Journal of Insights in Basic and Applied Sciences
مجلة رؤى في العلوم الأساسية والتطبيقية
Volume 2, Issue 2, 2026, Pages: 172-183
Journal homepage: https://jibas.com.ly/index.php/jibas/en

Econometric Analysis and Forecasting of Wheat Production in Libya (2000–2035)

Jamal Ali Mohamed Ehdadan *
Department of Agricultural Economics, Faculty of agriculture University of Benghazi, Benghazi, Libya

التحليل الاقتصادي القياسي والتنبؤ بإنتاج القمح في ليبيا (2000-2035)

جمال علي محمد إحديدان *
قسم الاقتصاد الزراعي، كلية الزراعة، جامعة بنغازي، بنغازي، ليبيا

*Corresponding author: jamal.ehdadan@uob.edu.ly

Received: March 27, 2026	Accepted: April 28, 2026	Published: May 20, 2026

Abstract:
Wheat production in Libya remains insufficient to meet growing domestic demand, increasing reliance on imports and exposing the country to external shocks. This study examines the structural economic determinants and future trajectory of wheat production using annual data from 2000 to 2023. The ARDL model is used to study the long-term and short-term relationships between wheat production and its main determinants, including barley production, wheat prices, barley prices, wheat imports, population size, and domestic demand. The boundary test results confirm a long-term equilibrium relationship (F = 9.34), while the error correction limit is negative and statistically significant (ECM = -0.72, p < 0.01), indicating that approximately 72% of short-term variances are corrected within one year. To generate reliable predictions independent of projections of extrinsic variables, the ARIMA model is applied according to the Box-Jenkins methodology. The optimal model, ARIMA (1,1,0), was selected based on the lower bound of the Akaike information Criteria. (AIC = -0.61). Diagnostic tests confirm the absence of a sequential correlation (LM test, p = 0.10) and the overall efficiency of the model. Forecast results indicate that wheat production is expected to Forecast results suggest that wheat production will remain relatively stable, fluctuating between approximately 130,000 and 132,70 tons annually through 2035 By integrating structural econometric analysis with univariate time-series forecasting, this study provides both economic interpretation and forward-looking evidence to support agricultural policy and food security planning in Libya.

Keywords: Wheat, Forecasting, Time series, EViews, Libya, Food security.

الملخص
لا يزال إنتاج القمح في ليبيا غير كافٍ لتلبية الطلب المحلي المتزايد، مما يزيد الاعتماد على الواردات ويعرض البلاد للصدمات الخارجية. تتناول هذه الدراسة المحددات الاقتصادية الهيكلية والمسار المستقبلي لإنتاج القمح باستخدام بيانات سنوية من عام 2000 إلى عام 2023. يُستخدم نموذج ARDL لدراسة العلاقات طويلة الأجل وقصيرة الأجل بين إنتاج القمح ومحدداته الرئيسية، بما في ذلك إنتاج الشعير، وأسعار القمح، وأسعار الشعير، وواردات القمح، وحجم السكان، والطلب المحلي. تؤكد نتائج اختبار الحدود وجود علاقة توازن طويلة الأجل (F = 9.34)، بينما حد تصحيح الخطأ سالب وذو دلالة إحصائية (ECM = -0.72، p < 0.01)، مما يشير إلى تصحيح ما يقرب من 72% من التباينات قصيرة الأجل خلال عام واحد. ولتوليد تنبؤات موثوقة مستقلة عن إسقاطات المتغيرات الخارجية، يُطبق نموذج ARIMA وفقًا لمنهجية بوكس-جينكينز. تم اختيار النموذج الأمثل، ARIMA (1,1,0)، بناءً على الحد الأدنى لمعيار معلومات أكايكي (AIC = -0.61).

تؤكد الاختبارات التشخيصية عدم وجود ارتباط تسلسلي (اختبار LM، p = 0.10) والكفاءة العامة للنموذج. تشير نتائج التنبؤ إلى أن إنتاج القمح سيظل مستقرًا نسبيًا، متذبذبًا بين 130,000 و132,70 طنًا سنويًا تقريبًا حتى عام 2035. من خلال دمج التحليل الاقتصادي القياسي الهيكلي مع التنبؤ أحادي المتغير للسلاسل الزمنية، تقدم هذه الدراسة تفسيرًا اقتصاديًا وأدلة استشرافية لدعم السياسة الزراعية وتخطيط الأمن الغذائي في ليبيا.

الكلمات المفتاحية: القمح، التنبؤ، السلاسل الزمنية، EViews، ليبيا، الأمن الغذائي.

Introduction

Wheat is a strategic food commodity in Libya, constituting a key component of daily caloric intake and national food security (European Commission, 2009; Libya Platform, 2020). However, domestic wheat production remains insufficient to meet growing demand, resulting in continued reliance on imports. Libya's arid climate, limited renewable water resources, and structural constraints in the agricultural sector pose significant challenges to expanding domestic production (Casas, 1999; UNDP, 2007). As is the case in many oil-exporting economies in the Middle East and North Africa region, the agricultural sector has become relatively marginal compared to the dominant hydrocarbon sector (European Commission, 2009). Libya's increasing reliance on wheat imports exposes the country to external shocks, particularly given the concentration of imports from a limited number of exporting countries (Ehdadan, 2025). This vulnerability underscores the importance of improving production planning and strengthening evidence-based agricultural policy design. Despite the strategic importance of wheat, empirical studies using econometric techniques and time-series forecasting to analyze wheat production dynamics in Libya remain limited. Accordingly, this study aims to forecast Libyan wheat production for the period 2024–2035 using the Autoregressive Integrated Moving Average (ARIMA) model. Furthermore, the distributed autoregressive (ARDL) approach is used to examine the long-term and short-term relationships between wheat production and its main economic determinants. By integrating forecasting and structural econometric analysis, the study provides predictive insights along with an economic explanation of wheat production behavior, contributing to policy formulation and planning for food security.

2. MATERIALS AND METHODS

2.1 Data Description

This study uses annual time series data covering the period from 2000 to 2023. Wheat production (WP) is defined as the dependent variable. To investigate the economic determinants of wheat production, the following explanatory variables were included: barley production (BP), wheat prices (WPRI), barley prices (BPRI) as a substitute crop, wheat imports (IMP), population size (POP), and domestic demand for wheat (DEM). All variables were obtained from official national statistical sources and relevant institutional publications. To stabilize variance and improve the statistical properties of the series, all variables were log-transformed prior to estimation.

2.2 Econometric Strategy

The experimental framework consists of two complementary elements. First, the distributed autoregression (ARDL) model is used to study the long-term and short-term relationships between wheat production and its economic determinants. Second, the integrated moving autoregression (ARIMA) model is used exclusively to forecast future wheat production. This dual approach enables both structural economic interpretation and statistical forecasting, thereby strengthening the robustness of policy-relevant conclusions.

2.3 ARDL Model Specification

To test for the existence of long-run equilibrium relationships among the variables, the ARDL bounds testing approach is applied. This methodology is appropriate when variables are integrated of order I (0) or I (1), but not I (2). The general ARDL (p, q_1, q_2, …, q_n) model can be expressed as: $WP_t = \alpha_0 + \Sigma\beta_i WP_{t-i} + \Sigma\gamma_j X_{t-j} + \varepsilon_t$

where WP_t represents wheat production, X_t denotes the vector of explanatory variables, and ε_t is the error term. Lag lengths are selected based on the Akaike Information Criterion (AIC). The existence of cointegration is examined using the bounds F-test. Upon confirmation of a long-run relationship, long-run coefficients are estimated and the associated Error Correction Model (ECM) is specified to capture short-run dynamics. Diagnostic tests, including serial correlation, heteroskedasticity, and stability tests, are conducted to ensure model adequacy and robustness.

2.4 ARIMA Model for Forecasting

To generate forecasts of wheat production for the period 2024–2035, the ARIMA model is applied following the Box–Jenkins methodology.

The modeling process involves:

1. Testing stationarity using the Augmented Dickey–Fuller (ADF) test.
2. Identifying appropriate lag orders using ACF and PACF functions.
3. Estimating alternative ARIMA specifications.

3. **Selecting the optimal model based on the minimum Akaike Information Criterion (AIC).**

The selected model is ARIMA (1,1,0), with AIC = -0.61.

Residual diagnostics confirm the absence of serial correlation (LM test, p = 0.13), indicating that the model is statistically adequate for forecasting purpose

Testing for Stationarity Two hypotheses are formulated for this study

Null hypothesis HO: variable is not stationary or got unit root.

Alternative H1: variable is stationary, the first method which can be used to check stationarity of the variables is to graph the series.

The first step to verifying the stability of the variables is to visualize the series using a graph.

Estimated wheat Production from 2000 to 2023 Using ARDL Model

R-squared is Hight 0.91 %, this model should be free form (serial correlation, the residual should be normal distrusted, and heteroskedasticity).

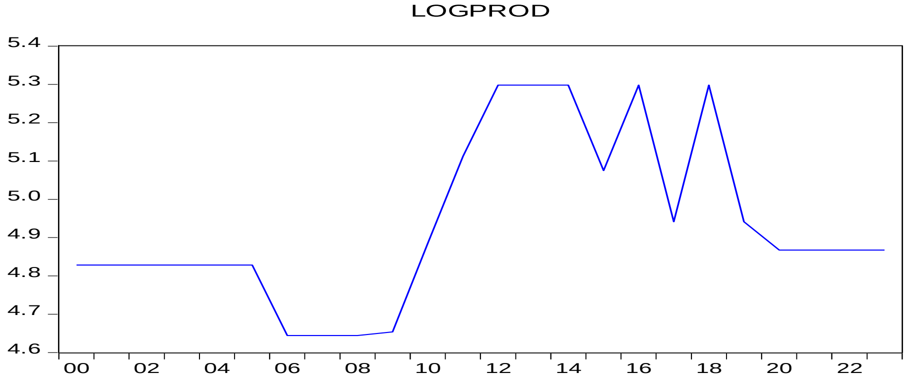

Figure (1) The original time series in logarithm for production of wheat

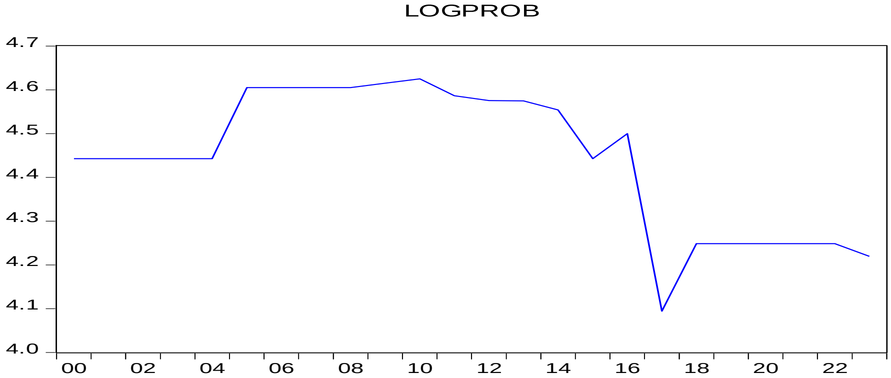

Figure (2): The original time series in logarithm of barley Production from 2000 to 2023

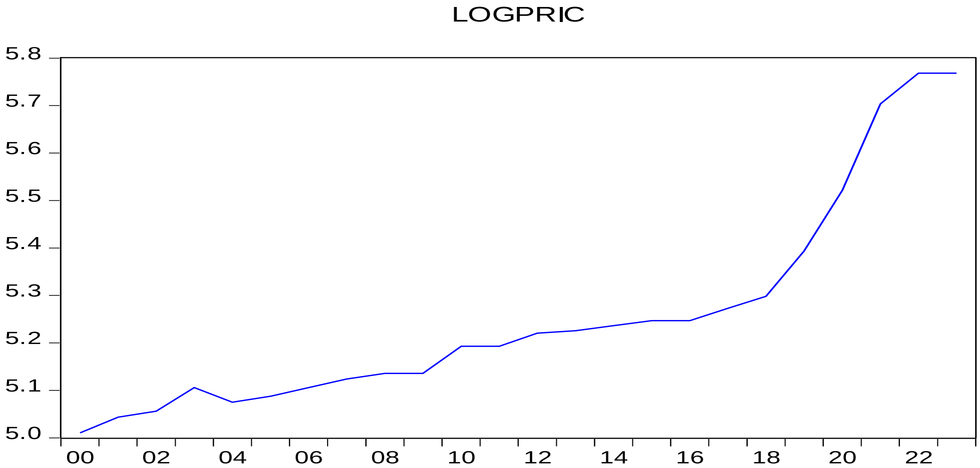

Figure (3): The original time series in logarithm of the price of wheat from 2000 to 2023

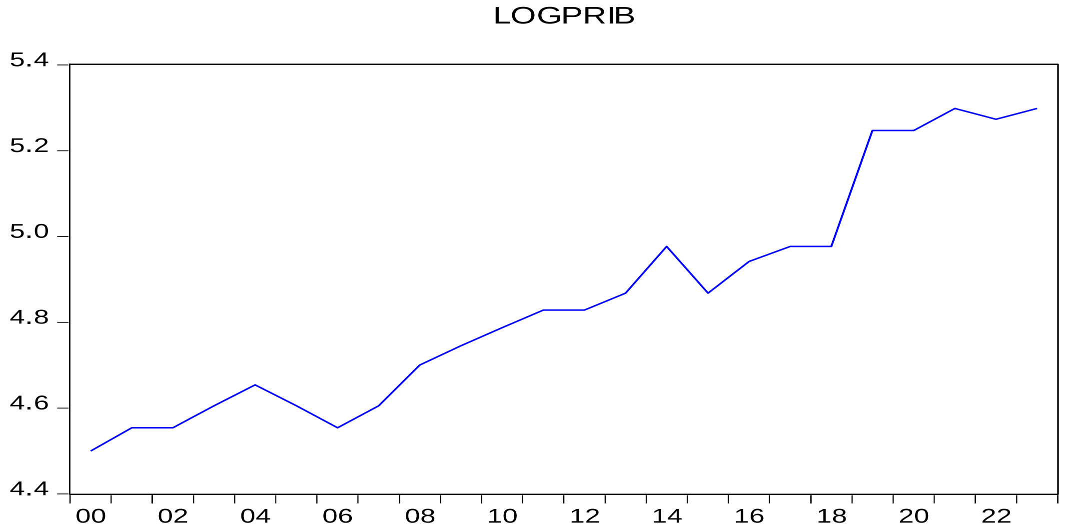

Figure (4): The original time series in logarithm of price of Barley from 2000 to 2023

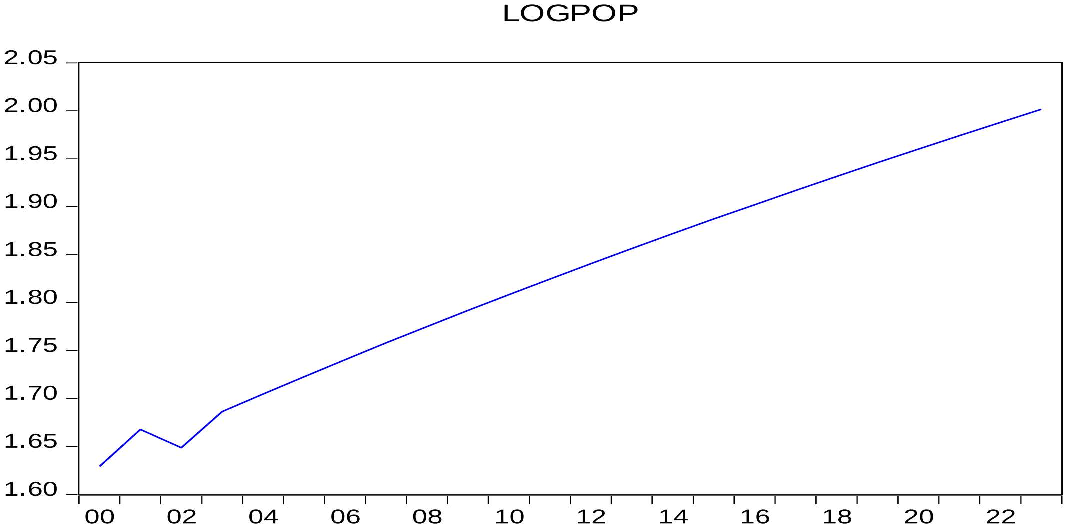

Figure (5): The original time series in logarithm of series of people from 2000 to 2023

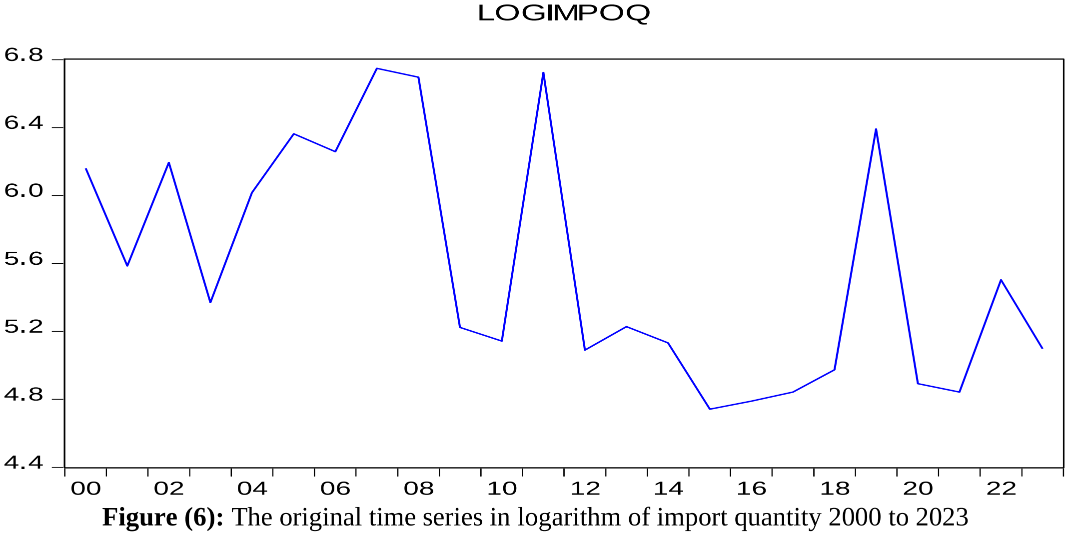

Figure (6): The original time series in logarithm of import quantity 2000 to 2023

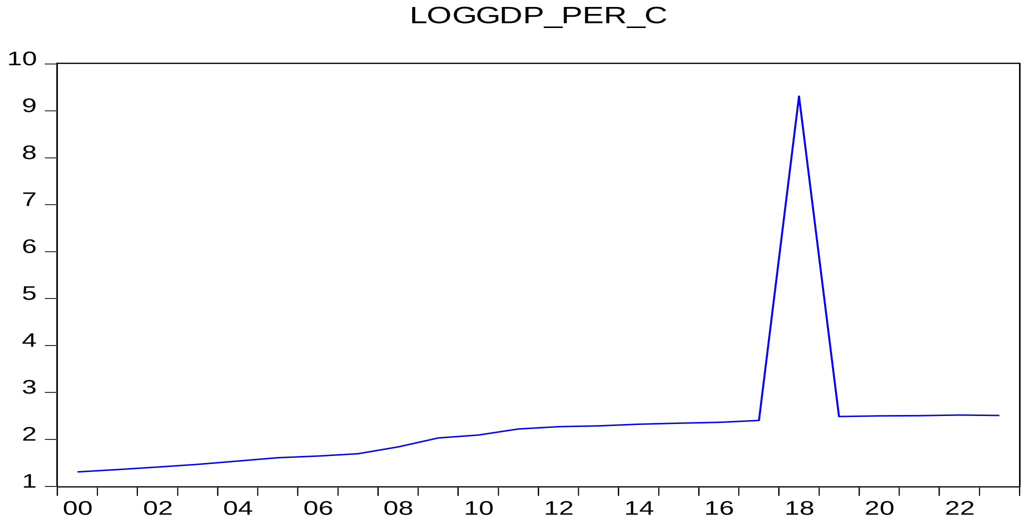

Figure (7): The original time series in logarithm of GDP per capital 2000 to 2023

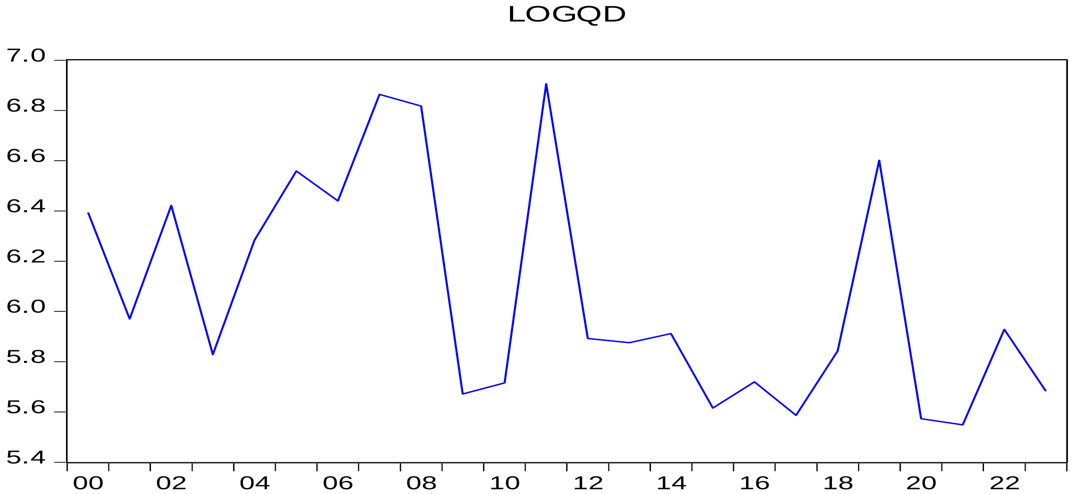

Figure (8): The original time series in logarithm of `QD (Quantity demand of wheat) 2000 to 2023

Table (1). Unit Root Analysis of the Variables

Variables	**level**				**First difference**			
	With trend	With Intercept	Without trend & Intercept	With trend & Intercept	With trend	With Intercept	Without trend & Intercept	With trend & Intercept
	ADF		ADF		ADF		ADF	
logprod							-6.95	
logprob						-6.79		
logpric								-4.39
logprib							-4.69	
logpop				-6.32				
logimpoq		-3.31						
loggdp per-c				-4.81				
logqd		-3.66						

Where Logprod= log prod wheat, Logprod=log prod of Barley, Logpric=log of price of wheat, Log prib= log of Barley price, logpop=log of people, Logimpoq= log of import quantity of wheat, LogGDP per Capital, Logqd =Log of quantity demand of wheat.

Using the augmented Dickey-Fuller (ADF) test for unit roots all variables are difference, the log A (wheat Production) will be stationary at the level with intercept, T-statistic= -6.78. more than -3.00 at 5% then we can reject the Null Hypothesis H0 and accept the alternative hypothesis.

Table (2) ARDL RESULTES

Dependent Variable: LOGPROD
Method: ARDL
Date: 03/03/26 Time: 01:12
Sample (adjusted): 2001 2023
Included observations: 23 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): LOGQD LOGPROB LOGPRIC LOGPRIB LOGPOP LOGIMPOQ LOGGDP_PER_C
Fixed regressors:
Number of models evalulated: 128
Selected Model: ARDL(1, 1, 0, 1, 0, 0, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOGPROD(-1)	0.280380	0.123778	2.265181	0.0412
LOGQD	1.222359	0.347528	3.517294	0.0038
LOGQD(-1)	-0.094441	0.047665	-1.981369	0.0691
LOGPROB	0.356385	0.150559	2.367079	0.0341
LOGPRIC	-0.747794	0.612360	-1.221168	0.2437
LOGPRIC(-1)	0.680303	0.538158	1.264133	0.2284
LOGPRIB	0.832347	0.388526	2.142318	0.0517
LOGPOP	-1.882564	0.726131	-2.592595	0.0223
LOGIMPOQ	-0.924978	0.237353	-3.897062	0.0018
LOGGDP_PER_C	0.028442	0.016915	1.681461	0.1165

R-squared	0.915243	Mean dependent var	4.941158
Adjusted R-squared	0.856564	S.D. dependent var	0.225638
S.E. of regression	0.085456	Akaike info criterion	-1.782621
Sum squared resid	0.094934	Schwarz criterion	-1.288928
Log likelihood	30.50014	Hannan-Quinn criter.	-1.658458
Durbin-Watson stat	1.257125		

*Note: p-values and any subsequent tests do not account for model selection.

Table (3): The result of ARDL Model

R^2	Serial correlation	Normal distribution test	Breusch-Pagan-Godfrey	ARDL Long Run and Bounds Test	Selected Model ARDL
0.91	0.13	0. 27	0.34	F- Statistic 9.43	(1, 0, 1, 0, 0, 0, 0, 1)

The first step in evaluating the model was to check whether serial correlation was present. Since the Chi-Square probability value (0.13) is higher than the 5% significance level, there is no basis for rejecting the null hypothesis. In practical terms, this means that the model does not show any evidence of serial correlation in the residuals. The second step involved assessing whether the residuals follow a normal distribution, using the Heteroskedasticity Test: Breusch-Pagan-Godfre The obtained probability value (0.34) is also above 5%, which indicates that the residuals are normally distributed. And The ARDL bounds test confirms the existence of a long-run equilibrium relationship between wheat production and its determinants. The calculated F-statistic (9.34) exceeds the upper critical bound at the 5% significance level, indicating cointegration among the variables. This result suggests that wheat production in Libya is structurally linked to its economic determinants in the long run. Finally, the model was examined for heteroskedasticity to ensure that the variance of the residuals remains constant over time. This confirms that the model is stable and suitable for reliable interpretation and forecasting

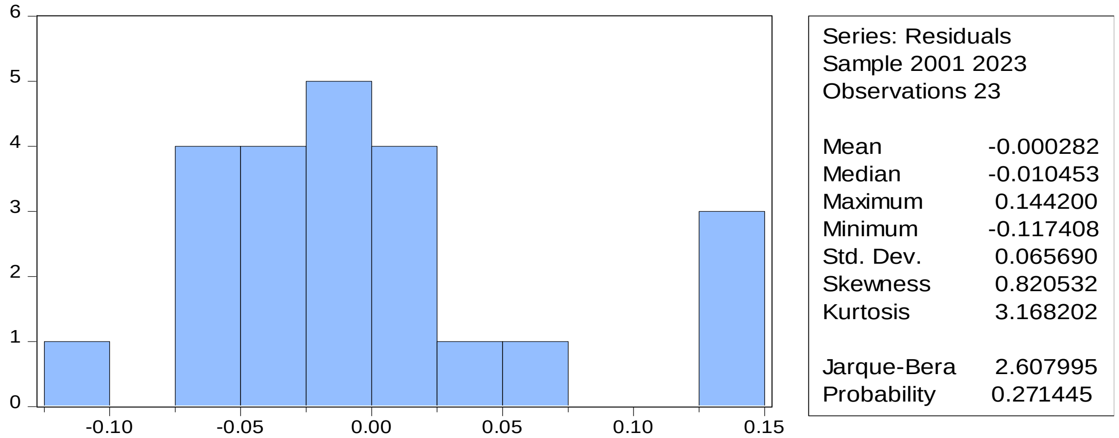

Figure (9) Normal distribution test.

To determine whether a long-run relationship exists among the variables, the ARDL bounds testing approach was employed. The computed F-statistic (9.43) exceeds the upper critical bound at conventional significance levels, leading to the rejection of the null hypothesis of no cointegration. This finding provides strong evidence of a stable long-run equilibrium relationship among the variables. More-over, the t-statistic (-5.81) further reinforces the existence of cointegration, confirming the robustness of the long-run association. To assess the stability of the estimated parameters over the study period, the CUSUM and CUSUM of Squares (CUSUMSQ) tests were conducted. These diagnostic tests examine potential structural breaks in the model. The graphical results indicate that the cumulative sum of recursive residuals remains within the 5% critical bounds, suggesting parameter stability. Consequently, no structural instability is detected, and the model can be considered reliable for policy analysis and forecasting within the sample period

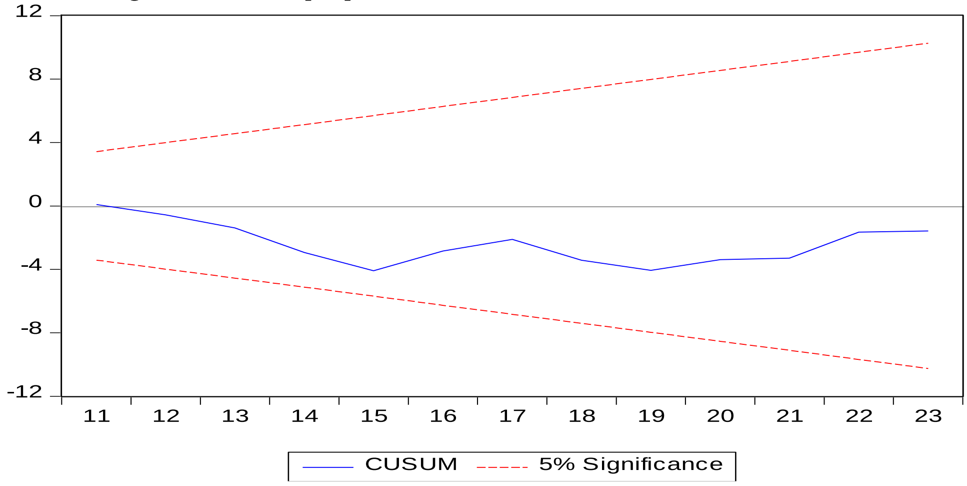

Figure (10) CUSUM test

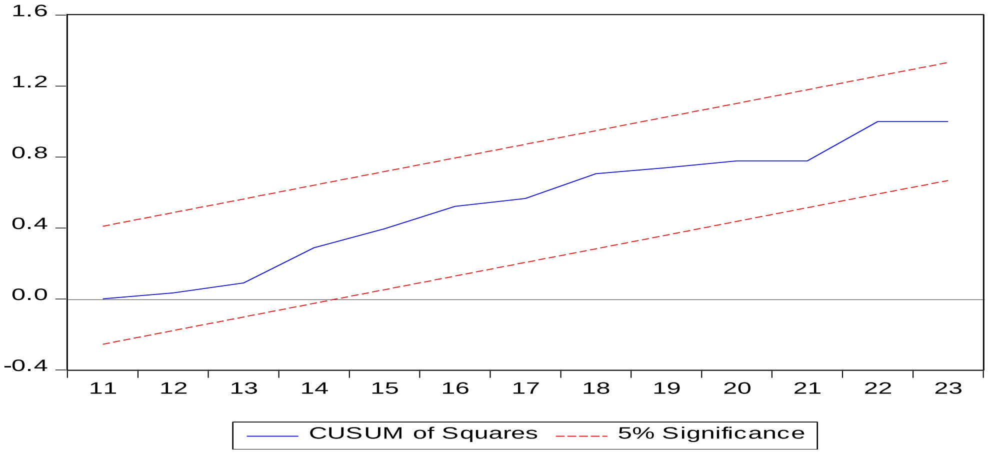

Figure (11) Test of Squares (CUSUMSQ)

Table (4) ARDL Error Correction Regression (ECM) Test

ARDL Error Correction Regression
Dependent Variable: D(LOGPROD)
Selected Model: ARDL(1, 0, 1, 1, 0, 0, 0, 0)
Case 1: No Constant and No Trend
Date: 03/02/26 Time: 02:03
Sample: 2000 2023
Included observations: 23

ECM Regression
Case 1: No Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGQD)	1.222359	0.115272	10.60412	0.0000
D(LOGPRIC)	-0.747794	0.258099	-2.897318	0.0125
CointEq(-1)*	-0.719620	0.066786	-10.77508	0.0000

R-squared	0.856206	Mean dependent var	0.001705
Adjusted R-squared	0.841826	S.D. dependent var	0.173233
S.E. of regression	0.068896	Akaike info criterion	-2.391316
Sum squared resid	0.094934	Schwarz criterion	-2.243208
Log likelihood	30.50014	Hannan-Quinn criter.	-2.354068
Durbin-Watson stat	1.257125		

The error correction coefficient (CointEq (-1)) is negative and statistically significant (-0.72, $p < 0.01$), confirming the existence of a long-run equilibrium relationship among the variables. The coefficient indicates that approximately 72% of short-run disequilibrium is corrected within one year, suggesting a relatively fast adjustment toward equilibrium. In the short run, wheat demand has a positive and significant effect on wheat production ($\beta = 1.22$, $p < 0.01$). In contrast, wheat prices have a negative short-run effect ($\beta = -0.75$, $p < 0.05$), which may reflect structural constraints and market inefficiencies within the domestic agricultural sector.

ARIMA Forecasting Model

To predict wheat production in Libya, the Autoregressive Integrated Moving Average (ARIMA) model was applied according to the Box-Jenkins methodology developed by George E. B. Box and Gwilym M. Jenkins (1970). Annual wheat production data for the period 2000–2023 were obtained from national statistical sources (Ehdadan, 2025). To stabilize variance and reduce data volatility, the wheat production series was transformed into natural logarithms. The stability of the time series was initially visually inspected and then formally tested using the Augmented Dickey–Fuller, a commonly used test in time series analysis to identify unit roots (James H. Stock and Mark W. Watson, 2015). The results indicated that the logarithmic series became stable after the first differentiation, demonstrating that the series is an I (1) first-order integral. Based on the Akaiki Information Criterion (AIC) minimum, the optimal prediction model was determined to be ARIMA (1,1,0). The estimated autoregression coefficient was statistically significant. Indicating that past changes in wheat production influence current production dynamics. Diagnostic tests were then conducted to validate the model's efficiency. The results confirmed that the residuals were free of serial correlation and that the model met the basic assumptions necessary for reliable time series forecasting (Chris Brooks, 2008). Using the estimated model, wheat production in Libya was forecasted for the period 2024–2035. The forecasts were generated using a logarithmic series and then converted back to the original production values (in tons) to facilitate interpretation and policy analysis.

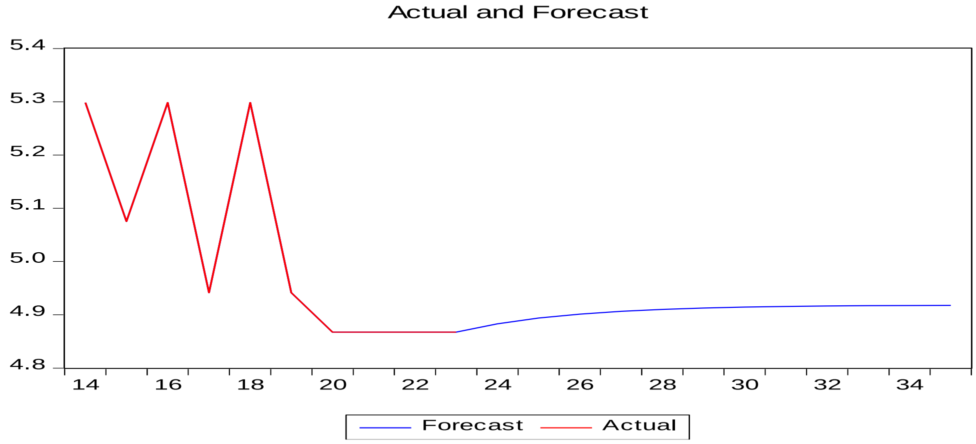

Figure (12) Actual and Forecast.

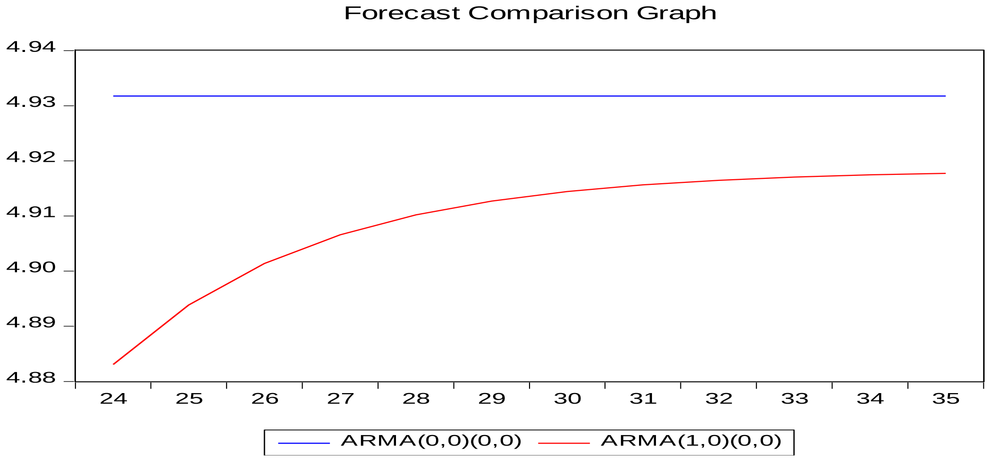

Figure (13) Forecast Comparison Graph.

Table (5) Method: ARMA Maximum Likelihood

Dependent Variable: D(LOGPROD)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 05/18/26 Time: 13:34
Sample: 2001 2023
Included observations: 23
Convergence achieved after 21 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001747	0.024658	0.070848	0.9442
AR(1)	-0.378567	0.140433	-2.695703	0.0139
SIGMASQ	0.024238	0.008238	2.942355	0.0081

R-squared	0.155595	Mean dependent var	0.001705
Adjusted R-squared	0.071154	S.D. dependent var	0.173233
S.E. of regression	0.166956	Akaike info criterion	-0.614342
Sum squared resid	0.557485	Schwarz criterion	-0.466234
Log likelihood	10.06493	Hannan-Quinn criter.	-0.577093
F-statistic	1.842654	Durbin-Watson stat	1.757855
Prob(F-statistic)	0.184293		

The constant term was initially included in the ARIMA estimation; however, it was found to be statistically insignificant. Therefore, the final specification of the model excludes the constant term to obtain a more parsimonious representation of the data. The final forecasting model is specified as ARIMA (1,1,0) without a constant term and can be expressed as:

$$\Delta \ln (PROD_t)=\phi_1 \Delta \ln (PROD_{t-1}) +\varepsilon_t$$

Where:

- $\ln (PROD_t)$ represents the natural logarithm of wheat production in Libya in year t.
- Δ denotes the first difference operator, indicating the change between two consecutive periods.
- ϕ_1 is the autoregressive coefficient of order one, capturing the influence of the previous period's change in wheat production on the current change.
- ε_t represents the white-noise error term assumed to be independently and normally distributed with zero mean and constant variance.
- t denotes the time period (year).

Table (6) ACF PACF

Date: 05/18/26 Time: 13:40
Sample: 2000 2035
Included observations: 23
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.121	0.121	0.3831	
		2	0.331	0.321	3.3757	0.066
		3	-0.143	-0.236	3.9612	0.138
		4	-0.159	-0.264	4.7265	0.193
		5	-0.184	-0.015	5.8105	0.214
		6	-0.108	0.050	6.2050	0.287

Results of Wheat Production Forecast (2024–2035)

The ARIMA forecasting model was employed to project wheat production in Libya for the period 2024–2035 based on historical data from 2000–2023. After transforming the production series into natural logarithms and ensuring stationarity through the Augmented Dickey–Fuller (ADF) test, the optimal ARIMA (1,1,0) specification was selected according to the minimum Akaike Information Criterion (AIC). Following model estimation, forecasts were generated for the next twelve years. The predicted values were then transformed back to their original scale using the exponential function to express the results in thousand tons of wheat production. The forecasting results indicate a gradual and relatively stable increase in wheat production over the projection period. Production is expected to rise from approximately 130.18 thousand tons in 2024 to around 132.70 thousand tons by 2035. The projected growth remains modest, suggesting that domestic wheat production will continue to expand slowly but without substantial structural change. This relatively limited increase reflects the structural constraints facing the Libyan agricultural sector, including water scarcity, climatic variability, and limited cultivated areas. Consequently, even with moderate growth in domestic production, Libya is likely to remain highly dependent on wheat imports to satisfy growing domestic demand. Overall, the forecasting results highlight that while domestic wheat production may experience slight improvements in the coming decade, these increases are unlikely to be sufficient to significantly reduce the country's reliance on international markets. Therefore, policy efforts should focus on enhancing agricultural productivity, improving irrigation efficiency, and adopting climate-resilient farming practices to strengthen national food security

Table (7) Forecasted wheat production (×1000 tons)

Years	**wheat Production**
2024	**130.18**
2025	**130.41**
2026	**130.64**
2027	**130.87**
2028	**131.10**
2029	**131.32**

2030	**131.55**
2031	**131.78**
2032	**132.01**
2033	**132.25**
2034	**132.48**
2035	**132.71**

Policy Implications

The findings of this study provide several important implications for agricultural policy in Libya. Although the forecasting results indicate a slight increase in wheat production over the forecast horizon, the projected growth remains modest and insufficient to meet the rapidly increasing domestic demand. This suggests that Libya will likely continue to rely heavily on wheat imports in the coming years. Therefore, policymakers should prioritize improving domestic wheat productivity through the adoption of modern agricultural technologies, improved seed varieties, and more efficient irrigation systems. Given the country's severe water scarcity, enhancing water-use efficiency in agriculture should be considered a strategic priority. In addition, strengthening institutional support for farmers, improving access to agricultural inputs, and promoting sustainable land management practices could contribute to increasing domestic production capacity. These measures may help reduce the country's vulnerability to international market fluctuations and enhance long-term food security.

Conclusion

This study investigated the structural determinants and future trajectory of wheat production in Libya using annual data for the period 2000–2023. The analysis combined the ARDL approach to examine long-run and short-run economic relationships with the ARIMA model to generate production forecasts. The ARDL results confirmed the existence of a long-run equilibrium relationship among wheat production and its key determinants. The error correction mechanism indicated a relatively rapid adjustment toward equilibrium, suggesting that short-run deviations are corrected efficiently over time. For forecasting purposes, the ARIMA model was applied following the Box–Jenkins methodology. The results suggest that wheat production in Libya is expected to remain relatively stable, remaining relatively stable around 130–132 thousand tons during the forecast period. Despite this modest growth, domestic production levels remain insufficient to meet the growing national demand for wheat. Consequently, Libya is likely to continue depending heavily on wheat imports in the foreseeable future. Overall, the findings highlight the need for comprehensive agricultural policies aimed at improving productivity, enhancing irrigation efficiency, and promoting sustainable agricultural practices. Strengthening domestic wheat production remains an essential component of improving national food security and reducing vulnerability to external market shock

Discussion

The results of the distributed autoregressive model indicate a strong relationship between wheat production in Libya, domestic demand, and wheat imports. The positive impact of domestic demand suggests that high consumption levels stimulate domestic production despite the structural constraints facing the agricultural sector. Conversely, the negative relationship between wheat imports and domestic production suggests that increasing reliance on imported wheat may weaken the incentives of local producers. The estimated error correction coefficient was negative and statistically significant, confirming a stable, long-term equilibrium relationship between the variables. The relatively high rate of adjustment indicates the ability to correct short-term shocks within a limited timeframe. However, the results also reflect the vulnerability of agricultural production in Libya, particularly given water scarcity, limited arable land, and market instability. The projections derived from the integrated moving average autoregressive model indicate that wheat production is expected to remain relatively stable during the period 2024–2035, fluctuating around 130,18–132,70 tons without significant long-term growth. This suggests that current production levels may not be sufficient to meet growing domestic demand for wheat, meaning continued reliance on imports in the coming years. Overall, these findings highlight the importance of improving irrigation efficiency, supporting local producers, and strengthening agricultural policies aimed at enhancing food security in Libya.

References

[1] Brooks, C. (2008). Introductory econometrics for finance (2nd ed.). Cambridge University Press.

[2] Casas, J. (1999). Economy and agriculture of the WANA region. International Center for Agricultural Research in the Dry Areas (ICARDA). http://www.icarda.cgiar.org/NARS/Economy.PDF

[3] Ehdadan, J. A. M. (2025, October 13–15). Quantifying and forecasting Libya's wheat gap: Implications for food security and import dependence—Analytical study using time series [Conference paper]. African-European Forum for Partnership and Development, Benghazi, Libya

[4] European Commission. (2009). Trade sustainability impact assessment (SIA) of the EU-Libya free trade agreement. Manchester, UK.

[5] Faraj, F. S., & Farhana, I. (2020, December 15). Determinants of wheat production in Libya. International Journal of Academic Research in Business and Social Sciences.

[6] Food and Agriculture Organization of the United Nations (FAO). (2021). The state of food security. Rome: FAO.

[7] Food and Agriculture Organization of the United Nations (FAO). (2022). Country brief: Libya – Food security and agriculture. Rome: FAO.

[8] Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., ... & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. Science, 327(5967), 812–818. https://doi.org/10.1126/science.1185383

[9] Jland, J., et al. (1985–1988). Influence of price and rate structures on municipal and industrial water use. Carbondale.

[10] Lawgali, F. F. (2009, April). Economic aspects of population growth and water consumption in Libya [Doctoral dissertation, Abertay University]. Dundee, UK.

[11] Libyan General Authority for Agriculture (LGAA). (2008). Features of the national strategy for food security in Libya.

[12] Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. Science, 333(6042), 616–620. https://doi.org/10.1126/science.1204531

[13] Minbar Libya. (2020, December 13). The Libyan diet. https://en.minbarlibya.org/2020/12/13/the-libyan-diet/

[14] Oxford Business Group (OBG). (2008). The report: Libya 2008. London, UK: Oxford Business Group.

[15] United Nations Development Programme (UNDP). (2007). Annual report. http://web.undp.org/publications/annualreport2007/

[16] United Nations Economic and Social Commission for Western Asia (UN-ESCWA). (2019). Water scarcity and drought in the Arab region. Beirut: UN-ESCWA.

[17] United Nations Population Fund (UNFPA). (2025). Libya world population dashboard. https://www.unfpa.org/data/world-population/LY