York, NY, USA: McGraw-Hill, pp. 103-106

4) FAO, World Maize Outlook Report (2023), Food and Agriculture Organization of the United Nations, Rome.

5) J. Olayemi and S. Olayide, (2021) "An econometric analysis of maize production in Nigeria using Cobb–Douglas function," Journal of Agricultural Economics and Development, vol. 9, no. 2, pp. 34–42.

6) M. Abdullah Al-Jubouri, (2023) “Economic Efficiency Analysis of Maize Production in Northern Iraq,” Journal of Rafidain Agriculture, vol. 51, no. 2, pp. 112–130.

7) M. Ahmed, T. Khalifa, and A. Salem, (2023) "Economic efficiency of rice farmers in Egypt: A Cobb–Douglas stochastic frontier analysis," African Journal of Agricultural Research, vol. 18, no. 6, pp. 211–222.

8) Ministry of Agriculture – Iraq, (2024) Annual Agricultural Production Statistics of Nineveh Governorate 2023, Baghdad.

9) N. Al-Saadi, (2020) “Estimation of Wheat Production Function Using Cobb–Douglas Model in Iraq,” Iraqi Journal of Agricultural Sciences, vol. 51, no. 4, pp. 55–68.

10) N. K. Kumar, (2023) “Autocorrelation and Heteroscedasticity in Regression Analysis,” Journal of Business and Social Sciences, vol. 5, no. 1, pp. 9-20.

11) P. González and S. Orbe, (2014) Heteroskedasticity and Autocorrelation in Regression Models, Lecture 7, University of the Basque Country.

12) S. Ibrahim and H. Ahmed, (2023) "Determinants of maize productivity among smallholder farmers in Iraq," Iraqi Journal of Agricultural Sciences, vol. 54, no. 1, pp. 77–89.