

## Assessing the Economic, Demographic, and Agricultural Determinants of Wheat Production in Libya: Evidence from an ARDL Approach (2000–2023)

Jamal Ali Mohamed Ehdadan \*

Department of Agricultural Economics, Faculty of agriculture, University of Benghazi, of Benghazi, Libya

تقييم العوامل الاقتصادية والديموغرافية والزراعية الرئيسية المؤثرة على إنتاج القمح في ليبيا خلال  
ARDL باستخدام نموذج (2000-2023)

جمال علي محمد احديدان \*

قسم الاقتصاد الزراعي، كلية الزراعة، جامعة بنغازي، بنغازي، ليبيا

\*Corresponding author: [Jamal.ehdadan@uob.edu.ly](mailto:Jamal.ehdadan@uob.edu.ly)

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### Abstract:

Ensuring adequate wheat production remains a major challenge for Libya, where domestic supply continues to meet fall short of national demand. This study examines the key economic, demographic, and agricultural determinants of wheat production During 2000–2023. An Autoregressive Distributed Lag (ARDL) approach is utilized to investigate the short-run adjustments and long-run equilibrium relationships between wheat production and its key determinants., including barley production, crop prices, imports, population growth, and domestic demand. The results confirm the existence of a stable long-run relationship. Domestic demand plays a significant positive role, while wheat imports and population growth exert negative pressures on local output of wheat. The interaction between wheat and barley suggests that production decisions are influenced by broader agricultural conditions rather than simple crop substitution. These findings reflect structural constraints within the Libyan agricultural sector, particularly limited resources and Rising consumption pressures Strengthening domestic production therefore requires policies that improve productivity, Improved resource use, and control excessive of imports. This study provides an integrated econometric assessment of wheat production dynamics in a resource-constrained economy, offering insights relevant for food security policy in Libya.

**Keywords:** Wheat production; Food security; ARDL approach; Wheat imports; Libya.

### المخلص

يُعد تحقيق الاكتفاء من إنتاج القمح تحدياً رئيسياً في ليبيا، حيث لا يزال الإنتاج المحلي غير قادر على تلبية الطلب المتزايد. تهدف هذه الدراسة إلى تحليل أهم العوامل الاقتصادية والديموغرافية والزراعية المؤثرة في إنتاج القمح خلال الفترة 2000–2023. ولتحقيق ذلك، تم استخدام نموذج الانحدار الذاتي للفجوات الزمنية الموزعة (ARDL) لدراسة العلاقات قصيرة الأجل وطويلة الأجل بين إنتاج القمح ومحدداته الرئيسية، والتي تشمل إنتاج الشعير، أسعار المحاصيل، الواردات، النمو السكاني، والطلب المحلي. أظهرت النتائج وجود علاقة توازنه طويلة الأجل بين المتغيرات محل الدراسة. كما تبين أن الطلب المحلي يمثل عاملاً محفزاً لزيادة إنتاج القمح، في حين أن الواردات والنمو السكاني يمارسان تأثيراً سلبياً على الإنتاج المحلي. وتشير العلاقة بين القمح والشعير إلى أن قرارات الإنتاج لا تعتمد فقط على الإحلال بين المحاصيل، بل تتأثر أيضاً بالظروف الزراعية العامة. وتعكس هذه النتائج وجود قيود هيكلية في القطاع الزراعي الليبي، خاصة فيما يتعلق بندرة الموارد

وارتفاع مستويات الطلب. وعليه، فإن تعزيز الإنتاج المحلي يتطلب تبني سياسات متكاملة تهدف إلى رفع الإنتاجية، وتحسين كفاءة استخدام الموارد، والحد من الاعتماد المفرط على الواردات. وتقدم هذه الدراسة تحليلاً اقتصادياً قياسيماً متكاملاً لديناميكيات إنتاج القمح في ظل بيئة محدودة الموارد، بما يوفر رؤى مهمة لدعم سياسات الأمن الغذائي في ليبيا.

**الكلمات المفتاحية:** إنتاج القمح؛ الأمن الغذائي؛ نهج ARDL؛ واردات القمح؛ ليبيا.

## Introduction

Wheat is a cornerstone of global food security and a vital staple for most populations, including Libya, where it constitutes the primary source of calories and an essential component of daily diets. Its importance extends beyond nutrition; it is also a political and economic commodity that directly affects national stability. Over the last two decades, Libya's wheat sector has faced persistent challenges in balancing domestic production with increasing local demand, resulting in a growing dependence on imports (FAO, 2023; World Bank, 2022). Understanding the factors that influence wheat production is therefore crucial for developing strategies that enhance agricultural productivity and reduce food insecurity. Between 2000 and 2023, multiple interconnected factors have affected wheat production in Libya. One major agricultural factor is barley production, which competes with wheat for similar resources such as water and land. Variations in barley production and prices often determine farmers' decisions regarding wheat and barley cultivation, depending on profitability and market incentives (FAO, 2021; USDA, 2020; Khalifa et al., 2020). Similarly, the price of wheat, both domestically and internationally, plays a decisive role. Rising wheat prices motivate farmers to increase cultivation, whereas declining prices discourage investment and reduce output (IMF, 2022; OECD-FAO, 2022). Economic indicators have also exerted a significant influence. Gross domestic product (GDP) per capita affects both agricultural investment capacity and consumer purchasing power. Periods of higher GDP per capita shift food consumption patterns, increasing demand for wheat-based products (World Bank, 2022; Ali et al., 2019). Meanwhile, population growth has been a consistent driver of demand expansion, intensifying pressure on agricultural systems that are already constrained by arid conditions and limited water resources (FAO, 2021; IPCC, 2021; Elhassan et al., 2018). Another critical factor is the quantity of imported wheat, which reflects both shortfalls in domestic production and broader economic conditions. When local production fails to meet demand, imports rise, exposing Libya to international price shocks and supply chain disruptions (FAO, 2023; World Bank, 2022). Additionally, the interplay between barley production and national wheat demand shapes overall production strategies, as shifts in consumption and resource allocation directly determine output trends (Sims, 1980; Stock & Watson, 2019). This study employs **time series analysis** to examine how these variables—barley production, barley and wheat prices, wheat demand, population size, GDP per capita, and wheat import quantities—have interacted to influence wheat production in Libya from 2000 to 2023. By analyzing these relationships, the research aims to identify the most significant determinants of wheat production and provide evidence-based recommendations for policies that strengthen national food security, stabilize agricultural markets, and promote sustainable resource management (FAO, 2021; World Bank, 2022; Box et al., 2015). Although wheat production is closely linked to food security in Libya, studies examining its main determinants remain relatively limited, especially those that analyze economic, demographic, and agricultural factors together over a long period of time. This study attempts to provide a broader understanding of the factors affecting wheat production by examining both short-term and long-term relationships using the ARDL approach. The findings may help support policies aimed at improving domestic production, reducing dependence on imports, and enhancing food security under the resource limitations facing the Libyan agricultural sector.

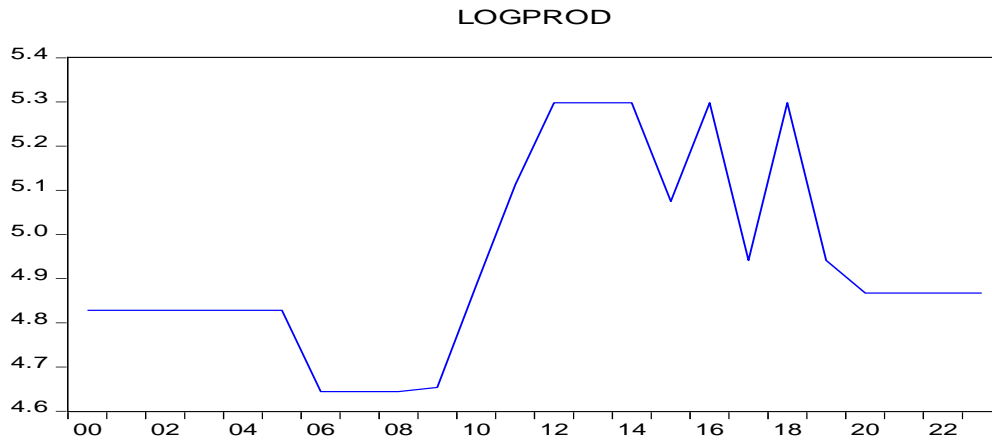
## Material and Methods

This study aims to identify and analyze the main factors influencing wheat production in Libya from 2000 to 2023 using time series analysis. The analysis was conducted with the EViews software, which enables the estimation and evaluation of econometric models over time. The variables included in the model were selected based on their relevance to wheat production and national food security. These variables are: barley production, wheat prices, barley prices, quantities of barley produced, the national demand for wheat, population size, GDP per capita, and the quantities of imported wheat. The data used in this study were obtained from reliable international sources such as the Food and Agriculture Organization (FAO), the World Bank, and the International Monetary Fund (IMF). Annual data covering the period from 2000 to 2023 were compiled and analyzed to examine how changes in these factors have affected wheat output. Time series analysis was applied to investigate the temporal relationships between these variables. Before estimating the model, the stationarity of each variable was tested, as non-stationary data can produce misleading regression results. Two hypotheses were formulated:

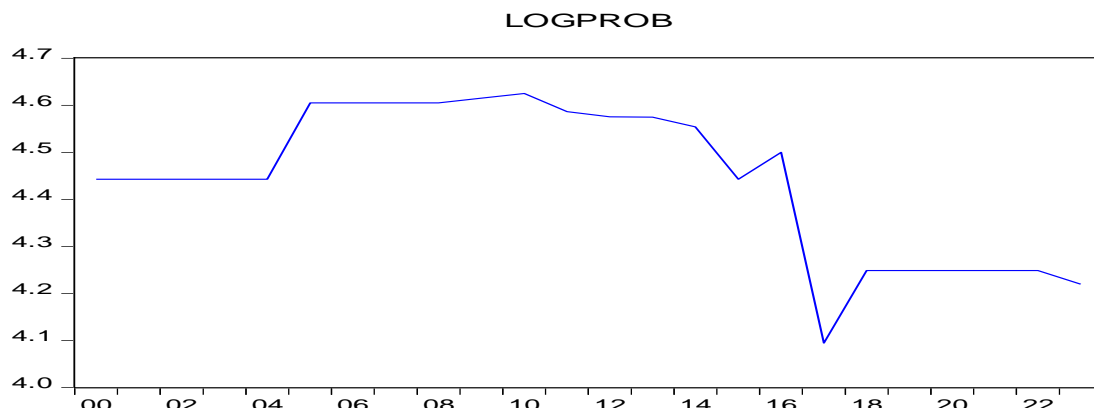
- ❖ **Null hypothesis ( $H_0$ ):** the variable is not stationary and contains a unit root.
- ❖ **Alternative hypothesis ( $H_1$ ):** the variable is stationary.

To verify stationarity, graphical analysis and formal statistical tests such as the Augmented Dickey-Fuller (**ADF**) test were applied. Once the data were confirmed to be stationary, the time series model was estimated, and diagnostic checks were conducted to ensure the validity and reliability of the results. This methodological framework allows for a comprehensive understanding of how economic, demographic, and agricultural factors have jointly shaped wheat production in Libya over the past two decades.

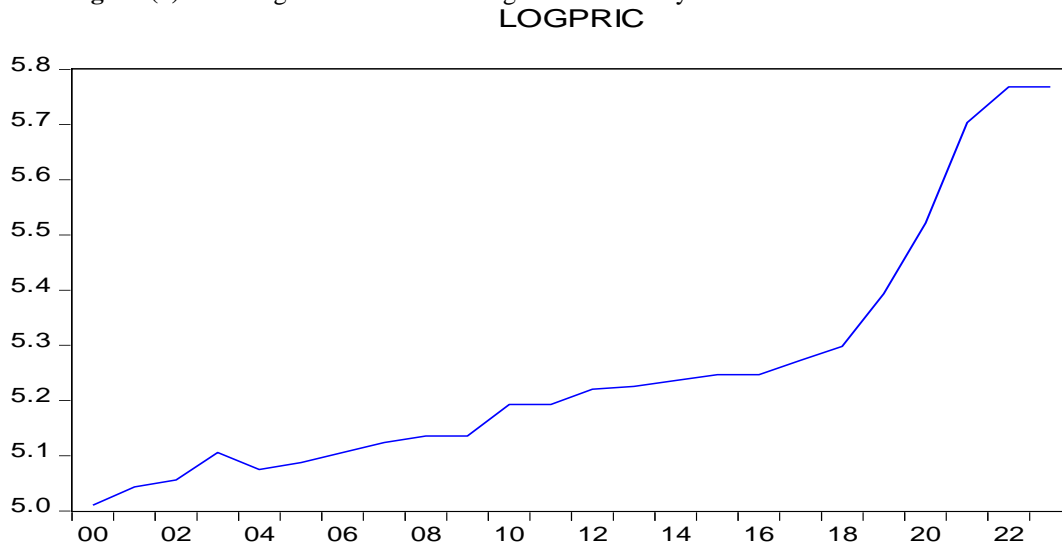
The first method that can be used to check the stability of variables is to plot the series graphically.



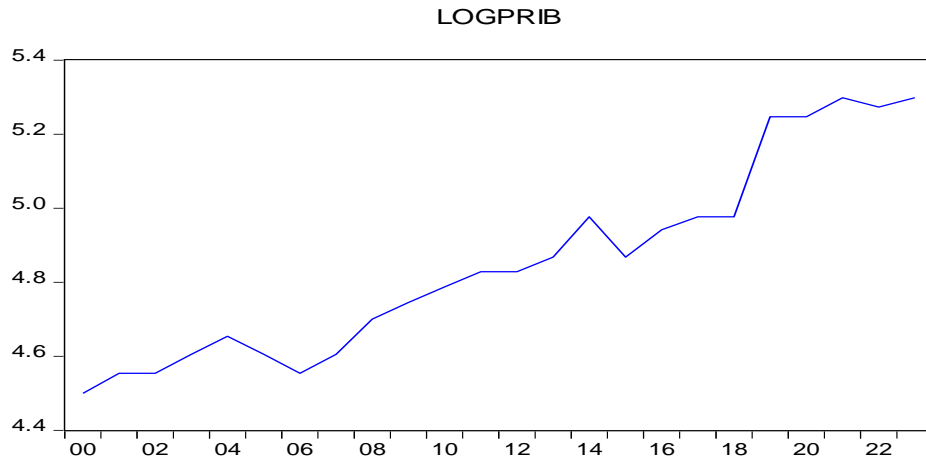
**Figure (1):** The original time series in logarithm of wheat Production from 2000 to 2023



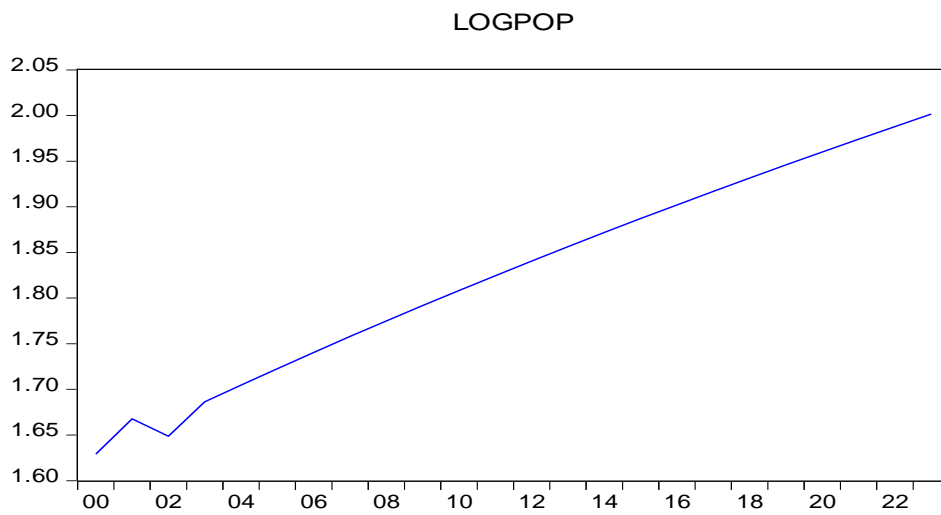
**Figure (2):** The original time series in logarithm of barley Production from 2000 to 2023



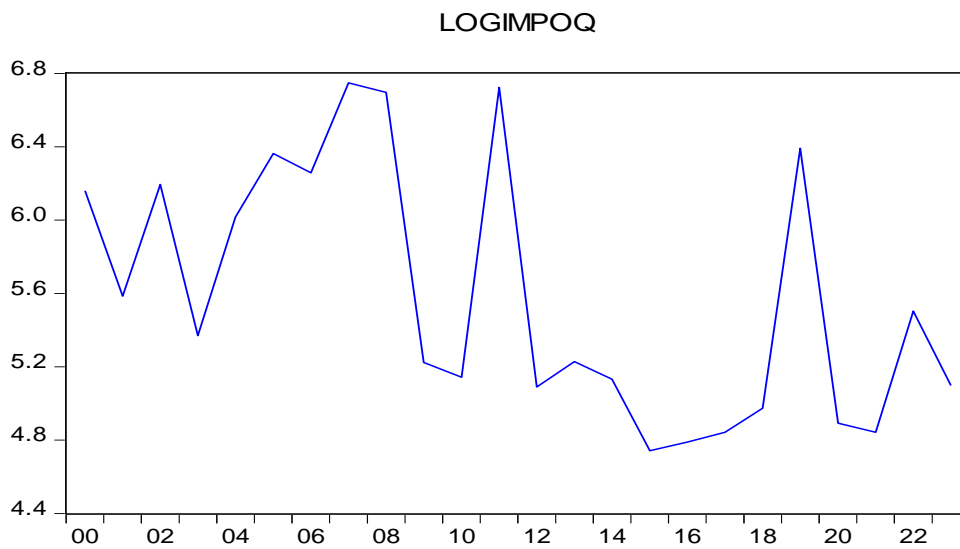
**Figure (3):** The original time series in logarithm of the price of wheat from 2000 to 2023



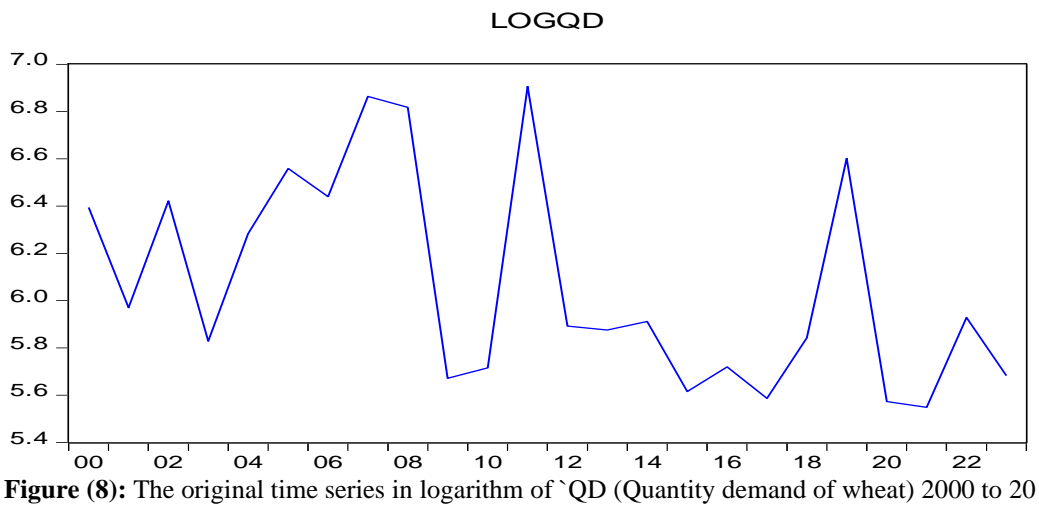
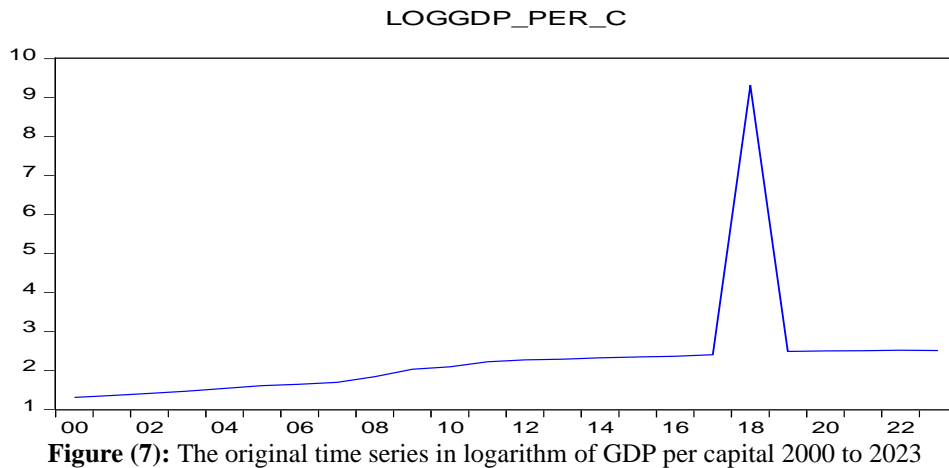
**Figure (4):** The original time series in logarithm of price of Barley from 2000 to 2023



**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



**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						
loggdper-c				-4.81				
logqd		-3.66						

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.

### introduction to the ARDL Method

In empirical research, understanding the dynamic relationships between economic and agricultural variables often requires methods capable of monitoring both short-term fluctuations and long-term equilibrium. The finite auto distributed regression (ARDL) model has emerged as one of the most effective econometric techniques for this

purpose. (Pesaran & Shin, 1999; Narayan, 2005) Unlike traditional cointegration techniques, the ARDL model is flexible in handling integrable variables of different orders, specifically I (0) or I (1), without requiring prior homogeneity testing across all series. This flexibility makes the ARDL model particularly suitable for applied research, where datasets often include a mix of constant and non-constant variables (Banerjee et al., 1993; Ewing & Thompson, 2007). One of the key strengths of the ARDL model is its ability to simultaneously estimate short-term dynamics and long-term relationships. This is crucial in agricultural economics, where immediate responses include changes in crop prices. These effects coincide with delayed effects from structural factors such as investment levels, population growth, or government policies. (Shrestha & Chowdhury, 2005; McNown et al., 2018) Furthermore, the ARDL model can accommodate relatively small sample sizes, making it suitable for studies covering limited time periods or countries with limited historical data (Hsiao, 2014; Tang et al., 2019). A key advantage of the ARDL model is its ability to include lagging values for both dependent and independent variables, allowing researchers to observe delayed or cumulative effects that are often overlooked in simpler regression models. For example, in agriculture, the impact of fertilizer prices or rainfall patterns on crop yields may not be immediately apparent but may emerge over one or more subsequent seasons. (Apergis & Payne, 2010; Narayan & Smyth, 2005). By incorporating these lags, The ARDL model offers a more precise and detailed understanding of causal relationships and adaptation processes over time. Methodologically, the ARDL model involves several steps. Initially, the integrative properties of all variables are evaluated to ensure that none of them are second-order integers or higher. (Pesaran et al., 2001; Gujarati & Porter, 2021). The optimal delay length is then determined using information criteria such as the Akaike Information Criterion (AIC) or the Schwartz-Bayesian Criterion (SBC), balancing model complexity with predictive performance (Narayan, 2005; Box et al., 2015). Finally, bounds testing is applied to detect cointegration, confirming whether a stable long-term relationship exists among the variables (Pesaran & Shin, 1999; McNown et al., 2018). In practical applications, ARDL has proven particularly valuable in investigating economic, financial, and agricultural systems. Researchers have used it to study the effects of energy consumption on economic growth (Apergis & Payne, 2010), the relationship between financial development and inflation (Narayan & Smyth, 2005), and the determinants of agricultural productivity under changing climatic conditions (Tang et al., 2019; Farooq et al., 2021). Its versatility in monitoring both immediate and delayed effects make it an essential policy analysis tool, helping governments and institutions understand the potential short- and long-term consequences of policy interventions. In general, the ARDL methodology provides a robust framework for analyzing time-series data, particularly when datasets are small, mixed in order of integration, or subject to delayed effects. By offering concurrent insights into short-term adjustments and long-term equilibrium, ARDL equips researchers and policymakers with actionable information to inform decisions and strategies across diverse fields, including agriculture, energy, and macroeconomic policy. (Pesaran et al., 2001; Apergis & Payne, 2010; Tang et al., 2019).

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### Scientific Interpretation of ARDL Model Results

Before estimating the ARDL model, all variables were converted to their natural logarithmic form to stabilize variance and minimize heterogeneous variance. The estimated coefficients are interpreted as elasticities. This conversion also helps to capture relative rather than absolute changes, which is particularly useful for long-term time series data. In this study, over the period 2000–2023, each coefficient represents the percentage change in wheat production resulting from a 1% change in the corresponding explanatory variable, with all other factors held constant. The estimated ARDL model (1, 0, 1, 0, 0, 0, 0, 1) provides valuable insights into the main determinants of wheat production in Libya. The high  $R^2$  value (0.915) indicates that approximately 91.5% of the variances in the logarithm of wheat production (LOGPROD) are explained by the included variables, confirming the overall quality of the model. The adjusted coefficient of determination (0.857) further reinforces this robustness, even after accounting for the number of independent variables. The coefficient of the lagging dependent variable.

**(LOGPROD (-1))** The positive and statistically significant value ( $\beta = 0.280$ ,  $p = 0.041$ ) indicates the continuity of wheat production over time. This means that current production levels are influenced by past production, reflecting the continuity of agricultural practices, accumulated experience, and structural constraints within the Libyan agricultural system.

**Turning to the wheat price (LOGPRIC)**, its current value shows a negative but statistically insignificant effect ( $\beta = -0.748$ ,  $p = 0.244$ ). This suggests that, in the short term, higher wheat prices do not significantly incentivize domestic wheat production in Libya. Farmers may not respond quickly to higher prices due to structural constraints, limited access to inputs, or delayed government support. Interestingly, the delayed value of the wheat price (LOGPRIC(-1)) carries a positive signal ( $\beta = 0.680$ ), although it is also statistically insignificant ( $p = 0.228$ ),

implying that producers may react to price changes with a time lag; that is, the effect of price incentives may materialize in later seasons rather than immediately.

**The LOGPROB** coefficient in the model is 0.356385, with a probability value of 0.0341, indicating statistical significance at the 5% level. This positive coefficient suggests that increased barley production is associated with increased wheat production (LOGPROD) in the Libyan context. From an economic perspective, although barley is theoretically considered a substitute crop for wheat, the observed positive relationship indicates a complementary or synergistic dynamic rather than direct competition. This may reflect the prevailing agricultural conditions in Libya, where improvements in resources, such as the availability of irrigation, agricultural inputs, and favorable climatic conditions, lead to a general expansion in cereal cultivation. Consequently, when barley production increases, wheat production tends to increase as well, likely due to favorable conditions and shared management practices. Furthermore, the result may indicate that farmers are employing crop diversification strategies, such as cropping wheat and barley in rotation or in adjacent fields, which increases overall cereal production. Therefore, LOGPROB serves as an important indicator of wheat production in this ARDL model, reflecting the broader agricultural environment rather than strict substitution effects between the two crops.

In the ARDL model, **the LOGPRIB coefficient**, representing the logarithm of the barley price, is 0.832347, with a probability value of 0.0517. This coefficient is only slightly significant at the 5% level, indicating that changes in the barley price can have a tangible impact on wheat production (LOGPROD), although the significance is only slightly above the lower bound. The positive sign of the coefficient suggests that higher barley prices are associated with increased wheat production. This may seem counterintuitive from an economic perspective, as higher prices for an alternative crop like barley might incentivize farmers to allocate more resources to barley rather than wheat. However, this result can be explained from the perspective of integration and resource availability in the Libyan agricultural sector. Price indices are likely to reflect general market conditions and farm profitability, as higher barley prices coincide with improved market incentives, increased farm income, and better access to agricultural inputs such as fertilizers, irrigation, and labor. These factors can indirectly support wheat production, allowing farmers to invest in multiple cereal crops simultaneously. Furthermore, the marginal significance of the LOGPRIB index highlights the sensitivity of wheat production to changes in the economic environment of alternative crops. While wheat and barley are often considered theoretical substitutes, the data suggest that barley prices may be indicative of broader agricultural and economic conditions, rather than simply a substitution effect, impacting farmers' ability to increase or maintain wheat production levels. In conclusion, the LOGPRIB index is an important economic indicator within the model, suggesting that barley price volatility can indirectly influence wheat production decisions, reflecting the interconnected dynamics of cereal crop markets in Libya.

On the other hand, **population growth (using a logarithmic function)** shows a significant negative impact ( $\beta = -1.883$ ,  $p = 0.022$ ). This result suggests that rapid population expansion puts pressure on available agricultural land and water resources, thus reducing per capita wheat production. This may also indicate urbanization and competition for resources, which negatively affect rural productivity.

**The quantity of wheat imports (LOGIMPOQ)** shows a strong and statistically significant negative relationship with domestic production ( $\beta = -0.925$ ,  $p = 0.0018$ ). This means that increased wheat imports lead to decreased domestic production, most likely because cheaper imported alternatives discourage domestic production.

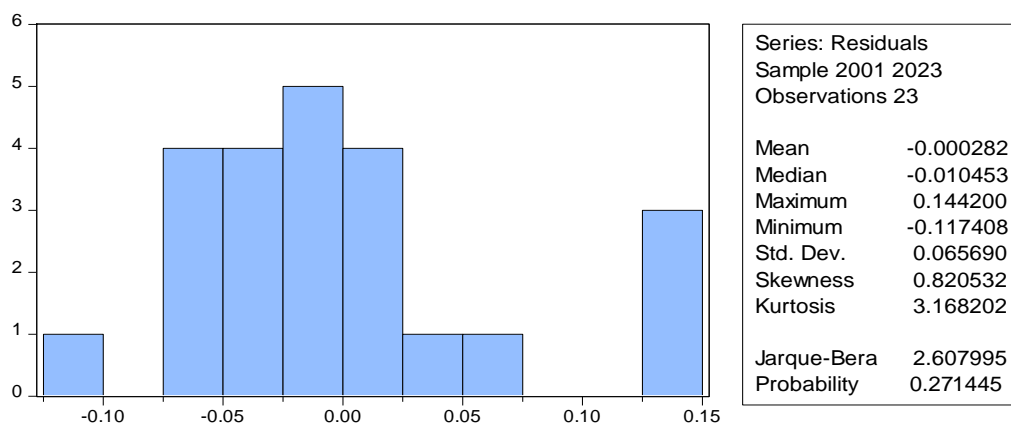
Conversely, **domestic demand for wheat (LOGQD)** exerts a positive and highly significant effect ( $\beta = 1.222$ ,  $p = 0.0038$ ). This indicates that higher demand stimulates local production, as producers respond to market needs and potential profitability. However, the lagged demand variable (LOGQD (-1)) is negative but marginally significant ( $p = 0.069$ ), implying a delayed adjustment process where production reacts with some inertia to changes in demand.

The effect of **GDP per capita (LOGGDP\_PER\_C)** is positive ( $\beta = 0.028$ ) but statistically insignificant ( $p = 0.116$ ), suggesting that improvements in national income do not directly translate into higher wheat production, possibly due to structural inefficiencies or weak linkages between economic growth and the agricultural sector. Overall, the model indicates that wheat production in Libya is significantly affected by barley price, population pressure, import levels, and domestic demand, while GDP per capita and wheat price have weaker or delayed effects. The Durbin–Watson statistic (1.26) shows mild autocorrelation, but the overall diagnostic indicators (low standard error, good AIC/SC values) confirm the adequacy of the estimated model.

**In sum**, the application of a logarithmic specification improves the robustness of the empirical model while enabling a direct elasticity-based interpretation of the results. This approach provides clearer insights into the degree of responsiveness of wheat production to changes in key economic and demographic drivers, offering a more policy-relevant understanding of production dynamics. The findings suggest that strengthening domestic wheat production requires a balanced policy framework that carefully manages reliance on imports, addresses the pressures associated with population growth, and reinforces market-based incentives to support local producers. Such an integrated approach is essential for enhancing production resilience and advancing long-term food security objectives.

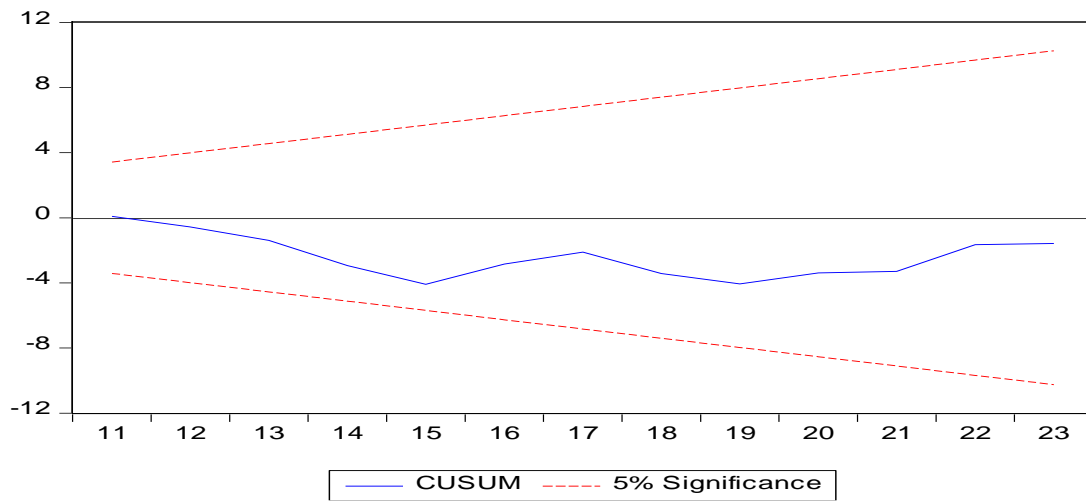
**Table (2): The result of ARDL Model.**

Serial correlation	Normal distribution test	heteroskedastic Breusch.Pagan Godfrey	Selected Model ARDL
0.13	0.27	0.34	1, 0, 1, 0, 0, 0, 0, 1

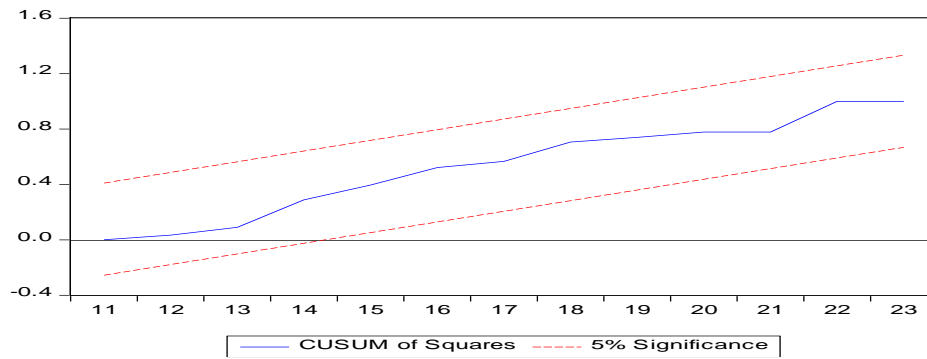


**Figure (9): Residual Normal Distribution Test**

To assess the model's robustness and consistency over time, the CUSUM and CUSUM-squared tests were applied. Graphical evaluation shows that the blue line's trajectory remained largely confined within the upper and lower red critical boundaries, indicating the overall stability of the model throughout the analyzed period. This temporary divergence suggests the identification of the expected short-term equilibrium relationship captured by the model for that specific year. Despite this isolated deviation, the overall pattern confirms the reliability and stability of the estimated model, thus reinforcing confidence in the validity of the experimental results. It is worth noting that the CUSUM test is used to test the reliability of variables in the short term, while the CUSUM-square test is used to test the reliability of variables in the long term. The variables remain stable in both cases.



**Figure (10): Stability (cusum) Test**



**Figure (11):** Cusum of Squares

## Conclusion

This study provides a detailed analysis of the key economic, demographic, and agricultural factors that influenced wheat production in Libya between 2001 and 2023. By applying an ARDL modeling approach to log-transformed variables, the analysis not only addresses issues of instability and scale but also provides a clear explanation of the relative responsiveness of wheat production to changes in economic and demographic conditions, as well as market indicators and policies. The empirical results highlight that domestic demand for wheat (LOGQD) is a major driver of wheat production. The statistically significant positive coefficient indicates that when domestic demand increases, farmers respond by expanding production, reflecting the adaptive nature of agricultural decisions to market needs. Similarly, the barley price (LOGPRIB) representing an alternative cereal crop, shows a positive effect on wheat production. This finding underscores the interdependence of different agricultural commodities: when barley prices rise, farmers may benefit from increased income or adopt integrated production strategies, which in turn stimulates wheat cultivation. Conversely, the results reveal that the volume of imported wheat (LOGIMPOQ) and population growth (LOGPOP) negatively impact domestic wheat production. These effects suggest that increased wheat imports can reduce incentives for domestic production, potentially displacing local output, while demographic pressures can strain available resources, including land, labor, and water, hindering production expansion. Interestingly, the price of wheat itself (LOGPRIC) and per capita GDP (LOGGDP\_PER\_C) show limited or mixed effects, indicating that wheat production in Libya is shaped by a complex network of factors rather than isolated variables. Taken together, these findings underscore the importance of comprehensive agricultural and economic policies. To boost domestic wheat production and ensure food security, policymakers need to strengthen mechanisms that stimulate domestic demand, carefully manage imports, and consider the broader economic environment, including alternative crop markets. Furthermore, supporting farmers—by providing access to inputs, technology, and market information—can help align production with both local needs and economic realities. **In conclusion**, wheat production in Libya is influenced by a multifaceted interplay between economic incentives, demographic pressures, and agricultural market dynamics. Addressing these factors through well-considered policies and investment strategies will enhance the resilience of the wheat sector, secure national food supplies, and support sustainable agricultural development in the coming years.

## References

- [1] Ali, H., Mohammed, A., & Khalid, S. (2019). Determinants of cereal production in North Africa: An econometric analysis. *Agricultural Economics*, 50(2), 123–137.
- [2] Apergis, N., & Payne, J. E. (2010). Energy consumption and economic growth: Evidence from the ARDL bounds testing approach. *Energy Economics*, 32(5), 1133–1140.
- [3] Banerjee, A., Dolado, J., Galbraith, J. W., & Hendry, D. F. (1993). *Cointegration, error correction, and the econometric analysis of non-stationary data*. Oxford University Press.
- [4] Box, G. E. P., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). *Time series analysis: Forecasting and control* (5th ed.). Wiley.
- [5] Elhassan, A., Salah, M., & Omar, K. (2018). Population growth and agricultural sustainability in arid regions. *Journal of Arid Agriculture*, 12(3), 211–228.
- [6] Ewing, B. T., & Thompson, M. A. (2007). A review of ARDL modeling in economics. *Journal of Economic Studies*, 34(3), 180–192.
- [7] Farooq, M., Ahmad, M., & Ali, S. (2021). Impact of climate change on cereal crop production using ARDL approach. *Sustainability*, 13(14), Article 7892.

- [8] Food and Agriculture Organization of the United Nations. (2021). *FAO statistical yearbook 2021: Food and agriculture data*. FAO.
- [9] Food and Agriculture Organization of the United Nations. (2023). *Libya: Cereal import and production reports*. FAO.
- [10] Gujarati, D. N., & Porter, D. C. (2021). *Basic econometrics* (6th ed.). McGraw-Hill Education.
- [11] Hsiao, C. (2014). *Analysis of panel data* (3rd ed.). Cambridge University Press.
- [12] International Monetary Fund. (2022). *Libya: Economic outlook and food security report*. IMF.
- [13] Intergovernmental Panel on Climate Change. (2021). *Climate change 2021: The physical science basis*. Cambridge University Press.
- [14] Khalifa, M., Salem, A., & Idris, F. (2020). Crop competition and cereal market dynamics in North Africa. *African Journal of Agricultural Economics*, 8(1), 55–70.
- [15] McNown, R., Sam, C. Y., & Goh, S. K. (2018). Bootstrapping the autoregressive distributed lag test for cointegration. *Applied Economics*, 50(13), 1509–1521.
- [16] Narayan, P. K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics*, 37(17), 1979–1990.
- [17] Narayan, P. K., & Smyth, R. (2005). Electricity consumption, employment and real income in Australia: Evidence from multivariate Granger causality tests. *Energy Policy*, 33(9), 1109–1116.
- [18] Organisation for Economic Co-operation and Development & Food and Agriculture Organization of the United Nations. (2022). *OECD-FAO agricultural outlook 2022–2031*. OECD Publishing.
- [19] Pesaran, M. H., & Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegration analysis. In S. Strøm (Ed.), *Econometrics and economic theory in the 20th century: The Ragnar Frisch Centennial Symposium* (pp. 371–413). Cambridge University Press.
- [20] Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289–326.
- [21] Shrestha, M. B., & Chowdhury, K. (2005). ARDL modelling approach to testing the financial liberalisation hypothesis. *Applied Economics*, 37(17), 1979–1990.
- [22] Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48(1), 1–48.
- [23] Stock, J. H., & Watson, M. W. (2019). *Introduction to econometrics* (4th ed.). Pearson.
- [24] Tang, C. F., Tan, B. W., & Ozturk, I. (2019). Environmental degradation and economic growth: Evidence from ARDL bounds testing approach. *Environmental Science and Pollution Research*, 26, 12345–12357.
- [25] Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, 66(1–2), 225–250.
- [26] United States Department of Agriculture. (2020). *World agricultural supply and demand estimates*. USDA.
- [27] World Bank. (2022). *Libya agricultural sector review: Food security and policy implications*. World Bank Publications.

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