Pak. J. Bot., 59(1): January 2027.

ARTICLE | DOI: http://dx.doi.org/10.30848/PJB2027-1(9)

FUTURE TRENDS OF WHEAT-PRODUCING COUNTRIES: MARKET DYNAMICS AND SUSTAINABILITY ANALYSIS (2025–2030)

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Abstract

This study seeks to formulate global wheat production projections for the 2025-2030 timeframe, considering the essential and strategic significance of wheat in global nutrition, and to assess the export capabilities of prominent wheat-producing nations. The data for this study were obtained from FAO, and wheat production data for the period 1961-2024 were analyzed using the ARIMA or ARIMAX model in the SAS 9.4 statistical software. According to the results, the total wheat production of the five largest producing countries will be 416.24 million tons (52.13%) in 2024, while, according to the ARIMA and ARIMAX models, production in these countries is projected to be between 433 and 461 million tons in the 2025–2030 period, with a six-year average of approximately 446 million tons. In general, the countries in question want to continue producing the same amount of wheat. Russia, Canada, and France all use strategies that focus on quality to make a lot of money per unit, such as investing in advanced agricultural technologies and promoting high-quality wheat varieties to attract premium prices in the market. The US, India, and Australia, on the other hand, want to send more wheat abroad to make more money. Currently, China and Pakistan prioritize food security and local storage due to their large population's food needs. Türkiye, on the other hand, buys more wheat and turns it into high-value goods like flour and pasta. During certain times, drought and other factors can also lead to big drops in production. Therefore, countries need to conduct research into drought-resistant, high-yield, or high-quality production methods to either increase or improve yields. Countries that successfully utilize new technologies to cope with such risks will have a strategic advantage in shaping the future of the global wheat economy by achieving higher yields or better quality.

Key words: ARIMA; Wheat, Global Warming, Leading Countries, Production Planning

Introduction

Nutrition is indispensable for the sustainability of human life. In the constantly changing world, ensuring adequate and balanced nutrition remains one of the most important global challenges. A country's economic development and social welfare depend on proper nutrition for a healthy life, which directly affects overall quality of life (Nalinci, 2013). Cereals are one of the most fundamental products in terms of nutrition worldwide, and wheat, in particular, is of great importance because of its use as food and animal feed. Wheat, which helps regulate the digestive system owing to its vitamin, mineral, and fiber content, is also an important source of energy due to its high carbohydrate content. According to Anon. (2026) data from 2023, in Afghanistan, 83%, 70%, and 75% of carbohydrate, energy, and protein intake, respectively, is obtained from cereals, while in Germany, these figures are 39%, 20%, and 20%, respectively; in Russia, 53%, 33%, and 30%, respectively; in Türkiye, 57%, 36%, and 35%, respectively; and in the USA, 39%, 20%, and 19%, respectively.

In recent years, climate change, largely caused by human activities, has led to a global increase in temperature and fluctuations in weather patterns, severely impacting agricultural production. Between 2011 and 2020, global temperatures increased by 1.1°C, with many countries experiencing record temperatures and extreme rainfall, and this situation is expected to continue in the coming periods. The most unpredictable factor in agriculture, weather, leads to decreases in yield and product quality due to heat waves and irregular rainfall. These changes directly affect wheat, one of the world's most important staple foods (Zheng & Zhang, 2025). Furthermore, the Russia-Ukraine war significantly disrupted wheat exports, especially from Ukraine, resulting in a serious contraction in the global supply. The closure of Ukrainian ports caused a supply shock in the global wheat market, resulting in rapid increases in wheat prices. Generally, war-related supply disruptions lead to instability in the wheat market, with prices returning to normal as the supply normalizes (Novotná *et al*., 2023).

Between 2019 and 2024, the average annual global wheat production was approximately 786.76 million tons, with China accounting for the largest share at 17.35%, followed by India at 13.83%, and Russia at 10.93%. Furthermore, the US ranks fourth with a 6.25% share, while France, Canada, and Australia contribute 4.33%, 4.13%, and 3.94%, respectively. Pakistan (3.46%), Ukraine (3.18%), and Germany (2.74%) are among the top 10, whereas Türkiye ranks 11th with a 2.54% production share. This data reveal that global wheat production is largely carried out by a few countries, and these countries play a critical role in terms of supply security (Anon., 2026).

Received: 26-01-2026 | Revised: 27-03-2026 | Accepted: 08-04-2026 | Online: 25-08-2026

With a trade volume of $51.4 billion in 2020, wheat ranks second only to soybeans as the most traded agricultural product globally. While 97 countries produce wheat, only 24 significantly contribute to the global market by providing over $1 billion in supply. China and India are major producers, they use their production for domestic consumption, while a small number of countries, such as Ukraine, lead in exports. In contrast, as of 2020, 75 countries imported at least $100 million worth of wheat, with countries with limited agricultural land, such as Egypt and Indonesia, being among the largest importers of wheat. The dependence of these countries on imports and the difficulty in replacing wheat could lead to serious economic and social impacts due to disruptions in global production and trade (Devadoss & Ridley, 2024).

Globally, wheat flour production averaged approximately 280 million tons in 2022-2023, with an average self-sufficiency rate of 100%. Türkiye has a high production capacity for wheat-based flour, pasta, and starch products, and as of 2023, it produced 11.4 million tons of wheat flour annually (The Union of Chambers and Commodity Exchanges of Türkiye Anon., 2023). Besides Türkiye, countries such as Kazakhstan (134.05%), Uzbekistan (156.51%), Germany (119.47%), and Argentina (111.18%) have also turned to exports with high self-sufficiency rates (Anon., 2025; Anon., 2025). These countries are among the main actors in foreign wheat flour trade and have significant shares in the world market. In addition to wheat flour, the pasta sector is a prominent sub-sector on a global scale. Specifically, the global pasta industry relies heavily on the production of durum wheat (*Triticum durum*), which is essential for high-quality pasta manufacturing. As of 2023, 16.4 million tons of pasta were produced worldwide, with 86% of this production carried out by 12 countries, including Italy, the USA, Türkiye, Egypt, Brazil, and Russia (Anon., 2025). The largest producer was Italy, with 3.96 million tons, followed by the USA with 2 million tons and Türkiye with 1.97 million tons.

In this context, the present research aims to provide a comprehensive analysis of global wheat production dynamics by examining long-term production trends and formulating medium-term projections for the years 2025-2030. The study employs time-series modeling techniques to project future output levels of major wheat-producing countries and evaluate their comparative export competitiveness. Furthermore, the study aims to add to the existing literature by offering ideas about how leading producers can boost agricultural productivity, promote sustainable production practices, and strengthen their resilience to global challenges like climate change, population growth, and food security concerns.

Materials and Methods

Materials: The primary data source for this study is the database from the Food and Agriculture Organization of the United Nations (FAOSTAT). In addition, numerous national and international datasets, as well as various academic articles, books, conference papers, and theses, were utilized during the research process. The data obtained in the study were evaluated within the framework of wheat production statistics from 1961 to 2024; the major producing countries worldwide and the global production level were analyzed comprehensively.

Methods: Based on FAOSTAT data from 1961 to 2024, the production quantities of the world and the top 5 leading wheat-producing countries were separately organized in Microsoft Excel. Their competitive situations were analyzed in Microsoft Excel, and for forecasting, ARIMA models were used in the SAS 9.4 statistical program. The best model was selected based on 10 criteria, including the Akaike Information Criterion (AIC) and the Schwarz/Bayesian Information Criterion (BIC), with the model satisfying the most criteria being chosen as the best model.

ARIMA estimation method: The ARIMA model was developed by Box & Jenkins (1976) and known by this name. This model is a statistical method used to model linear relationships in stationary time series. This model consists of three components: an autoregressive (AR) term expressing the dependence on past values, an integration (I) term enabling the stationarization of non-stationary data through difference calculation, and a moving average (MA) that takes into account past estimation errors. It is defined by the form ARIMA (p, d, q), which includes the p, d, and q degrees of the AR, I, and MA terms, respectively (Ali *et al*., 2025). These models minimize the AIC by combining unit root tests (Ventura *et al*., 2019). The maximum likelihood method is used to estimate the ARIMA parameters, and this method is similar to the least squares (LS) method, indicating that its estimators provide more efficient estimation results than other estimators (Sardar *et al*., 2023). Time series forecasting provides significant contributions to decision-makers and policymakers in many areas such as weather, traffic, agricultural production, supply chain management, and financial investments (Cao *et al*., 2020).

The AR model evaluates prior values from a time series, indicating a linear link between present and previous asset values, particularly in the financial industry (Zeng, 2024).

Formula 1 illustrates the formula that defines the AR portion.

$$y_t = \alpha + \sum_{i=1}^{p} \varphi_i * y_{t-i} + \varepsilon_t \quad (1)$$

In an AR model (equation 1), y_t represents the estimated dependent variable value at time t, α is the constant coefficient, φ specifies the influence of previous values on the current period, and p denotes the model's degree (number of periods). The random error term, ε_t, accounts for external influences not included in the model with zero mean and constant variance (Wang *et al*., 2025).

The MA model predicts future values based on previous mistakes and shocks. Because it can explain the variance of earlier forecast mistakes, the MA model is effective against short-term volatility (Zeng, 2024). Formula 2 shows the formula for defining the MA portion.

$$y_t = \alpha + \sum_{i=1}^{q} \theta_i * \varepsilon_{t-i} \quad (2)$$

Formula (3) shows the formula for defining the ARMA portion.

$$y_t = \left(\alpha + \sum_{i=1}^{p} \varphi_i * y_{t-i} + \varepsilon_t\right) + \left(\sum_{i=1}^{q} \theta_i * \varepsilon_{t-i}\right) \quad (3)$$

The formula defining ARIMA is shown in (4).

$$y_t = \left(\alpha + \sum_{i=1}^{p} \varphi_i * y_{t-i} + \varepsilon_t\right) * (1-B)^d + \left(\sum_{i=1}^{q} \theta_i * \varepsilon_{t-i}\right) \quad (4)$$

To simplify the notation for analysis, the ARIMA model can be summarized using the Backshift Operator (B) notation as shown in Equation (5):

$$\varphi_P(B) * (1 - B)^{\mathrm{d}} * Y_{\mathrm{t}} = \theta_Q(B) * \varepsilon_{\mathrm{t}} \qquad (5)$$

The ARIMAX (p, d, q) model improves the ARIMA framework by incorporating exogenous factors that potentially influence the dependent time series. This expansion is significant because it accounts for events that are not captured by the data's internal history, such as policy shifts or economic shocks (Song, 2025). The ARIMAX model can be formulated as follows:

$$\varphi_P(B) * (1 - B)^{\mathrm{d}} * Y_{\mathrm{t}} = \theta_Q(B) * \varepsilon_{\mathrm{t}} + \beta X_t \qquad (6)$$

The mathematical expression of the ARIMA and ARIMAX model is as follows:

Y_t : value of the variable at time t
X_t : exogenous (external) variable affecting the time series
Y_{t-i}: past values at time t–i (i = 1, 2, ..., p)
φ_i: estimated coefficients of the AR model for the i^{th} lag period
θ_i: estimated coefficients of the MA model for the i^{th} lag period
β: coefficient of the exogenous variable
$\varphi_p(B)$: p-order autoregressive (AR) polynomial
$\theta_q(B)$: q-order moving average (MA) polynomial
d: order of differencing required to achieve stationarity
$(1 - B)^d$: d-order differencing operator
B : backshift operator (for example, $BY_t = Y_{t-1}$)
ε_t : error term (white noise) at time t.

The following steps were performed to make predictions using ARIMA or ARIMAX in the SAS statistical program:

1. Data Collection and Organization: The raw data subjected to analysis were obtained from the FAO Statistical Database, and the dataset was reorganized by checking for missing or erroneous observations. The data were then organized in a suitable Microsoft Excel format for analysis according to the SAS 9.4 guidelines.

2. Stationarity Test: Trends, seasonality, structural changes, and random fluctuations observed in time series may indicate that the series is not stationary, that is, that it contains a unit root. In such cases, to ensure that the series does not contain a unit root and to ensure stationarity, difference calculations or seasonal adjustment methods are generally applied to the data. The most frequently recommended method in the literature for solving this problem is the difference calculation method (Tüzemen, 2020). The presence of a unit root can be detected using the Augmented Dickey-Fuller (ADF) or Phillips-Perron (PP) tests (Palabıçak, 2019). In this study, the ADF test was used to test the series stationarity. For non-stationary series, first-order differentiation was performed to make the series suitable for statistical modeling.

3. Model Setup: Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) are used to determine the appropriate p and q parameters. In cases where these methods are insufficient, information-requiring criteria such as AIC and BIC are also used (Yonar *et al*., 2021). In this study, the best alternative models were determined using the Smallest Canonical Correlation (SCAN) and Extended Sample Autocorrelation Function (ESACF) methods with the SAS statistical software. Additionally, ACF and PACF plots were carefully examined to validate the residuals of the ARMAX model, ensuring the robustness of the forecasting framework.

4. Model Selection: In this study, the AIC and the BIC were used as the primary statistical criteria in determining the most suitable model. These indices are critical in establishing a balance between the fit of the model to the data and the number of parameters; the model with the lowest AIC and BIC values is considered the most statistically efficient model (Uzundumlu & Ateş, 2025). The prediction performance of the model was validated by comparing the predicted values with the actual data for the period from 2019 to 2024. According to Uzundumlu & Dilli (2023), selecting a model that satisfies these information criteria ensures that the parameters are statistically valid and that the residuals are minimized.

5. Diagnosis and control: In the process of evaluating model quality, residuals are examined using ACF, PACF, and IACF graphs to check whether the residuals exhibit white noise characteristics (Mishra *et al*., 2021; Anon., 2025). The presence of white noise in the residuals supports the validity of the model and ensures its acceptance as the most suitable. In this study, there were instances where the residuals of the selected model showed slight deviations from a normal distribution, but it was preferred because it exhibited white noise, and its results were as expected.

6. Interpretation and Evaluation: The estimated values were evaluated in comparison with the trends from previous years. Increases or decreases in production were interpreted in detail and comprehensively, in line with the findings of the statistical analysis.

The Herfindahl-Hirschman Index (HHI) and concentration ratios (CR_n): The Herfindahl-Hirschman Index (HHI) is a globally accepted metric for assessing market concentration and competition, calculated by summing the squares of individual companies' market shares (Herfindahl, 1950; Lauraeus *et al*., 2021). The HHI is a widely accepted method for measuring market concentration and was developed to assess market structure and quantitatively measure market power (Uzundumlu *et al*., 2022; Çetinkaya, 2025). The contributions of the five countries with the largest wheat production or exportation shares were considered.

$$\mathrm{HHI} = \sum_{i=1}^{n} \mathrm{MS_i}^2 \qquad (5)$$

MS_1 = The proportion of global wheat production or exportation contributed by the leading country.

MS_5 = The proportion of global wheat production or exportation contributed by the fifth-ranking country.

Here, when the HHI is considered in the range of 0-1, values close to 0 indicate intense competition and the presence of numerous firms with similar characteristics. A value of 0.180-0.990 (1800-9990) indicates that some firms are dominant in the market, indicating an oligopoly structure. A value of 1.00 (10,000) indicates a single firm with a 100% market share, resulting in a monopoly (Krugman & Wells, 2021; Uzundumlu *et al.*, 2022).

Market concentration metrics, such as the Concentration Ratio (CR), are used to analyze oligopolies in several sectors. The CR generally assesses the combined market shares of the top 2 to 10 firms in a market, forming the oligopoly group. These enterprises are few but interconnected; therefore, their market share reflects market strength and competitive structure. Low CR values imply a competitive market with many similar-sized enterprises, whereas high CR values indicate an oligopolistic or monopolistic structure with a few dominant firms (Shepherd, 2018; Pavić Kramarić *et al.*, 2022).

This research looked at the five major wheat-producing or exporting nations in terms of overall production. Formula 6 displays the market shares of these main producers, providing information on the level of market concentration and competitive structure in the worldwide wheat industry.

$$\mathrm{CR}_i = \sum_{i=1}^{n} MS_i \qquad (6)$$

CR_i = Concentration ratio of the top i firms
MS_i = Market share of the i^{th} largest firm
n = Number of top firms considered (5 for CR_5)

Concentration ratios, particularly CR_1 and CR_5, are widely used as indicators to assess market structure and the level of competition within an industry. CR_1, where the firm with the largest market share holds less than 20% of the market, generally indicates a competitive market (Sánchez Pajuelo, 2024), values over 40% show that the business has adequate ability to affect pricing and output, and it is often the dominant firm in an oligopolistic market. In contrast, CR_5 provides a wider assessment of market concentration by summing the market shares of 5 leading firms. Values under 40% suggest a highly competitive environment, whereas figures exceeding 60% indicate a concentrated oligopolistic structure dominated by a few influential firms. A single firm controlling the market, on the other hand, reflects a monopolistic scenario (Shepherd, 2018; Pavić Kramarić *et al.*, 2022).

Results and Discussion

Predictive modeling and diagnostic analysis for the world's leading manufacturing nations: This section evaluates ARIMA and ARIMAX models utilizing AIC and BIC criteria to forecast wheat production for the world and leading countries as accurately as possible. We used diagnostic tests to examine the validity of the optimal models, and we compared the average projections for the 2019–2024 period to the actual observed values. As shown in Table 1, these tests confirm that the residuals follow a white noise process.

A detailed examination of Table 1 reveals that while the ARIMA(0,1,1) model is optimal for Global and U.S. data whereas the ARIMAX(0,1,1) specification provides a superior fit for Russia. In the cases of China and India, the ARIMAX(1,1,0) model was selected, whereas ARIMA(1,1,2) proved more effective for France, and other countries. It is noteworthy that in several instances, models with lower AIC and BIC values were bypassed in favor of alternatives that exhibited better coefficient significance and passed all diagnostic rigor. Regarding France, despite the inherent volatility in production followed by 5–6 year stabilization periods, the selected model was prioritized due to its superior capacity to capture these cyclical trends and provide more reliable long-term forecasts.

Between 1961 and 2024, global wheat production surged from 222.36 million tons to 798.48 million tons, establishing a long-term growth trajectory that is expected to persist through the 2025–2030 period. According to the forecasting model, average production is projected at 839.67 million tons, with annual figures demonstrating a steady incremental rise from 816.66 million tons in 2025 to 862.68 million tons by 2030. The projections are closely aligned with recent data from Anon., (2026) and the Anon., (2025), which validates the model's accuracy and consistency with international benchmarks. This steady growth is driven by advancements in farming technology, higher productivity, and optimized management of farmland. Ultimately, these developments will be crucial in strengthening global food security and meeting the rising global demand for food.

The alignment of this study's results with current production levels validates the model's accuracy and presents a positive outlook for future global output. While Erenstein *et al.*, (2022) summarize regional yield fluctuations and trends, our study provides a more granular evaluation by focusing on the five largest wheat-producing nations. Using up-to-date data, we illustrated shifting growth patterns and the strategic adaptation of major producers within the global supply chain. Furthermore, our approach significantly advanced the framework developed by Mostafaeipour *et al.*, (2020). Unlike their research, which emphasized the technical accuracy of single-year forecasts, this study evaluated a six-year horizon based on 64 years of longitudinal data. This long-term perspective facilitated evidence-based strategic planning for global wheat agriculture.

China's wheat production has grown considerably over the years, going from 14.25 million tons in 1961 to 140.1 million tons by 2024. Using a six-year moving average, we think that output will reach 148.26 million tons between 2025 and 2030. The study showed that the Compound Annual Growth Rate (CAGR) was 3.69% from 1961 to 2024. It dropped to 1.07% from 2019 to 2024, but it is expected to rise again to 1.57% from 2025 to 2030. These numbers indicate that output is steadily rising, but China's share of global production is expected to stay very stable, only changing from 17.32% to 17.33%. In the end, the result means that China will keep boosting its domestic supply, but its place in the global market will stay the same.

The U.S. Department of Agriculture (Anon., 2025) estimates that China's wheat production will range between 136.6 and 140.1 million tons during the 2023–2025 period, while Anon., (2026) recorded a production of 140.10 million tons for 2024. Our study forecasts an average wheat production of 148.26 million tons over a six-year period, with annual estimates of 139.59, 138.00, and 142.63 million tons for the years 2023–2025. According to UN projections (Mottaleb *et al*., 2023), China is expected to require 109–113 million tons of wheat by 2030 and 123–144 million tons by 2050. While this comparison is consistent with short-term USDA and FAOSTAT data, it also aligns with long-term UN projections. Our projections indicate that China can fulfill its increasing demand, with production surpassing 150 million tons by 2030. Therefore, our study provides a robust perspective for both short-term forecasts and long-term strategic planning.

India's wheat production expanded significantly, rising from 10.9 million tons in 1961 to 113.29 million tons in 2024. The study indicates a compound annual growth rate (CAGR) of 3.77% for the 1961–2024 period and 2.12% for 2018–2024 and is projected at 1.48% for 2024-2028. As the world's second-largest producer, India accounted for 12–13% of global production after 2020, with this share forecasted to reach approximately 14% by 2025–2030. This 1-1.5% increase in market share reflects a strengthening position both in absolute output and global standing.

Sunil & Sindhu (2020) used historical data on wheat production from 1949 to 2016 in an ARIMA(0,1,1) model to predict that India's output from 2017 to 2022 would be between 100 and 106 million tons. Nath *et al*., (2019) used an ARIMA(1,1,0) model to predict production for the years 2023 to 2026. The results were estimates of 106.71, 108.07, 109.43, and 110.79 million tons. Using an ARIMAX(1,1,0) model, our study said that the output would be between 110 and 116 million tons. But the real amount made in 2023 and 2024 was only 110 to 113 million tons. The fact that what we thought would happen and what actually happened match up showed that the model was correct and fitted with what has already been said about it.

ARIMA model selection for world wheat production forecasting

Table 1. Statistical comparison of ARIMA and ARIMAX models based on information criteria (AIC, BIC) and forecast error (MFE).

Countries	Model	AIC	BIC	2019-2024 MFE	p	WNP	RN	ACR
World	**ARIMA(0,1,1)**	2248.21	2250.33	0.22	+	+	+	+
	ARIMA(1,1,1)	2248.16	2250.27	0.25	-+	+	+	+
	ARIMA(2,1,1)	2248.16	2250.28	0.21	-+	+	+	+
	ARIMA(5,1,1)	2248.21	2250.32	0.21	-+	+	+	+
China	**ARIMAX(1,1,0)**	2126.48	2137.20	0.25	+	+	+	+
	ARIMAX(2,1,0)	2126.97	2139.83	0.14	-+	+	+	+
	ARIMAX(0,1,0)	2127.52	2143.10	0.53	+	+	+	+
India	**ARIMAX(1,1,0)**	2073.07	2079.49	-0.50	+	+	+	+
	ARIMAX(0,1,0)	2073.76	2080.19	-0.67	+	+	+	+
	ARIMAX(1,1,1)	2075.03	2083.60	-0.52	-+	+	+	+
USA	**ARIMA(0,1,1)**	2094.63	2096.74	1.78	+	+	+	+
	ARIMA(1,1,0)	2097.70	2099.82	-0,16	-+	+	+	+
	ARIMA(1,1,1)	2094.03	2096.15	3.00	-+	+	+	+
	ARIMA(2,1,1)	2094.20	2096.31	2.36	+	-	+	-
Russia	**ARIMAX(0,1,1)**	1126.30	1132.16	1.31	+	+	+	+
	ARIMAX(0,1,2)	1126.53	1133.86	2.90	-	+	+	+
	ARIMAX(2,1,0)	1128.05	1135.03	1.08	+	+	+	+
	ARIMAX(1,1,0)	1129.16	1135.05	-1.80	+	+	+	+
France	**ARIMA(1,1,2)**	1997.99	2000.04	8.72	+	+	+	+
	ARIMA(1,1,1)	2002.59	2004.70	7.66	+	+	+	+
	ARIMA(1,1,0)	2004.95	2007.06	6.67	+	+	+	+
	ARIMA(3,1,0)	2006.56	2008.68	7.06	+	+	-	-
	ARIMA(1,1,0)	2058.94	2071.80	-1.80	+	+	+	+
	ARIMA(1,1,1)	2059.87	2074.87	0.14	+	+	+	+
Others	**ARIMA(1,1,2)**	2162.88	2165.00	2.16	+	+	+	+
	ARIMA(2,1,1)	2162.88	2164.99	2.11	-+	+	+	+
	ARIMA(1,1,1)	2163.03	2165.14	1.60	-+	+	+	+
	ARIMA(1,1,0)	2182.93	2185.04	-0.11	+	+	-	-

Notes on statistical metrics:

p: Statistical significance level for AR, MA, and Dummy variable coefficients

WNP: White Noise Process; verified via Ljung-Box test for residual independence

RN: Residual Normality; confirmed through the Jarque-Bera test for error distribution

ACR: Autocorrelation check; assessed using Durbin-Watson statistics or ACF plots

Worldwide wheat production and outlooks

Figure 1 shows the global wheat production forecast for the years 1961-2030.

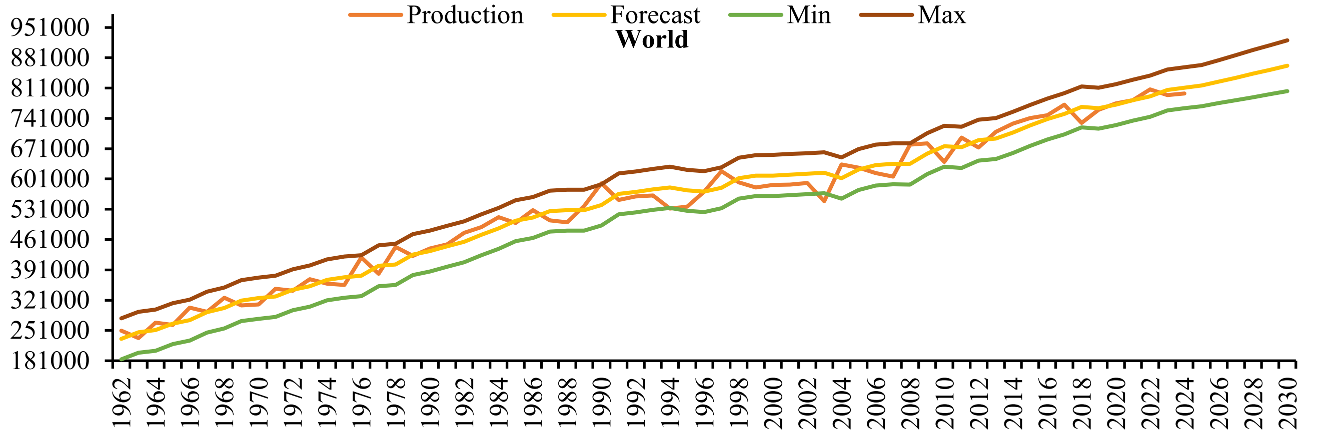

Fig. 1. Projected global wheat production (in thousand tons) between 1961 and 2030.

Wheat production patterns and future projections in China

Figure 2 depicts China's wheat output prediction for the years 1961-2030.

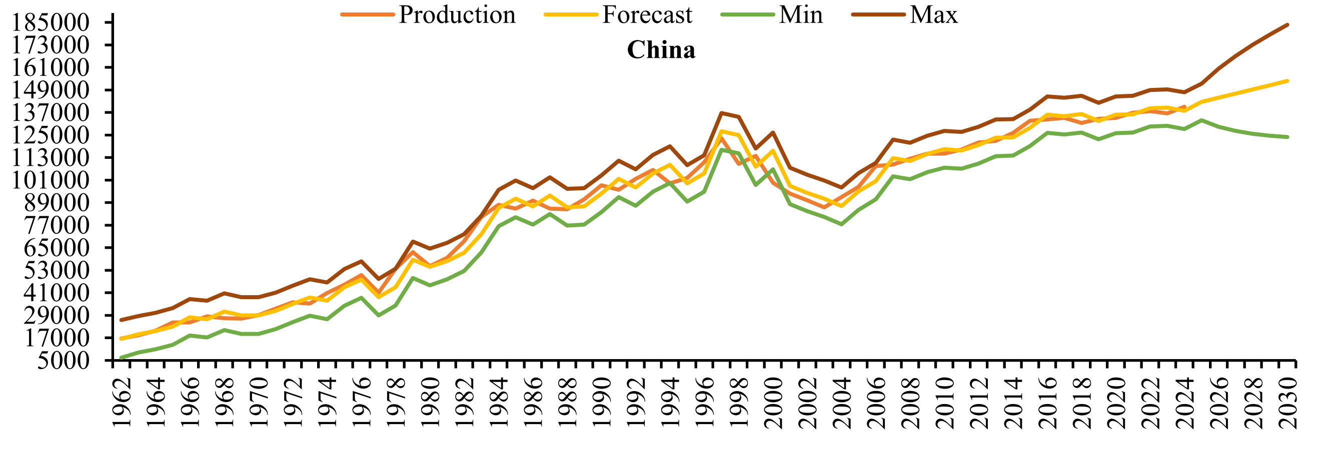

Fig. 2. Projected Chinese wheat production (in thousand tons) from 1961 to 2030.

Wheat production trends and forecasts in India

Figure 3 shows the average, minimum, and maximum wheat production estimates for India from 1961-2024 to 2025-2030.

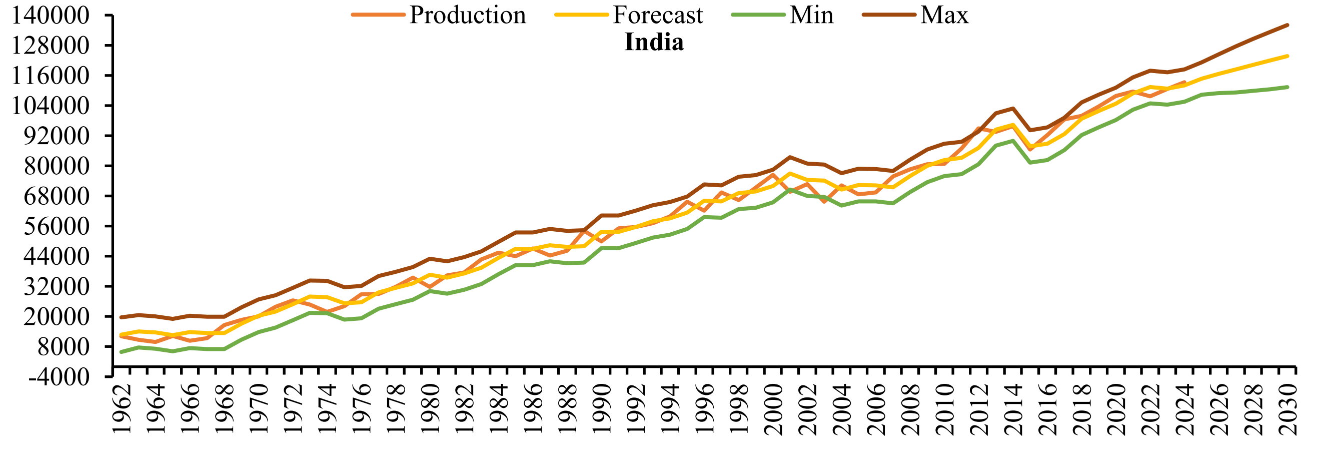

Fig. 3. Trends and projections of wheat production in India from 1961 to 2030 (thousand tons).

Trends and projections of wheat production in the USA

Figure 4 presents the projected minimum and maximum wheat production forecasts for the United States from 1962 to 2030, derived from wheat production statistics spanning 1961 to 2024.

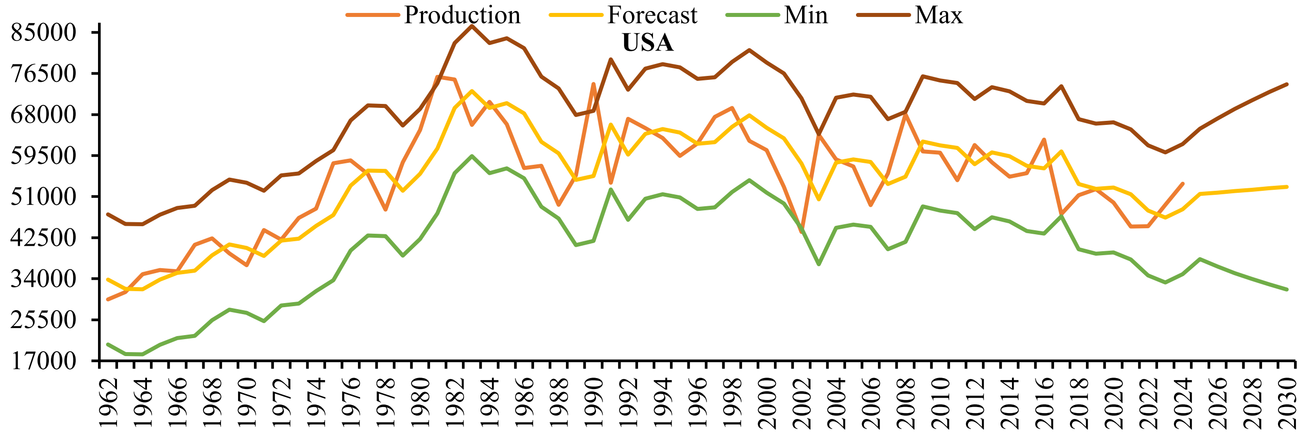

Fig. 4. Wheat production forecast for the USA in 1961-2030 (thousand tons).

Trends and future pathways for wheat production in Russia

Figure 5 shows the average, minimum, and maximum wheat production estimates for Russia from 1992-2024 to 2025-2030.

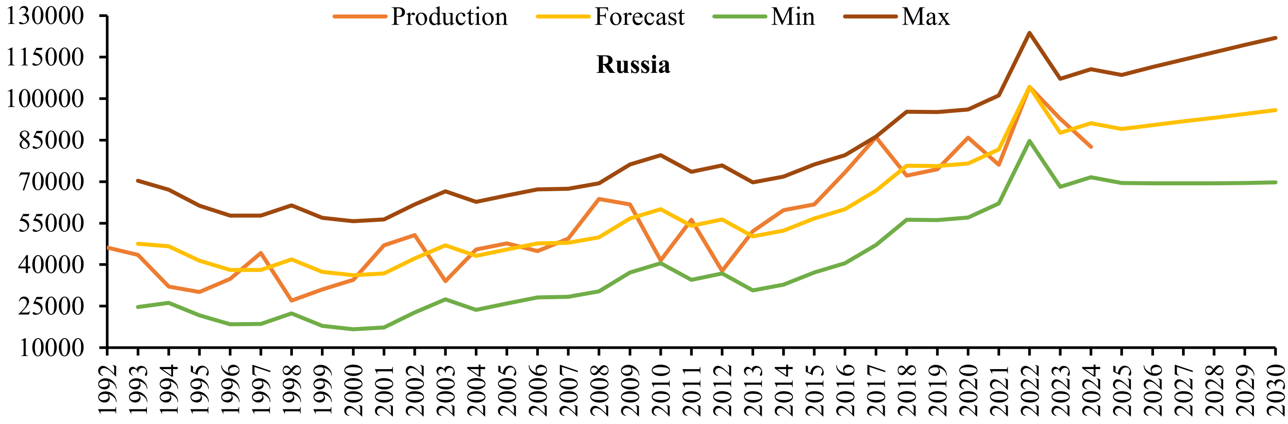

Fig. 5. Projected wheat production for Russia between 1992 and 2030 (thousand tons).

Trends and future pathways for wheat production in France

Figure 6 shows the projected wheat production for France from 1961 to 2030.

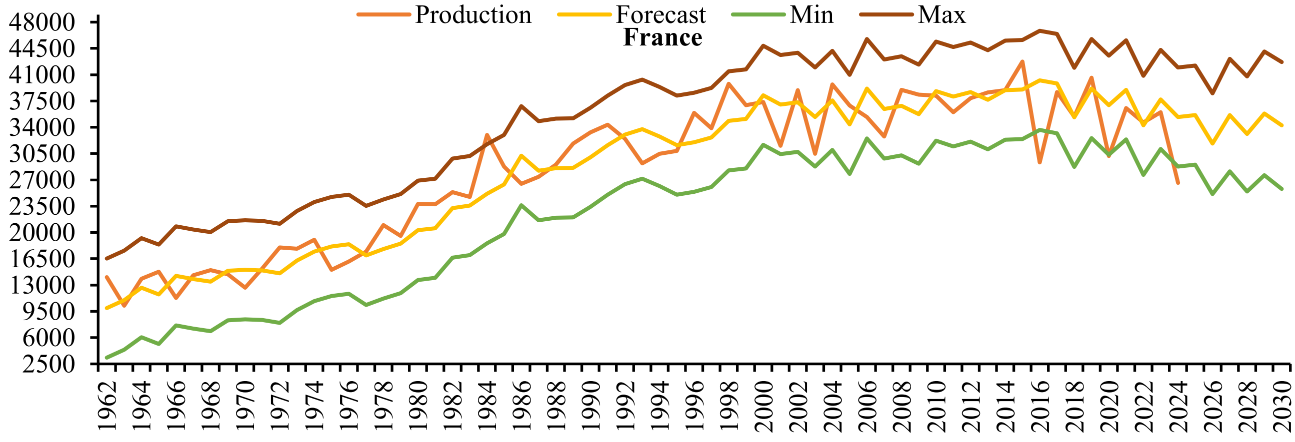

Fig. 6. Projected wheat production for France between 1961 and 2030 (thousand tons).

Aggregate wheat production of the leader producers: Historical trends and future.

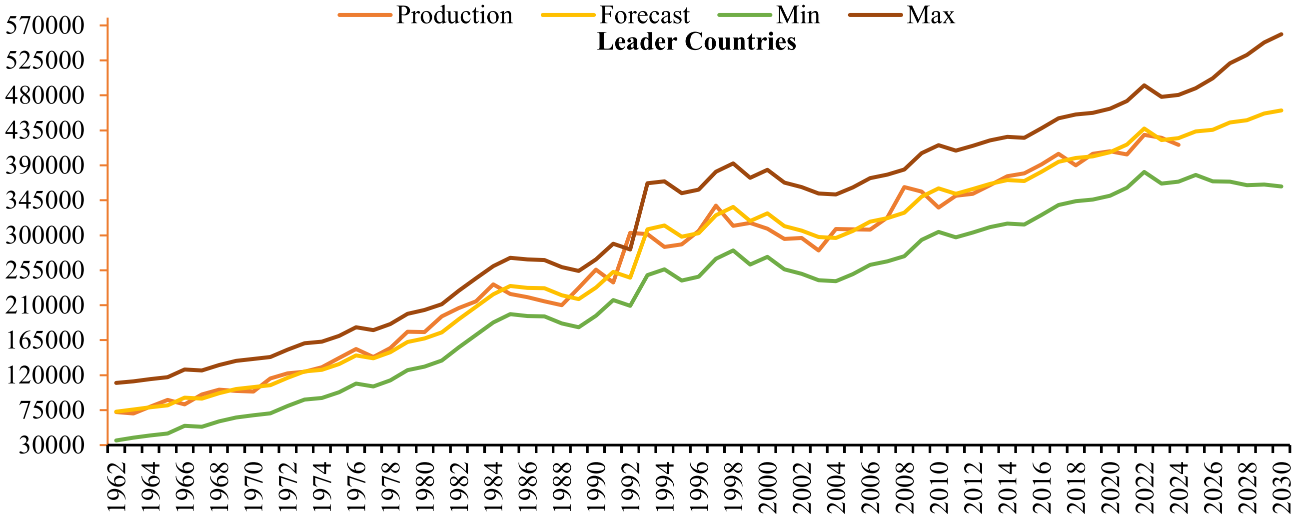

Fig. 7. Projected wheat production for leader producers countries between 1961 and 2030 (thousand tons).

Figure 7 was obtained based on the total data of the countries without applying any analysis. The combined share of leader wheat-producing countries is expected to grow from 52.69% to 53.19% between 2019 and 2024 and again between 2025 and 2030.

In 1961, the USA produced 33.54 million tons of wheat, increasing to 53.65 million tons by 2024. Although dummy variables were incorporated into the model to account for structural breaks, they remained statistically insignificant; thus, the ARIMA(0,1,1) model was identified as the optimal fit, projecting an average production of 52.29 million tons for the 2025–2030 period. The CAGR is calculated at 0.75% for 1961–2024, 0.75% for 2018–2024, and is forecasted at 0.19% for 2024–2030. While the U.S. accounted for 12% of global production in the 2000s, its share declined to 7–8% after 2010 and is expected to be approximately 6% between 2025 and 2030. When compared with official data and estimates, our predictions become even more consistent. While the Anon., (2025) projects US wheat production of 49.1, 53.7, and 54.0 million tons from 2023 to 2025, our analysis forecasts significantly lower levels of 46.67, 48.40, and 51.56 million tons. Furthermore, Anon., (2026) indicates that US wheat production in 2023 and 2024 was 49.31 and 53.65 million tons, respectively. These actual figures are close to both the USDA estimate and our estimate, demonstrating that our findings are feasible and credible, even after accounting for potential downside risks to future production increases. Findings by Coughlan de Perez *et al.*, (2023) indicate that extreme heat events are becoming significantly more frequent in both the US Midwest and China, increasing the likelihood of years in which critical temperature thresholds for wheat enzymes are exceeded, often coinciding with severe drought. These increased climatic stresses help explain our predictions that, despite an absolute increase in US wheat production, its share of global production is declining, reflecting limitations in yield growth compared to other regions.

Russia's wheat production was 46.16 million tons in 1992 and 82.59 million tons in 2024. For the past ten years, the area of Russia that grows wheat has stayed the same at 26–29 million hectares. However, the average yield has slowly gone up thanks to the use of technology and fertilizers, reaching 3,550 kg per hectare during this period, which contributed to a production exceeding 100 million tons that year. The start of the war in 2022 prompted efforts to minimize production losses in wheat, a crucial crop for human nutrition. According to Anon., (2026) statistics, the yield was increased to 3,550 kg during this period, leading to a production exceeding 100 million tons that year. In 2024, however, a decrease of approximately 1.8 million hectares, extreme frost events in May, and adverse climatic conditions, including frost, drought, excessive heat, fires, and irregular rainfall in the European part of the country, further exacerbated the production decline (Anon., 2025). According to the Anon., (2025), Russia will grow 91.5 million tons of wheat in 2023, 81.6 million tons in 2024, and 87.5 million tons in 2025. This study, on the other hand, says that Russia will grow 87.67, 91.05, and 89.04 million tons of wheat in those years. Anon., (2026) said that Russia would grow 92.78 million tons of wheat in 2023 and 82.59 million tons of wheat in 2024. These differences show that our study has a more optimistic view of wheat production. We believe that Russia will be able to grow its agricultural production to 96 million tons by 2030 as long as climate change doesn't become too severe. This conclusion is because Russia is powerful and flexible and has made a lot of progress in technology.

France's wheat production was 9.57 million tons in 1961 and 26.61 million tons in 2024, a decrease of approximately 26% compared to 2023, having reached this level in 1986. The average wheat production estimate for France between 2025 and 2030 is 34.38 million tons, while estimates using dummy variables put the average production at 28.76 million tons during this period. However, after major disruptions in 1993-2003 and 2016, production in France increased instead of decreasing. Therefore, the predictions in this study are based on ARIMA data. Anon., (2025) states that wheat production in France will significantly decrease in 2024 due to adverse weather conditions, resulting in one of the lowest wheat harvests since the 1980s for France, the largest grain producer in the European Union. This situation could affect France's share of the global wheat supply and regional food security. In contrast, Anon., (2025) projects total French wheat production for 2023-2025 at 36.00, 26.60, and 34.20 million tons, respectively. Our forecast is for these figures to be 37.71, 35.38, and 35.63 million tons, respectively, for the same period, with small decreases in 2026 and 2028. This projection indicates a recovery in 2025, suggesting that our estimates will be more consistent in subsequent years. The country, which had a 4.33% share of world production between 2019 and 2024, will lose ground, and its share will be 4.09% between 2025 and 2030.

Others countries: Based on data covering the period 2019-2024, the production dynamics of the six countries following the top five leading countries in global wheat production (Canada (4.13%), Australia (3.94%), Pakistan (3.46%), Ukraine (3.18%), Germany (2.74%), and Türkiye (2.54%), which together hold a strategic share of 20.21%, show significant differences. In the analysis based on Anon., (2026) data, Pakistan is positioned as the most stable actor in the group with the highest growth potential, both increasing its total production from 24.3 million tons to 31.8 million tons and raising its unit yield from 2805 kg/ha to 3268 kg/ha. In contrast, Germany, which has reached its technological limits and has the highest unit yield in the group, at approximately 7400 kg/ha, faces structural saturation and a risk of production contraction as its total production decreases from 23 million tons to 18.5 million tons. Australia (14-41 million tons) and Canada (22-35 million tons) show high volatility in production outputs, confirming the extreme dependence of these countries' supply security on climatic fluctuations. While Türkiye follows a static course with approximately 20 million tons of production and a yield in the 3000 kg/ha range, Ukraine is struggling to stabilize its production capacity, which has decreased from 32 million tons to 22 million tons due to the impact of geopolitical instability, leading to concerns about food security in the region and potential impacts on global markets.

Competitive situation in wheat production or export of countries in terms of HHI and CR from 1961-2024: The competitive situation in production or export in terms of HHI and CR is given in Tables 2 and 3.

The leading wheat producing countries from 1961 to 2024 are given in Table 2.

HHI values, which were quite high during the 1961-1970 period, decreased over the years, falling to 0.07 in the 2021-2024 period. This decrease indicates that the market has grown to include more countries and competition has increased. CR_1-CR_5 values show a similar trend, indicating a decrease in the market share of the largest producers and a broader range of competition. While countries like Soviet Union, USA, and China were prominent producers in the 1960s, countries like India, Russia, and France have been added to this list in subsequent years; the rise of India, in particular, is noteworthy. Furthermore, the number of wheat-producing countries has also increased significantly, rising from 95-97 between 1961 and 1970 to 123-125 in the 2021-2024 period. These data reveal that competition in global wheat production has increased over time, and the market is becoming more evenly distributed among more countries. Global production will become increasingly concentrated between 2025 and 2030, with Asian countries dominating and China and India emerging as significant producers. As traditional Western producers like the United States and France lose market share, the global production system will shift from a monopolistic to an oligopolistic system.

Table 3 presents the leading wheat exporting countries from 1961 to 2024.

Table 2. Competitive situation of world wheat production over the years.

Years	HHI	HHI^{-1}	CR_1	CR_2	CR_3	CR_4	CR_5	Major producing countries	Number of countries
1961-1970	0.10	10.27	26.08	39.02	47.40	53.16	57.94	USSR, USA, China, Canada, India	95-97
1971-1980	0.09	10.95	22.83	36.33	48.00	55.16	59.87	USSR, USA, China, India, France	96-99
1981-1990	0.08	12.75	16.37	32.08	44.79	53.58	59.15	China, USSR, USA, India, France	99-102
1991-2000	0.08	12.75	18.64	29.86	40.93	46.92	52.59	China, India, USA, France, Russia	102-123
2001-2010	0.06	17.01	16.41	28.22	37.39	45.21	51.02	China, India, USA, Russia, France	122-124
2011-2020	0.06	15.57	17.55	30.65	39.65	47.15	52.18	China, India, Russia, USA, France	122-123
2021-2024	0.07	14.91	17.32	31.18	42.34	48.39	52.59	China, India, Russia, USA, France	123-125
2025-2030*	0.07	15.04	17.33	31.27	42.07	48.18	52.20	China, India, Russia, USA, France	123-130

Source: (Anon., 2026)

Note: Data is estimate-based. World totals were calculated using the sum of the top five countries and estimated values for other countries; the relevant ratios were derived from this total

Table 3. Status of leading countries in world wheat exports.

Years	HHI	HHI^{-1}	CR_1	CR_2	CR_3	CR_4	CR_5	Major producing countries	Number of countries
1961-1970	0.21	4.65	37.04	59.54	71.67	80.39	87.27	USA, Canada, Australia, USSR, France	49-51
1971-1980	0.24	4.20	41.81	60.80	73.15	82.93	87.57	USA, Canada, Australia, France, USSR	47-51
1981-1990	0.20	5.09	35.24	53.58	67.88	80.06	85.77	USA, Canada, France, Australia, Argentina	49-50
1991-2000	0.15	6.58	28.07	45.76	60.64	72.98	79.63	USA, Canada, France, Australia, Argentina	54-103
2001-2010	0.10	10.39	21.48	34.34	47.07	57.64	65.51	USA, France, Canada, Australia, Russia	99-101
2011-2020	0.08	12.86	14.90	29.48	41.53	52.12	61.38	USA, Russia, Canada, France, Australia	101-116
2021-2024	0.07	14.35	14.58	27.55	39.00	49.63	58.10	Russia, Australia, Canada, USA, Ukranie	106-117

Source: (Anon., 2026)

During the period starting with wheat exports from 49–51 countries in 1961–1970, the United States was the largest exporter. Studies conducted after 2011 show that while the United States maintained its leadership, Russia, the largest country of the former Soviet Union, became the second-largest exporter. Examining the period 2021–2024, it can be seen that Russia and Australia rose to first place, the United States dropped to fourth place, and Canada maintained its third-place position. Recently, the main wheat exporters are ranked as follows: Russia (14.58%), Australia (12.97%), Canada (11.45%), the United States (10.63%), and Ukranie (8.47%). The HHI index was higher than 0.18 from 1961 to 1990, indicating that the market was an oligopoly. After 1991, the market showed signs of monopolistic competition with a more rapid decline in competitiveness. According to the concentration index, the share of the top five countries exceeds 50%, indicating an oligopolistic market. Analysis of wheat export volume and value data allows for indirect conclusions about the quality of wheat exported by specific countries. According to the Anon., (2026) data for the 2021–2024 period, when wheat export volume and revenue shares are considered together, relative price and value-added differences emerge among countries. Russia's share of export volume is 14.58%, while its revenue share rises to 14.96%, indicating an advantage in unit export value. Similarly, in Canada, this ratio increased from 11.45% to 12.97%, in the United States from 10.63% to 11.78%, and in France from 8.13% to 8.24%, pointing to a relative revenue advantage. Australia's share, on the other hand, had a more even structure, with only a small increase from 12.97% to 13.49%. Conversely, the decline in revenue share from 8.47% to 5.94% in Ukraine indicates that exports occur at lower unit prices. In this context, it is assessed that Russia, Canada, and the USA are in a relatively advantageous position in terms of export value, while Ukraine has an export structure based on price competition.

Conclusion

In the global wheat market, the correlation between the export volumes and revenues of strategically important countries serves as the primary determinant of product quality and market demand. Data indicate that since 1961, the number of producing countries has grown from 90 to over 120, while the number of exporters has increased from 50 to 110, suggesting that the market expansion phase is nearing completion and transitioning toward a more concentrated structure, as evidenced by 2030 projections. China, India, Russia, the US, and France are still the main producers in this process, and their combined production share is expected to rise to 53.19%, maintaining their lead. Russia, Canada, Australia, and Ukraine are already important players in global trade, but they have a strategic advantage because they have a lot of agricultural land and good logistics facilities. Therefore, these places will be the most important as global production hubs. However, there are rising heatwaves and long-term drought risks in countries such as the US and France, which are already world leaders. These problems make it difficult to maintain stable production. Countries such as Russia and France, on the other hand, maximize their revenues because their exports are worth more than the amount they send abroad. They do this by using quality factors such as protein content, gluten levels, and hardness to obtain higher prices. Another strategy used by Australia and India is based on volume. However, second-generation producers, such as Pakistan and Türkiye, must move beyond merely increasing output. To see growth in high-value exports, they must ensure that quality standards are always met. In conclusion, in the face of climate risks that deeply affect even traditional powers such as France and the US, the ability of emerging actors such as Russia, Canada, and Ukraine to maintain their production potential and for developing producers such as Pakistan and Türkiye to ascend in the global hierarchy will depend on R&D efforts in heat- and drought-resilient wheat varieties alongside technological adaptations that ensure quality sustainability.

Acknowledgments

The authors gratefully acknowledge that this study on wheat production forecasts for leading countries and worldwide for 2023–2027 was based on and benefited from a Master's thesis completed at Atatürk University, Institute of Science, Department of Agricultural Economics, Erzurum, Türkiye.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author's Contributions: A.S. Uzundumlu: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review and editing, Visualization, Supervision. E.Ş. Esgin: Validation, Resources, Writing – review and editing.

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