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Article

An Economic and Econometric Analysis of the Impact of Key Economic Variables on Cotton Production in Iraq

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Abstract: Cotton remains an essential crop for Iraq's industry, contributing substantially to its gross domestic product, employment, and input to local industry. Despite its importance, cotton production in Iraq was subject to fluctuations between 1995 and 2021, averaging a land area of 13,690 hectares (range from 3 to 26,995 hectares) and averaging a production level of 24,078 tons (range from 3 to 45,278 tons). This study examined the influence of some major economic factors, including the land area, gross domestic product, crop price index, and productivity, on cotton production in Iraq through a time-series econometric model. The results from the unit roots tests, including the Augmented Dickey-Fuller and Phillips-Perron tests, showed that the variables were non-stationary at their level but became stationary after first differencing. This study adopted the Autoregressive Distributed Lag model, which was appropriate for this study due to its ability to capture the short-run and long-run effects, especially for small samples. The results showed that the variables explained about 94% of the fluctuations in cotton production, thereby indicating the existence of a long-run equilibrium relationship among the variables. The error term was -0.339, which indicated that deviations from equilibrium correct themselves after a period of about three years. The Gross Domestic Product was found to have a significant positive influence on cotton production in Iraq, while the crop price index was seen to positively influence cotton production, with a small degree of responsiveness for farmers in the short-run as well as the long-run. Productivity was seen to positively influence cotton production in Iraq. This study therefore highlights the need for the use of cointegration and error correction models for more reliable results compared to regression models. It therefore recommended that the government should ensure that cotton farmers are provided with essential items, irrigation systems, as well as price support, while at the same time improving their productivity through integrated strategies for marketing and agricultural credit to stabilize cotton production in Iraq. From the results obtained, this study showed that for cotton production in Iraq to improve, there was a need for economic interventions to ensure that cotton was not neglected.

Keywords: Economic Analysis, Cotton Crop, Production, ARDL Model

1. Introduction

Cotton, in general, is viewed as one of the most crucial agricultural crops in the world, coming only after food crops in terms of its level of importance due to its extensive uses. Its fibers are used for the manufacture of quality textiles, medical cotton, upholstery, as well as vegetable oil, thereby making cotton one of the most crucial raw materials for industry. In relation to the Iraqi economy, the agricultural sector has played a crucial role in the country's economy, contributing immensely to the country's gross domestic product as well as national income, while at the same time providing the country with essential food items as well as employment opportunities for a large number of its population. Moreover, the agricultural sector serves as the main source of raw materials for local industries, thereby creating economic integration between industries, which has helped in the development of the country's industries [1]

Unlike food crops, which are crucial for the economies of developed as well as developing countries, cotton, as an industrial crop, has gained popularity in developed economies due to its contribution to the development of industry as well as employment. The development of cotton contributes to economic development through the creation of employment opportunities, enhancement of agricultural activities, as well as the creation of economic savings, thereby reducing reliance on imported goods. Nevertheless, cotton development in Iraq has faced a number of challenges that have contributed to a decline in its production as well as an increase in its cost of production. Issues such as water scarcity, soil deterioration, traditional farming methods, economic factors, as well as social factors in rural areas have contributed to a decline in the development of this crucial crop due to their negative influence on its production.

In the past, the utilization of cotton was restricted to only 4% of the raw material used in the industry; nevertheless, this increased to 74% after a century of industrial growth and development. However, the production of cotton in Iraq has been limited and inconsistent, among other reasons, due to repeated cultivation, which has affected the genetic composition of the crop, discouraging farmers from engaging in its production [2]. In addition to providing raw material for industrial growth, the seeds of the crop contain 60% protein and 18-26% oil, which can be used for human and animal consumption, and soap and detergent production. Cottonseed oil contains 25-45% protein and 10-15% oil, and the oil contains saturated and unsaturated fats, both of which are present in higher proportions than in other vegetable oils. The residual material left after the removal of the seeds is utilized for the manufacture of explosives, artificial silk, and plastics, thereby serving the military and industrial sectors. Thus, it can be seen that the crop of cotton not only holds economic importance but is also a commodity of nutritional value. However, the cultivation of the crop poses the need to address the challenges that affect the production of the crop [3].

Research Problem: The agricultural industry of the developing countries, such as Iraq, is affected by a number of problems, including the reduction of arable lands and the stability of crop yields, specifically of the crops of cotton. The local production of cotton is low, meeting the demand of the country only to a limited extent. This situation is further worsened by the increase in the country's population, along with the increase in the number of industries, such as the textile industry, that utilizes the crop. Thus, the difference between the demand and supply of the crop is large, with the national prices not serving the purpose of motivating the local producers, thereby leading to the import of the crop.

Research Aim: The aim of the study is to identify the major economic determinants of cotton crop production in Iraq from the period of 1995 to 2021. It will be conducted using the contemporary theory of time series, including unit roots, cointegration, and the error correction model. In addition, it will seek to estimate the elasticities of output with respect to the economic determinants. This will be a quantitative appraisal of the economic determinants of the crop's production. It will be beneficial in assessing the economic determinants of the crop's production, including the role of prices, climate, and the overall economic environment of the country during the specified period.

Research Importance: Cotton crops are of significant economic importance to Iraq, with the country's production of the crop declining over the last few decades. Elucidating the determinants of the country's production of the crop is of critical importance, considering the crop's importance to the country's agricultural industry. It will be beneficial to the country's policymakers, considering the role it will play in the formulation of policies that will seek to motivate local farmers, enhance their income, and stimulate the production of the crop.

Research Hypothesis: The research hypothesis for this study is that the decision to enhance cotton production by farmers can be influenced by a number of factors, which can be price-related or non-price-related factors, as well as positive factors or negative factors, with the behavior of cotton farmers aligning with or diverging from economic logic.

2. Materials and Methods

1. Materials

This study focuses on cotton as the main crop to be analyzed. Information concerning areas cultivated, total production, productivity, prices, and Gross Domestic Product (GDP) was obtained from official Iraqi sources, including:

Republic of Iraq – Ministry of Agriculture – Planning and Follow-up Department – Agricultural Statistics Directorate.

Ministry of Planning and Development Cooperation – Central Statistical Organization and Information Technology – Agricultural Statistics Directorate – Index Numbers Section.

The data covered the period from 1995 to 2021. In addition, relevant scientific research and published literature were consulted to support the theoretical and empirical framework of the study.

2. Methodology (Building the Study Model)

The study adopts an econometric analytical approach based on cointegration analysis and the Error Correction Model (ECM) to obtain more accurate and reliable results. The analysis was conducted using the advanced statistical software **EViews**.

Cointegration tests are employed to examine the existence of a long-run equilibrium relationship among the study variables. Traditional cointegration techniques require that all variables be integrated at the same order. However, Pesaran and Ark (1996) introduced the Autoregressive Distributed Lag (ARDL) approach, which allows testing long-run relationships among variables integrated at different orders, provided that none of them is integrated of order two, I(2).

Unlike traditional least squares-based cointegration techniques, the ARDL model is fundamentally based on unit root testing procedures [4].

3. Unit Root Test

Economic time series exhibit a deterministic trend over time; hence, they are non-stationary processes. Estimation of these processes using a typical regression model leads to spurious regression results. To avoid spurious regression, time series processes are analyzed using a cointegration framework [5].

The first step in cointegration analysis is to test for the presence of unit roots and determine the order of integration of each variable included in the model. Although several unit root tests exist, the Augmented Dickey–Fuller (ADF) test is the most widely used.

The ADF test is estimated under three alternative specifications:

Without constant and trend, With constant only, With constant and time trend,

to test the null hypothesis of a unit root against the alternative hypothesis of stationarity [6].

The general form of the ADF test equation is:

$$\Delta Y_t = \beta Y_{t-1} + \sum_{j=1}^{k} \beta_{j+1} \Delta Y_{t-j} + e_t \qquad (1)$$

In addition to the ADF test, the Phillips–Perron (PP) test is applied. The PP test corrects for serial correlation and heteroskedasticity in the error term of the unit root regression without adding lagged difference terms.

The estimator of the long-run variance in the PP test is given by:

$$S_u^2 = T^{-1} \sum_{t=1}^{T} \hat{U}_t^2 + 2T^{-1} \sum_{j=1}^{L} \sum_{t=j+1}^{T} \hat{U}_t \hat{U}_{t-j} \qquad (2)$$

The Phillips–Perron test has the same asymptotic distribution as the Dickey–Fuller test and uses the same critical values, since both tests are based on similar statistical foundations.

Within the ARDL framework, both the Augmented Dickey–Fuller (ADF) test and the Phillips–Perron (PP) test are performed to ensure that the variables are integrated of order I(0) or I(1), but not I(2) [7].

Determining the Optimal Lag Length

To properly specify the dynamic structure of the VAR (Vector Autoregression) model, it is necessary to determine the appropriate lag length. Selecting an optimal lag order is essential to avoid econometric problems such as autocorrelation, model misspecification, and loss of degrees of freedom.

Several statistical criteria are commonly used for lag selection, the most important of which are the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC/BIC), Hannan–Quinn Criterion (HQ), and the Likelihood Ratio (LR) test.

1. Akaike Information Criterion (AIC)

The Akaike Information Criterion introduces a penalty term when additional explanatory variables (lags) are included in the model. Besides determining the optimal lag length, it is also used to evaluate the predictive performance of regression models.

The AIC is calculated as follows:

$$AIC = e^{\frac{2k}{n}} \frac{\sum u_i^2}{n} = e^{\frac{2k}{n}} \frac{RSS}{n} \qquad (3)$$

Where:

k: Number of estimated parameters (including B_0)

n: Number of observations

RSS: Residual Sum of Squares

In natural logarithmic form, it is written as:

$$\ln AIC = \frac{2k}{n} + \ln\left(\frac{RSS}{n}\right) \qquad (4)$$

Where:

$\ln AIC$: Natural logarithm of AIC

$\frac{2k}{n}$: Penalty term

The preferred lag length is the one that minimizes the AIC value.

2. Schwarz Information Criterion (SIC/BIC)

The Schwarz Information Criterion (also known as Bayesian Information Criterion, BIC) is used to determine the optimal lag length and assess the predictive accuracy of the regression model [8].

Compared to AIC, SIC imposes a stronger penalty for additional parameters, which often leads to selecting more parsimonious models.

It is calculated as:

$$SIC = n^{\frac{k}{n}} \frac{\sum u^2}{n} = n^{\frac{k}{n}} \frac{RSS}{n} \qquad (5)$$

In logarithmic form:

$$\ln SIC = \frac{k}{n} \ln N + \ln\left(\frac{RSS}{n}\right) \qquad (6)$$

The optimal lag length is selected based on the minimum SIC value.

3. Hannan–Quinn Criterion (HQ)

The Hannan–Quinn (HQ) criterion is similar to both AIC and SIC. It is derived from the maximized log-likelihood function and includes an additional penalty term related to the number of estimated parameters. However, the magnitude of the penalty differs from both AIC and SIC.

The preferred lag length is the one corresponding to the smallest HQ value. When different information criteria suggest different lag lengths, it is common to rely on theoretical considerations in addition to statistical evidence [9].

The HQ criterion is calculated as:

$$HQ = N \ln\left(\frac{RSS}{n}\right) + 2K \ln(\ln N) \qquad (7)$$

Where:

N: Number of observations

K: Number of estimated parameters

4. Likelihood Ratio (LR) Criterion

The Likelihood Ratio (LR) test compares two nested VAR models (one under the null hypothesis and the other under the alternative hypothesis) to determine whether adding additional lags significantly improves model fit.

It is calculated as:

$$LR = (N - K)[\ln | \Omega_1 | - \ln | \Omega_2 |] \qquad (8)$$

Where:

N: Number of observations

K: Number of estimated parameters (including B_0)

Ω_1: Estimated variance–covariance matrix of residuals under the null hypothesis

Ω_2: Estimated variance–covariance matrix of residuals under the alternative hypothesis [10]

The optimal lag length is selected when the LR statistic is statistically significant and supported by the information criteria.

Estimating Research Outcomes with the ARDL Model:

There are various techniques for testing long-run relationships between variables: Johansen-Juselius method, Engle-Granger cointegration test, etc. However, these techniques assume that all variables are integrated of the same order but fail to produce unbiased and efficient results for small samples.

In light of these limitations, the Autoregressive Distributed Lag (ARDL) method has emerged as a popular technique for long-run relationship testing. The ARDL method allows for a distinction to be made between dependent and independent variables while providing unbiased and efficient results without any risk of autocorrelation. The ARDL method is applicable for stationary variables at level (I(0)), integrated of order one (I(1)), a combination of I(0) and I(1), but not for variables integrated of order two (I(2)). The ARDL method is highly appropriate for small sample size and short-term series data because it allows for a differentiation between short-run and long-run effects within a single equation [11].

Using the ARDL method, it is possible to estimate a complementary relationship between a dependent variable and independent variables for both short-run and long-run periods as well as to measure the effect size of each variable. The ARDL method is distinct from other cointegration techniques: Engle-Granger method, Durbin-Watson cointegration test (CRDW), Johansen cointegration method within Vector Autoregression (VAR) models, etc. [11].

1. ARDL Model Specification

The general form of the ARDL model with one dependent variable and k independent variables can be expressed as follows:

$$\Delta LPro_t = a_0 + a_1 LCa_{t-1} + a_2 LGDP_{t-1} + a_3 LSp_{t-1} + a_4 LY_{t-1} + \sum_{i=1}^{m} B_1 \, \Delta LPro_{t-i} + \sum_{i=1}^{m} B_2 \, \Delta LCa_{t-i} + \sum_{i=1}^{m} B_3 \, \Delta LGDP_{t-i} + \sum_{i=1}^{m} B_4 \, \Delta LSp_{t-i} + \sum_{i=1}^{m} B_5 \, \Delta LY_{t-i} + e_t \qquad (9)$$

Where:

a_0 is the intercept or constant term

a_1 ... a_4 are the long-run coefficients

B_1 ... B_5 are the short-run coefficients

e_t is the stochastic error term

2. Bounds Testing for Cointegration

Before estimating ARDL parameters, it is essential to verify whether a long-term equilibrium relationship exists among the variables. This is achieved using the Unrestricted Error Correction Model (UECM) framework and the bounds testing approach [12].

The bounds testing procedure involves two steps:

Test for long-run relationship:

The null hypothesis states that no long-term relationship exists among the variables:

$$H_0: B_0 = B_1 = B_2 = 0$$

The alternative hypothesis asserts the presence of cointegration:

$$H_1: B_0 \neq B_1 \neq B_2 \neq 0$$

The computed F-statistic is compared to critical bounds: the lower bound (I(0)) and the upper bound (I(1)). If the F-statistic exceeds the upper bound, the null hypothesis is rejected, indicating a long-run equilibrium relationship among the variables. If the F-statistic falls below the lower bound, the null is accepted, indicating no cointegration.

Estimate long-run and short-run parameters:

Once cointegration is confirmed, both long-run and short-run coefficients of the ARDL model are estimated simultaneously, capturing the dynamic adjustment of the dependent variable to changes in independent variables.

The logarithmic transformation of variables was applied to linearize relationships:

$$LPro = b_0 + b_1 LCa_{t-1} + b_2 LGDP_{t-1} + b_3 LSp + b_4 LY + e_t \qquad (10)$$

3. Study Variables

The variables used in the model are defined as follows:

Pro (Production): Domestic industrial cotton production measured in tons per year. It reflects the ability of local production to meet domestic demand, considering climate variations and farmers' cultivation preferences.

Ca (Cultivated Area): Total area cultivated with cotton, a key determinant of production volume.

GDP (Gross Domestic Product): Indicator of overall economic activity and sectoral contributions to national production. Higher GDP growth often signals improved investment opportunities and an enabling environment for agricultural development.

Sp (Crop Price Index): Measures the effect of crop prices on production. Higher domestic prices incentivize increased output. The index is calculated as (Price in comparison year/Price in base year) × 100.

Y (Productivity): Production per unit area (e.g., tons per dunam). Productivity captures efficiency gains and is critical for understanding the impact on total cotton production.

4. Diagnostic Tests in ARDL

Unlike traditional regression models, the Durbin–Watson statistic is not appropriate for detecting autocorrelation in ARDL models, as lagged variables are explicitly included. Instead, standard diagnostic tests are employed:

LM Test for autocorrelation

Breusch–Godfrey Serial Correlation Test

ARCH Test to detect conditional heteroskedasticity and potential autocorrelation in the error terms

These tests ensure that the ARDL model is correctly specified and reliable for both short-run and long-run inferences.

3.Results and discussion

3.1. Descriptive and graphical analysis of the reality of cotton crop production in Iraq

Among the most vital industrial crops, cotton takes its rightful place in the industrial and agricultural sectors of many nations, especially Iraq. The production of cotton in Iraq during the period between 1995 and 2021 ranged between 17,560 to 3 tons on an average of 14,740 to 3 hectares of land. There are remarkable fluctuations in the production of cotton during the period under review, especially in the recent years. From Table 1 above, the average cultivated area under cotton production was 13,690 hectares; however, the highest cultivated area was recorded in 2005 at 26,995 hectares, while the least cultivated area was recorded in 2021 at 3 hectares of land. The government incentives to boost production led to an increase in the cultivated areas of cotton in 2005 and 2010. However, the decline in cultivated areas over the last five years (Figure 1) can be attributed to a number of factors, including the government's reluctance to buy farmers' products, which led to low purchase prices; deteriorating macroeconomic conditions; and conflicts in some regions of Iraq. The average production in Iraq from 1995 to 2021 was 24,078 tons. It should be noted that there are large fluctuations in production over time, as well as a downward trend in recent years. The maximum production value was recorded in 2010 at 45,278 tons, while the minimum production value was recorded in 2021 at 3 tons. As can be observed in Figure 1, there was an increase in production from 2005 to 2010. During this time, there was an increase in cultivated area as well as stability in other influencing factors. The average yield in Iraq from 1995 to 2015 was 1,613 kg/hectare. The maximum yield was recorded in 2010 at 2,201 kg/hectare, while the minimum yield was recorded in 2021 at 1,000 kg/hectare. The above discussion reveals that there are technical and climatic factors as well as competition from other crops that influence cotton production. The reduction in the cultivated area for cotton is attributed to insufficient irrigation water as well as Iraq's dependence on purchasing intermediate and final products from other countries, which are derived from the cotton crop.

Table 1. Area, Production, and Yield of Cotton in Iraq (1995–2021)

Years	Cultivated area (Hectare)	Production (Ton)	Yield (Kg/ha)
1995	14740.00	17560.00	1191.00
2000	19727.00	32767.00	1661.00
2005	26995.00	42843.00	1587.00
2010	20571.00	45278.00	2201.00
2015	13781.00	30076.00	2182.00
2020	15.00	22.00	1466.00
2021	3.00	3.00	1000.00
Average	**13690.00**	**24078.00**	**1613.00**

[13] Republic of Iraq, Ministry of Agriculture, Planning and Monitoring Department, Department of Agricultural Statistics (1995–2021).

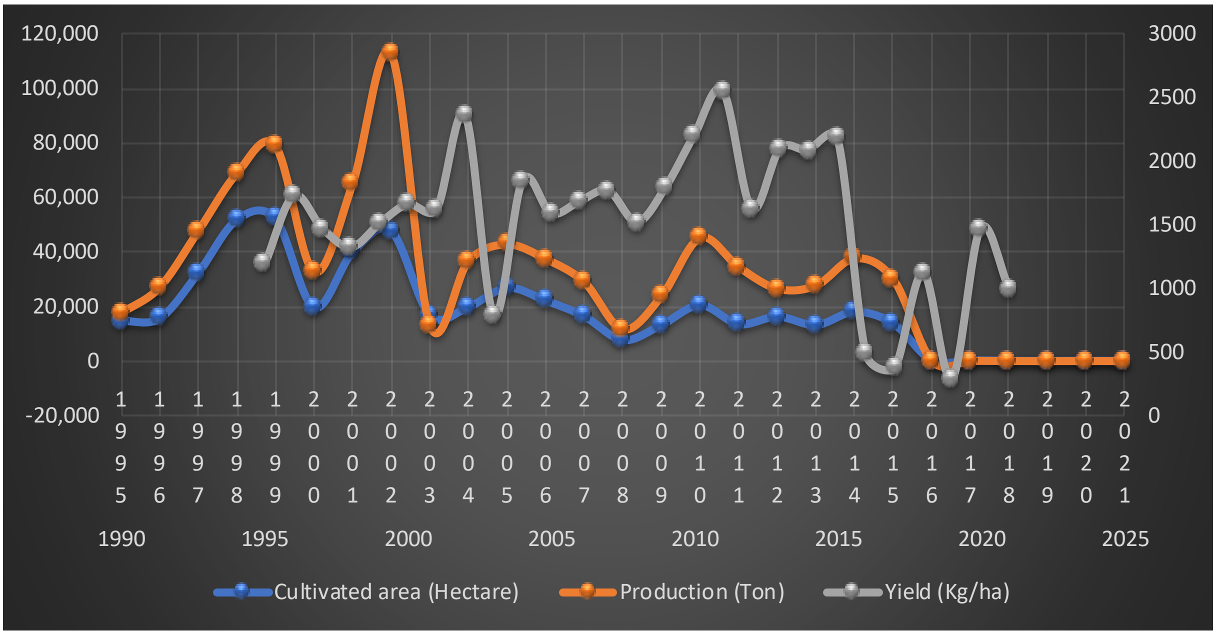

Figure 1. llustrates the trends in cultivated area, production, and yield of cotton in Iraq during the period 1995–2021.

3.2. Economic and Econometric Analysis of Study Variables (1995–2021):

Variables included in the study:

Dependent variable is Pro (in tons). Independent Variables: Independent variables are Ca (cultivated area in hectares), Gdp (Gross Domestic Product in millions of dinars), Sp (crop price index), and Y (productivity in kg h^{-1}).

3.2.1. Unit Root Test Results

The unit root tests conducted for the study variables using both the ADF and PP methods present the results of the ADF test under three specifications: with a constant, with a constant and trend, and without either. The findings indicate that some variables are non-stationary at their levels, as the calculated t-statistic exceeds the critical value at the chosen significance level. Consequently, the null hypothesis of a unit root cannot be rejected, implying that these series are not stationary in their levels. However, the time series for the crop price index (Sp) and productivity (Y) were found to be stationary at level. After applying the first difference, the results reveal that all variables become stationary, as the calculated t-statistics fall below their respective critical values. This outcome aligns with standard econometric theory, which suggests that most economic variables are non-stationary in levels but become stationary after first differencing [14].

Similarly, the second unit root test, the PP test, produced results consistent with those of the ADF test. The variables, production (Pro), cultivated area (Ca), and gross domestic product (GDP)—were non-stationary at their levels but became stationary after taking the first difference. The tables below present the results of both the Dickey-Fuller and Phillips-Perron test.

Table 2. Results of the ADF test for variables

Level		LCa	LPro	LSp	LY	LGdp
Constant	t-Stat.	-0.656000 No	-0.641800 No	-4.911400 ***	-4.444700 ***	-0.765600 No
With Constant & Trend	t-Stat.	-1.020800 No	-0.015600 No	-5.014300 ***	-4.444700 **	-4.605000 ***
Without Constant & Trend	t-Stat.	2.207100 No	0.534000 No	-0.061200 No	-0.541800 No	1.760100 No
First Difference	t-Stat.	**d(LCa)**	**d(LPro)**	**d(LSp)**	**d(LY)**	**d(LGdp)**
Constant	t-Stat.	-7.970300 ***	-11.757300 ***	-8.578300 ***	-8.127200 ***	-6.764200 ***
With Constant & Trend	t-Stat.	-7.465100 ***	-6.465300 ***	-9.348400 ***	-7.921300 ***	-6.571400 ***
Without Constant & Trend	t-Stat.	-7.428200 ***	-11.981600 ***	-8.774900 ***	-8.363800 ***	-6.773800 ***

NOTE: (*) significant at 10%, (**) significant at 5%, (***) significant at 1%, and (no) Not significant

Table 3. Results of the PP test for the variables

Level		LPro	LCa	LGdp	LSp	LY
Constant	t-Stat.	- 2.646100no	- 2.541000no	- 2.494200no	-4.911400 ***	-4.449600 ***
With Constant & Trend	t-Stat.	-3.212300 *	-3.403000 *	-4.695300 ***	-5.014300 ***	-4.449100 **
Without Constant & Trend	t-Stat.	0.516100no	2.132000no	1.783600no	-0.215600no	-0.745700no
First Difference	t-Stat.	**d(LPro)**	**d(LCa)**	**d(LGdp)**	**d(LSp)**	**d(LY)**
Constant	t-Stat.	-12.300400 ***	-6.782500 ***	-17.240600 ***	-15.395600 ***	-8.537500 ***
With Constant & Trend	t-Stat.	-14.913800 ***	-6.401400 ***	-15.441200 ***	-14.891500 ***	-8.410700 ***
Without Constant & Trend	t-Stat.	-11.395400 ***	-6.059000 ***	-6.418800 ***	-15.019000 ***	-8.782600 ***

NOTE: (*) significant at 10%, (**) significant at 5%, (***) significant at 1%, and (no) Not significant

3.2.2. Lagging Rank Test for the VAR Model

Criteria for lag selection in VAR modeling: Multiple efforts were made to optimize the adherence to economic criteria. Before undertaking the ARDL test, it is vital to establish an appropriate lag length given the sensitivity of the model to lag structure. The table shows the estimates of both short-run and long-run relationships. Three information criteria were used to establish four lag lengths; these criteria are also used to establish four lag lengths [15].

Table 4. Lagging Selection Criteria for VAR Technique for Variables

lag	LR	Logl	AIC	SC	HQ	FPE
0	NA	-65.88647	7.798837	8.386287	7.90517	9.76e-05
1	71.64487	-6.182082	5.418108	7.807866	5.88661	1.21e-05
2	64.6744	-985.6449	113.0778	115.9450	112.724	1.18e+42
3	1.18e+4*	-64.65847*	119.0541	121.1428	119.407	2.54e+44
4	50.68779	78.29757	0.571143*	4.752219*	1.48652*	5.30e-07*

3.2.3. Cointegration test (bound test)

From Table (5), it is evident that the calculated F-value (9.146) is greater than its critical value, thereby leading to rejection of the null hypothesis and acceptance of cointegration between the variables in the model. The overall model's significance at 1% is also evidenced by the F-value of 9.146. Further, it is evident that the calculated value (-7.722) is less than its critical value at 1% in support of cointegration between the variables in the model.

Table 5. Bounds Testing for Model Variables

F-Bounds Test Null Hypothesis: No level relationship			
Test Statistic	**Value**	**Significant**	**I(0) I(1)**
			Asymptotic: n=1000
F-Statistic	9.1465100	0.01	2.3800 : 3.200
K	4.00	0.05	2.7900 : 3.8700
		0.25	3.1500 : 4.0800
		0.10	3.6700 : 4.6600
Sample size	24.00		Finite sample: n=35.00
t- Bounds Test Null Hypothesis: No level relationship			
Test Statistic	Value	Significant	I(0) I(1)
t-Statistic	-7.72200	0.01	-2.2600 : -3.2500
		0.05	-2.5300 : -3.5700
		0.25	-3.1800 : -4.1200
		0.10	-3.4200 : -4.8900

3.2.4. Estimating results using the ARDL distributed lag model

Several attempts were made to optimize the model results in accordance with economic criteria. **Table 6** presents the estimated results, where both the short-run and long-run dynamics of the model are captured through the lagged terms. The model exhibits high sensitivity to the lag structure. The R^2 statistic indicates a strong goodness of fit, with a value of 0.94, meaning that 94% of the variability in the dependent variable is explained by the independent variables included in the model, while the remaining 6% is captured by the stochastic component.

The findings from the t-test show that all the independent variables, as a whole, explain a significant amount of the variation observed in the dependent variable. Each of the t-values calculated is significantly larger than the critical value at the 5% significance level. The Durbin-Watson value cannot be calculated because the model contains the lagged dependent variables. Further diagnostic tests were conducted, as described later. The findings from the ARDL bounds test show that the short-run coefficients have the same sign and significance as the long-run coefficients, although the former have slightly smaller coefficient values. In the log form, the coefficients represent the elasticities. The error correction term, EC(t-1), is statistically significant at the 1% level with the expected negative sign, achieving a value of -0.339. This shows that any deviation from the equilibrium of the domestic production of cotton, denoted by Pro, is corrected at a rate of 33.9% annually. This shows that the production of cotton will return to equilibrium after a period of about 2.94 years. The coefficient of the change in cultivated area, Ca, is positive and statistically significant at the 5% level with a value of 0.350. This shows that the increase in the cultivated area significantly contributes to the domestic production of cotton. The change in GDP shows a positive coefficient of 0.189, statistically significant at the 5% level. This shows that the increase in the GDP of the key sectors of the economy, including the agricultural sector, directly contributes to the production of cotton. The crop price index, SP, shows a positive coefficient of 0.113, statistically significant at the 10% level. This shows that a unit increase in the crop price index leads to a corresponding increase of 1.1 units in the production of cotton, as the increase in the crop prices will encourage the expansion of the cultivated area. Productivity, yield, shows a positive coefficient of 0.126, statistically significant at the 5% level, indicating that the yield per unit area significantly contributes to the production of cotton.

Table 6. Estimated Short-Run ARDL Model Results

Variables	Coefficient	Standard Error	t-İstatistic	Probability
D(LCa)	0.35029300	0.14979900	2.07569600	0.074600
D(LCa (-1))	0.32146200	0.17635000	1.76234700	0.137600
D(LCa (-2))	0.11693400	0.05430200	2.19376500	0.062600
D(LCa (-3))	0.12510200	0.04167400	3.47211800	0.003600
D(LGdp)	0.18945700	0.03660300	5.36181400	0.000500
D(LGdp (-1))	0.00362900	0.03438900	0.43171500	0.935800
D(LGdp (-2))	0.42229500	0.05314300	6.15874200	0.000300
D(LSp)	0.11368200	0.01454700	3.42160000	0.095400
D(LSp (-1))	0.03624600	0.00924100	0.71174400	0.550400
D(LY)	0.00329700	0.02921100	0.17741300	0.913500
D(LY(-1))	0.12648200	0.03286400	3.91071800	0.004600
Error correction model	-0.33968300	0.11051100	-2.42916200	0.027300

(R^2) 0.94580900

Adjusted (R^2) 0.90006700

Durbin – Watson Istatistic 2.01984300

LPro=0.350*LCa+0.189*LGdp + 0.113*LSp+ 0.126*LY

Table 7. Results of the ARDL (Long-Run Equation) Model Estimation

Variables	Coefficient	Standard Error	t-İstatistic	Probability
LCa	0.78769700	0.30128500	2.45815900	0.028400
LGdp	0.42852900	0.18435000	2.71343600	0.571100
LSp	0.46930300	0.21039800	1.98495300	0.056300
LY	1.32127600	0.74730300	1.78467500	0.127600
C	52.9313700	0.21566100	64.8916800	0.000100
ECt=LProt−(0.787LCat+0.428LGDPt+0.469LSpt+1.321LYt+52.931)				

In order to assess how domestic production in Iraq reacts to changes in cultivated area, gross domestic product (GDP), crop price index, and productivity, partial elasticities are computed for these variables using a Vector Error Correction Model (VECM) as applied in the Autoregressive Distributed Lag (ARDL) approach over the relevant time period. The results are presented in Table 7. The results show that cultivated area, in both its short-run and long-run elasticities, plays a significant role in influencing domestic production. The computed value for cultivated area is 0.350. This means that if cultivated area increases by 10%, domestic production in Iraq would increase by 3.5% in the short run and 7.8% in the long run. The results also show that GDP's elasticity is 0.189. If GDP increases by 10%, domestic production in Iraq would increase by 1.8% in the short run and 4.2% in the long run. The crop price index's short-run elasticity is 0.113. This means that if there is a 10% increase in the crop price index, domestic production in Iraq would increase by 1.1% in the short run. The long-run effect would be 4.6%. The results show that if productivity improves by 10%, domestic production in Iraq would increase by 1.2% in the short run and 13.1% in the long run.

These elasticities have significant practical implications for agricultural policies. That is, under ceteris paribus, a 10% increase in area would correspond to a 32.78% increase in domestic production of cotton, a 10% increase in GDP would correspond to a 52.91% increase, a 10% increase in crop price index would correspond to an 88.49% increase, and a 10% increase in productivity would correspond to a 79.36% increase.

The model is also subjected to various diagnostic tests, all of which are passed by this model. The results of the Breusch-Godfrey Lagrange multiplier test for serial correlation show that the model is free of autocorrelation, as the calculated p-value is greater than .05, which is 0.1057.

The results of the Breusch-Pagan-Godfrey test for heteroscedasticity show that the model is also free of variance instability, as indicated by a calculated p-value of 0.7965, which is greater than .05, as well as the results of the ARCH test, which show a calculated p-value of 0.8673, also greater than .05, as shown in Figure 2 below. The results of the Jarque-Bera normality test show that.

Table 8. Diagnostic Test Results: LM, Breusch–Pagan–Godfrey, and ARCH Tests

Lagrange Multiplier Test for Autocorrelation: LM	
F-statistic	1.50271400
Probability	0.105700
Heterogeneity Problem Test : ARCH	
F-statistic	0.10538400
Probability	0.867300
Heterogeneity Problem Test	
F-statistic	0.37377900
Probability	0.796500

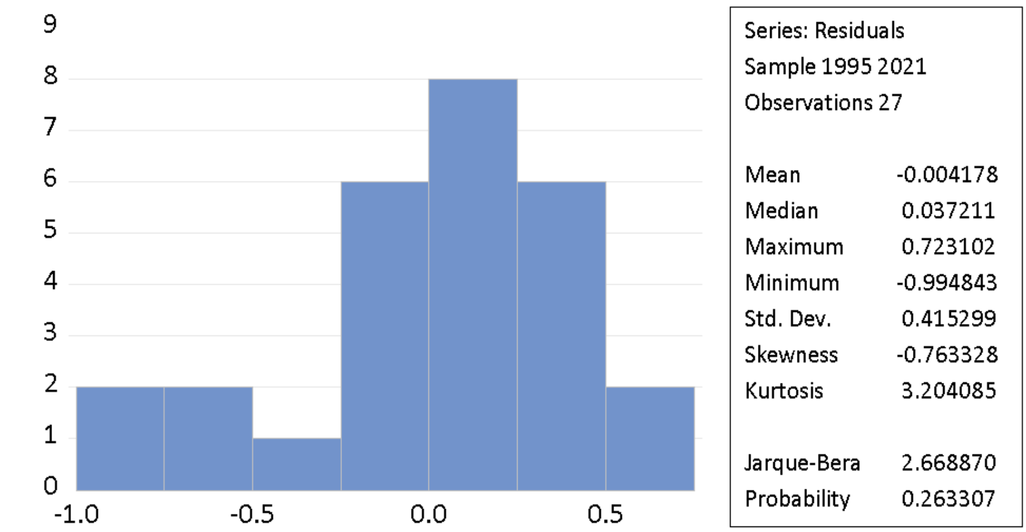

Figure 2. Normal distribution of the model residues

The Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) test is used to test the structural stability of the estimated parameters in the model. The stability of the parameters in the ARDL model can be confirmed if the CUSUMSQ plot lies entirely within the 5% critical bounds; if the CUSUMSQ lies outside these bounds, then the estimated parameters are unstable [16].

As presented in Figure 3 above, the CUSUMSQ lies entirely within the 5% bounds over the entire sample period. This implies that the estimated parameters are stable; this supports the stability of the study variables, as well as the long-run and short-run consistency of the model.

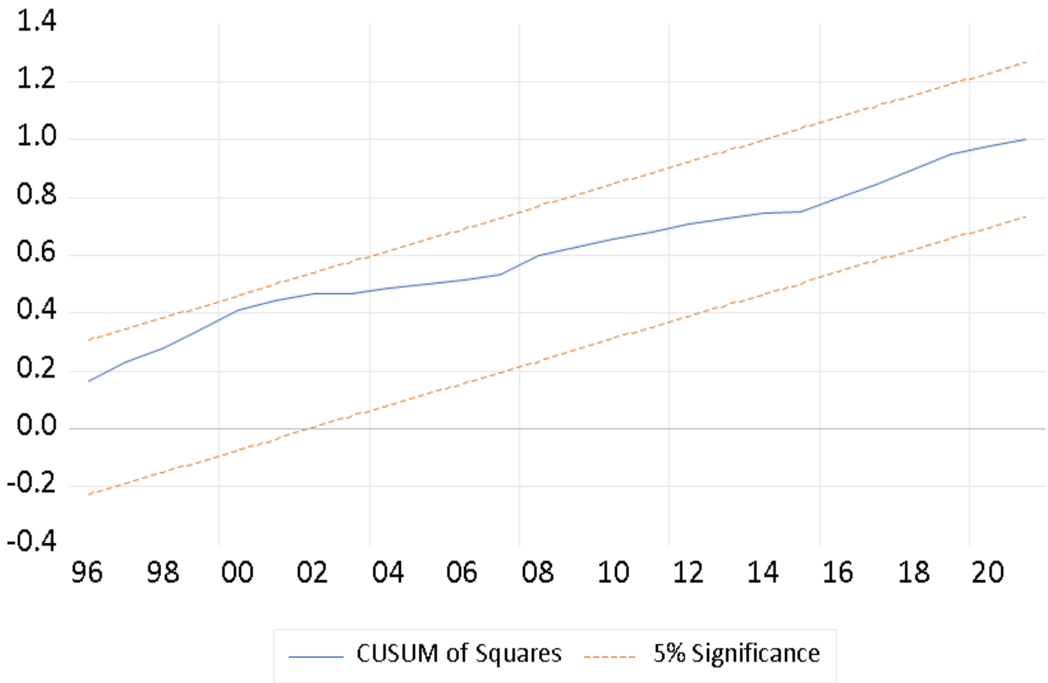

Figure 3. Cumulative sum of cumulative remainders squared

4. Conclusions

a. It has been recognized that cotton is one of the major industrial crops. The agricultural sector forms a vital part of the Iraqi economy, contributing substantially to the Gross Domestic Product (GDP) as well as the Gross National Product (GNP).

b. The study reveals that the Arithmetic Cointegration Method (ARDL) with the Error Correction Model (ECM) provides more precise and coherent results compared to traditional statistical methods.
c. A large number of time series are non-stationary due to their sensitivity to economic and political conditions, as depicted by the trends that affect the variables in the same or opposite directions. Therefore, reliance solely on traditional econometric techniques may not generate reliable results.
d. The descriptive as well as graphical methods for analysing the cotton crop reveal that there has been a major decline in total cotton production as well as the total area under cotton cultivation, especially during the most recent five-year period.
e. The rate at which production changes indicate a major imbalance, as production requires a period of three years to get aligned.
f. GDP has a significant positive impact on cotton production, which proves that GDP acts as a major determinant for the quantities produced.
g. The change in the total area under cotton cultivation reveals a positive as well as significant result at a 5% level, which proves that there has been an increase in the total area under cotton cultivation, thereby contributing to the total production in Iraq.
h. The positive as well as significant result for the price reflects that there is a potential for increasing cotton production due to a rise in prices. However, the farmers seem to be least affected by the expected prices, as depicted by the low short-run as well as long-run elasticities for the cotton price index.
i. It has been observed that despite the consistent increase in cotton prices during the period under consideration, there has not only been no increase in cotton production but a significant decline in production, especially during the most recent period.

Recommendations

a. The study recommends that economic analyses that use time-series data to measure the level of integration should incorporate the use of unit roots tests, as most time-series data exhibit non-stationarity at statistically significant levels and respond to economic as well as political factors.
b. It would therefore be appropriate to design effective preemptive pricing strategies that would protect the cotton farmer from price fluctuations with the ultimate aim of increasing the area under cultivation as well as production.
c. Acknowledging the significance of elasticity as a short-run as well as long-run indicator for effective agricultural planning, the study found that the value of elasticity was below one; however, the level was deemed acceptable for agricultural reforms that could alleviate the reduction in the production of this critical crop.
d. It would be essential to develop a unified database for prices as well as other critical information concerning this critical crop. Currently, time-series data concerning this crop are obtained from different sources, which do not coincide with one another, leading to inaccurate information that could interfere with scientific research.
e. The government should consider providing the cotton farmer with the essential needs for this crop as well as reducing the cost of procurement, especially for seeds, fertilizers, as well as agricultural tools and machinery. This would ensure that the farmer remains motivated to cultivate competitive crops, thereby reducing the level of production; therefore, modern technology should be employed for cotton farming.
f. It would be essential to develop agricultural training as well as extension strategies that would go hand in hand with price support strategies for the cotton farmer.

g. It would be essential to implement strategies that would improve production efficiency, including the use of improved seeds, modern irrigation techniques, as well as the use of fertilizers.
h. It would be essential to develop pricing strategies that would protect the cotton farmer from market as well as agricultural credit risks.

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