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STATISTICAL AND PREDICTIVE ANALYSIS OF BROILER CHICKEN PRODUCTION IN THE WORLD'S MAJOR PRODUCING COUNTRIES: A TIME-SERIES APPROACH

ANÁLISE ESTATÍSTICA E PREDITIVA DA PRODUÇÃO DE FRANGOS DE CORTE NOS PRINCIPAIS PAÍSES PRODUTORES MUNDIAIS: UMA ABORDAGEM DE SÉRIES TEMPORAIS

ANÁLISIS ESTADÍSTICO Y PREDICTIVO DE LA PRODUCCIÓN DE POLLOS DE ENGORDE EN LOS PRINCIPALES PAÍSES PRODUCTORES DEL MUNDO: UN ENFOQUE DE SERIES TEMPORALES

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ABSTRACT

Chicken meat is the most consumed source of animal protein worldwide. United States, Brazil, and China account for more than 40% of global production. This study examines whether their production trajectories exhibit long-term growth, temporal association, and statistical predictability. The objective was to conduct a statistical and predictive analysis of chicken meat production from 1961 to 2022. The methodology integrated descriptive statistics, inferential analysis, and univariate time-series modeling based on ARIMA, supported by moving averages and seasonal decomposition for trend assessment. The results revealed strong temporal association between Brazil and China ($r \approx 0.983$) and between Brazil and the United States ($r \approx 0.991$). Inferential analysis showed no statistically significant difference between the mean production levels of Brazil and China ($p = 0.618$), while a highly significant difference was observed between Brazil and the United States ($p < 0.001$). Descriptive indicators demonstrated higher relative variability for Brazil (CV ≈ 97.0%) and China (CV ≈ 92.4%) compared with the United States (CV ≈ 57.4%). ARIMA-based forecasts indicate continued production growth in all three countries in the short to medium term. The findings confirm long-term growth, strong temporal association, and statistical predictability, highlighting structural differences in scale and variability.

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Keywords: Poultry Production. Time Series. Inferential Statistics. ARIMA Modeling. Agroeconomic Analysis.

RESUMO

A carne de frango é a fonte de proteína animal mais consumida no mundo. Os Estados Unidos, o Brasil e a China respondem por mais de 40% da produção global. Este estudo examina se as trajetórias de produção desses países apresentam crescimento a longo prazo, associação temporal e previsibilidade estatística. O objetivo foi realizar uma análise estatística e preditiva da produção de carne de frango de 1961 a 2022. A metodologia integrou estatística descritiva, análise inferencial e modelagem de séries temporais univariadas baseada em ARIMA, com suporte de médias móveis e decomposição sazonal para avaliação de tendências. Os resultados revelaram forte associação temporal entre o Brasil e a China (r ≈ 0,983) e entre o Brasil e os Estados Unidos (r ≈ 0,991). A análise inferencial não mostrou diferença estatisticamente significativa entre os níveis médios de produção do Brasil e da China (p = 0,618), enquanto uma diferença altamente significativa foi observada entre o Brasil e os Estados Unidos (p < 0,001). Os indicadores descritivos demonstraram maior variabilidade relativa para o Brasil (CV ≈ 97,0%) e a China (CV ≈ 92,4%) em comparação com os Estados Unidos (CV ≈ 57,4%). As projeções baseadas no modelo ARIMA indicam crescimento contínuo da produção nos três países no curto e médio prazo. Os resultados confirmam o crescimento de longo prazo, a forte associação temporal e a previsibilidade estatística, destacando diferenças estruturais em escala e variabilidade.

Palavras-chave: Produção Avícola. Séries Temporais. Estatística Inferencial. Modelagem ARIMA. Análise Agroeconômica.

RESUMEN

La carne de pollo es la fuente de proteína animal más consumida en todo el mundo. Estados Unidos, Brasil y China representan más del 40% de la producción mundial. Este estudio examina si sus trayectorias de producción exhiben crecimiento a largo plazo, asociación temporal y previsibilidad estadística. El objetivo fue realizar un análisis estadístico y predictivo de la producción de carne de pollo de 1961 a 2022. La metodología integró estadística descriptiva, análisis inferencial y modelado univariado de series de tiempo basado en ARIMA, respaldado por promedios móviles y descomposición estacional para la evaluación de tendencias. Los resultados revelaron una fuerte asociación temporal entre Brasil y China (r ≈ 0,983) y entre Brasil y Estados Unidos (r ≈ 0,991). El análisis inferencial no mostró diferencias estadísticamente significativas entre los niveles de producción promedio de Brasil y China (p = 0,618), mientras que se observó una diferencia altamente significativa entre Brasil y Estados Unidos (p < 0,001). Los indicadores descriptivos mostraron una mayor variabilidad relativa en Brasil (CV ≈ 97,0%) y China (CV ≈ 92,4%) en comparación con Estados Unidos (CV ≈ 57,4%). Los pronósticos basados en ARIMA indican un crecimiento continuo de la producción en los tres países a corto y mediano plazo. Los resultados confirman el crecimiento a largo plazo, una fuerte asociación temporal y la predictibilidad estadística, destacando las diferencias estructurales en escala y variabilidad.

Palabras clave: Producción Avícola. Series Temporales. Estadística Inferencial. Modelado ARIMA. Análisis Agroeconómico.

1 INTRODUCTION

Animal-based foods constitute important sources of nutrients, containing significant concentrations of amino acids, vitamins, and minerals essential for health maintenance (Smet and Vossen, 2016). In this context, broiler poultry production stands out as one of the most profitable livestock activities (Kopler, 2023; Chen et al., 2020), driven by productive characteristics such as a short life cycle (≈45 days) and relatively low cost when compared to other animal protein supply chains (Ogino et al., 2021). As a result, global poultry meat production has expanded substantially over recent decades (Sendetska et al., 2017), with estimates indicating that worldwide chicken meat production may reach approximately 139.19 million tonnes by 2025 (Uzundumlu, 2022).

Estimates for the period from 2019 to 2025 indicate that chicken meat production is expected to reach 139.19 million tonnes in 2025, representing growth of approximately 180% relative to the historical average for 1961–2018 (Uzundumlu and Dilli, 2023). This expansion is associated with the need to meet food demand from a growing population, with projections from the United Nations (UN) indicating approximately 8.3 billion people by 2026 (UN, 2024). Within this context, the United States, Brazil, and China remain the largest producers, jointly accounting for 40.9% of global production (Uzundumlu and Dilli, 2023). In absolute terms, estimated average production levels are 20.7 million tonnes for the United States, 16.7 million tonnes for Brazil, and 15.1 million tonnes for China. In addition, Brazil stands out as the world's largest exporter, accounting for approximately 30% of global exports, followed by the United States (~20%) and the European Union (Uzundumlu and Dilli, 2023).

Table 1

Broiler chicken production by country

Countries	Models	1961-2018 (A)	2019-2025 (B)	Change 100 * (BA)/A
USA	2,1,3	9,749.14	20,787.25	113.22
China	5,1,0	5,237.58	15,155.35	189.36
Brazil	1,1,4	4,403.84	16,701.71	279.25
Russia	3,1,0	2,012.99	5,190.26	157.84
India	4,1,2	865.50	4,235.46	389.37
Mexico	0,1,4	1,220.91	3,660.43	199.81
Indonesia	3,1,0	732.51	3,788.73	417.22
Japan	2,1,1	1,132.81	2,398.04	111.69

Iran	3,1,0	694.49	2,363.03	240.25
Peru	1,1,1	604.27	2,496.93	313.21
Others	1,1,1	19,280.28	49,747.07	158.02
World Total	1,1,1	45,903.58	128,509.48	179.96

Source: Uzundumlu & Dilli (2023).

From a nutritional and socioeconomic perspective, chicken meat has become one of the most widely consumed animal proteins worldwide, being recommended for different age groups and recognized as a relevant source of nutrients (Kralik et al., 2018). Another central aspect, especially for low-income countries, is its relatively lower cost compared to other meats, such as beef and pork, which increases its importance for food security. As a result, chicken production is sensitive to population demand and economic conditions, particularly in developing regions. Projections indicate that global demand for chicken meat and other poultry products may double by 2050, associated with population growth, urbanization, and changes in consumption patterns (Franzo et al., 2023; Kleyn et al., 2021; Mottet et al., 2017). In addition, poultry production contributes economically through job and income generation, especially in communities with limited resources (Prabowo et al., 2023; Ngongolo et al., 2021; Kraetzer; Balthazar, 2021).

Despite the consensus regarding global expansion, the literature still lacks integrated comparative analyses that describe, with statistical rigor and a long-term temporal perspective, how the production trajectories of the three main producers (United States, Brazil, and China) evolve simultaneously in terms of growth, stability, and temporal association, as well as their forecasting capability based on historical series. Considering that these countries concentrate a large share of global production and play distinct roles in the market (production and exports), understanding their historical dynamics is relevant to support economic interpretations and strategic decision-making in the sector. In this sense, data science and time-series approaches have been employed to investigate production patterns and support forecasting in different agri-food contexts (Balthazar; Silveira; Silva, 2024; Zheng et al., 2024; Castro Junior, et al., 2022; Tang et al., 2022; Pitesky et al., 2020).

Accordingly, this study is based on the hypothesis that the three largest broiler chicken producers worldwide exhibit related production trajectories over time, allowing the identification of growth patterns and the prediction of future production. The null hypothesis (H_0) states that the annual broiler chicken production series of the United States, Brazil, and China exhibit a long-term growth trend, present positive temporal association among them, and are adequately predicted by univariate time-series models (ARIMA) (Schaffer, 2021).

The alternative hypothesis (H_1), in turn, states that at least one of the countries does not exhibit consistent growth and/or does not present relevant temporal association and/or is not adequately predicted by ARIMA, indicating distinct structural dynamics (Bressan, 2004). Population and export factors are discussed as explanatory mechanisms based on the literature and historical context, but are not modeled as direct causal determinants in this version of the study.

Thus, the objective of this study was to statistically and predictively analyze broiler chicken production between 1961 and 2022 in the three main producing countries worldwide (United States, Brazil, and China), focusing on the characterization of historical evolution, comparison of stability, and identification of temporal associations among the series. Specifically, the aims were to: (i) describe the annual production of each country using descriptive statistics (measures of central tendency, dispersion, and variation); (ii) perform inferential analyses comparing mean production levels between countries; and (iii) apply time-series methods and ARIMA models to evaluate trends and project production over a future horizon.

2 MATERIAL AND METHODS

2.1 DATASET

The database used in this study was obtained from a survey conducted by the United Nations Food and Agriculture Organization (FAO) and processed by Our World in Data. The selected dataset covers broiler chicken production in the major producing countries, including time-series data detailing production volumes over the years. The dataset is publicly available on the Our World in Data website under a Creative Commons Attribution license (CC BY), as published by Our World in Data.

2.2 DATA PREPROCESSING

Data preprocessing followed the recommendations of the study conducted by Zhu et al. (2024) as a multi-stage procedure, with primary emphasis on data cleaning. The first stage consisted of error detection, including the removal of duplicates, missing values, and inconsistencies. The second stage involved diagnosis, in which the nature of the identified errors was assessed, distinguishing between legitimate data and anomalies. Finally, the correction stage involved the application of techniques such as imputation to fill missing values and specific methods for outlier treatment.

2.3 DESCRIPTIVE STATISTICS

Descriptive statistics were employed to characterize the distribution and variability of annual chicken meat production in the three main producing countries (United States, Brazil, and China) over the analyzed period. For each country, the annual series were summarized using measures of central tendency and dispersion, allowing direct comparison between production levels and relative stability. Measures of central tendency, including the mean and median, were calculated, as well as dispersion measures, including standard deviation, minimum and maximum values, and range (maximum–minimum). To compare variability among countries with different production scales, the coefficient of variation (CV) was used. Graphical analysis was conducted using boxplots for each country in order to represent the distribution of annual values, highlighting the central position (median), dispersion (quartiles), and potential extreme values. Additionally, time-series plots (production versus year) were constructed to visualize historical evolution and allow inspection of long-term behavior and visual comparison among production trajectories.

2.4 INFERENTIAL ANALYSIS

Inferential analysis was employed to evaluate the existence of statistically significant differences between the annual mean chicken meat production of the main producing countries analyzed. Comparisons were performed in a pairwise manner, considering the Brazil–China and Brazil–United States pairs, since Brazil occupies an intermediate position in the global production scenario. For this purpose, the Student's t-test for independent samples was applied, as described by Larson (2006), adopting a significance level of 5% ($\alpha = 0.05$). Prior to applying the test, the annual production series were standardized to reduce scale effects among countries and allow direct comparison between means. Standardization was performed consistently across the series, preserving their temporal structures.

In addition, the test assumptions were evaluated in an exploratory manner. Homogeneity of variances was examined through inspection of dispersion measures and graphical representations (boxplots), aiming to verify the compatibility of the series with the application of the classical t-test. Considering the large sample size of the annual series (1961–2023), the normality assumption was addressed in light of the Central Limit Theorem, allowing application of the test even in the presence of moderate asymmetries. Finally, although the observations correspond to time-series data, the inferential analysis was conducted on aggregated annual values, assuming approximate independence between observations for the purpose of comparing historical means. This approach had a comparative and complementary character to the descriptive and temporal analyses and was used exclusively to assess structural differences in mean production levels over the analyzed period.

2.5 PREDICTIVE ANALYSIS

Predictive analysis was conducted to identify temporal behavior patterns and to project the future evolution of chicken meat production between 1961 and 2023. Initially, moving average smoothing methods were applied to observe the central trend of the series and reduce short-term noise. Subsequently, seasonality was assessed through additive decomposition of the series, allowing the isolation of trend, cyclical, and irregular components. Monthly and annual growth rates were also calculated to quantify the intensity and stability of production growth in each country. Analysis of historical trends enabled the identification of periods of expansion and contraction, which were interpreted in light of external factors documented in the literature, such as input cost shocks, exchange rate fluctuations, sanitary events (e.g., avian influenza), and climatic crises. Finally, the ARIMA (AutoRegressive Integrated Moving Average) model was employed for short- and medium-term forecasting, with parameters (p, d, q) selected based on the AIC and BIC criteria and model validation performed using metrics such as RMSE, MAE, and R^2. This integrated approach combined statistical and historical evidence to estimate the future behavior of the series and assess the production robustness of each country.

3 RESULTS AND DISCUSSIONS

3.1 BRAZIL–UNITED STATES–CHINA COMPARISON: DESCRIPTIVE ANALYSIS

The descriptive statistical analysis of chicken meat production among the three largest global producers allowed comparison of Brazil’s relative position with respect to its main competitors. In comparison with China (Table 2), the average Chinese production (5.62 million tonnes) was slightly higher than that of Brazil (5.16 million tonnes). The medians showed similar behavior, with values of 3.08 million tonnes for China and 2.87 million tonnes for Brazil, reflecting asymmetric distributions influenced by higher values in more recent years.

In terms of variability, both countries exhibited high dispersion, with similar standard deviations (5.23 million tonnes for China and 5.05 million tonnes for Brazil). The minimum value observed for Brazil (122.7 thousand tonnes) was lower than that recorded for China (445 thousand tonnes), while the maximum values were similar, reaching approximately 14.8 million tonnes in both cases. The range was slightly larger for Brazil (14.71 million tonnes) compared to China (14.36 million tonnes), indicating greater absolute variation over the analyzed period.

Table 2

Statistical comparison of production between Brazil and China

Measurement	Brazil	China	Difference / Observation
Mean	5,158,886	5,617,267	China slightly larger,
Median	2,872,200	3,080,000	China more consistent in the center,
Standard Deviation	5,045,134	5,231,837	China more dispersed
Minimum	122,770	445,000	Brazil used to produce much less
Maximum	14,833,000	14,800,000	Very close
Range	14,710,230	14,355,000	Brazil somewhat more variable

In the comparison between Brazil and the United States (Table 3), pronounced differences in production levels are observed. The average production of the United States was approximately 10.53 million tonnes, a value substantially higher than that observed for Brazil. The medians reinforce this difference, with 9.78 million tonnes for the United States and 2.87 million tonnes for Brazil, indicating distinct central production levels over the analyzed period.

In terms of dispersion, the standard deviation of U.S. production (6.09 million tonnes) was higher than that of Brazil, reflecting greater absolute variability associated with the larger production scale. The minimum value recorded for the United States (2.61 million tonnes) exceeded the Brazilian median, while the U.S. maximum value (20.19 million tonnes) was significantly higher than the maximum observed for Brazil (14.83 million tonnes). The production range in the United States (17.59 million tonnes) also exceeded that of Brazil (14.71 million tonnes), indicating greater absolute variation over the period.

Table 3

Statistical comparison of production in Brazil vs. the USA

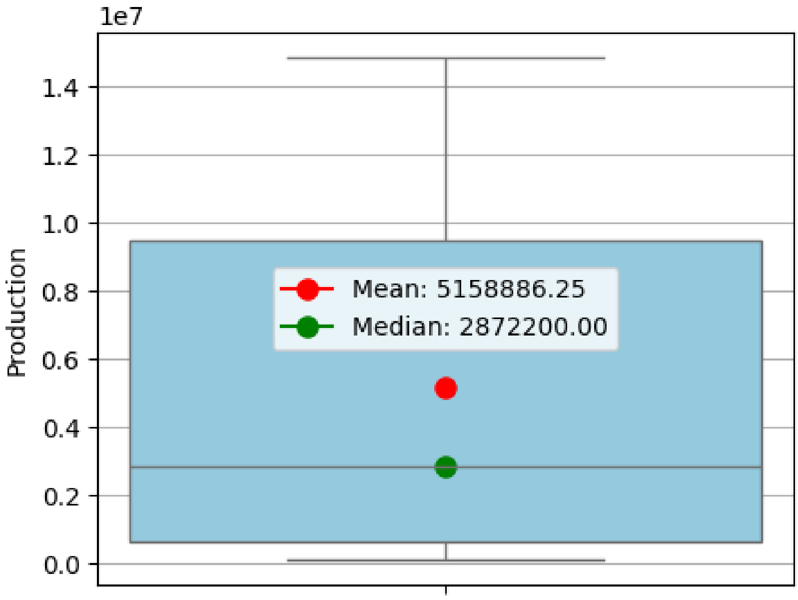
Measurement	Brazil	China	Difference / Observation
Mean	5,158,886	10,530,714	USA almost double that of Brazil
Median	2,872,200	9,783,785	USA far superior in the center
Standard Deviation	5,045,134	6,090,030	USA more dispersed, but on a larger scale

Minimum	122,770	2,607,689	US minimum is already higher than Brazil's median
Maximum	14,833,000	20,197,090	USA reach far higher levels
Range	14,710,230	17,589,401	USA more variable, but at a high level

The individual analysis of Brazilian chicken meat production indicates an asymmetric distribution of values over the analyzed period (Figure 1). The mean of the series (≈5.16 million tonnes) was higher than the median (≈2.87 million tonnes), evidencing positive skewness in the data distribution. The dispersion of the Brazilian series was high, with low minimum values and maximum values exceeding 14 million tonnes. This variability is reflected by the wide observed range and the high coefficient of variation of Brazilian production, estimated at approximately 97%.

Figure 1

Box plot of Brazilian production highlighting the average and median



Chinese production also exhibited an asymmetric distribution over the analyzed period (Figure 2). The mean of the series (≈5.62 million tonnes) was higher than the median (≈3.08 million tonnes), characterizing positive skewness similar to that observed for Brazil. The dispersion of Chinese production was high, with an approximate range of 14.35 million tonnes. The coefficient of variation of the series was estimated at approximately 92.4%, indicating lower relative variability than that observed for Brazilian production.

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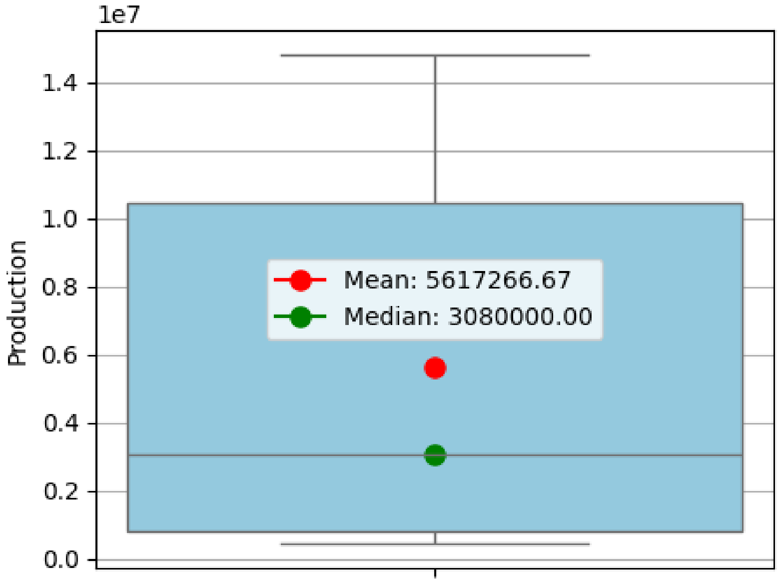
Figure 2

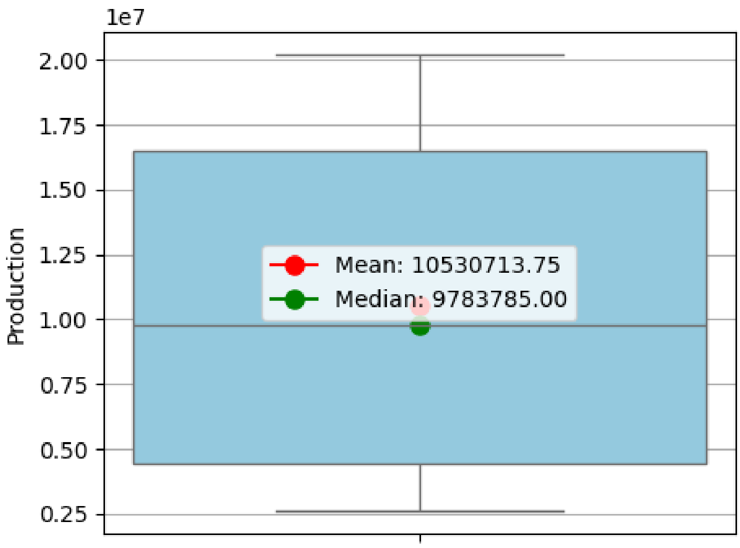
Box plot of Chinese production highlighting the average and median



U.S. production exhibited a more balanced distribution compared to the Brazilian and Chinese series (Figure 3). The mean production value (≈10.53 million tonnes) was close to the median (≈9.78 million tonnes), indicating lower skewness in the distribution of values over the analyzed period. Although the series presents a wide range, estimated at approximately 17.6 million tonnes, the coefficient of variation of U.S. production was the lowest among the three countries, with an approximate value of 57.4%, reflecting lower relative variability.

Figure 3

Box plot of the American production highlighting the average and median

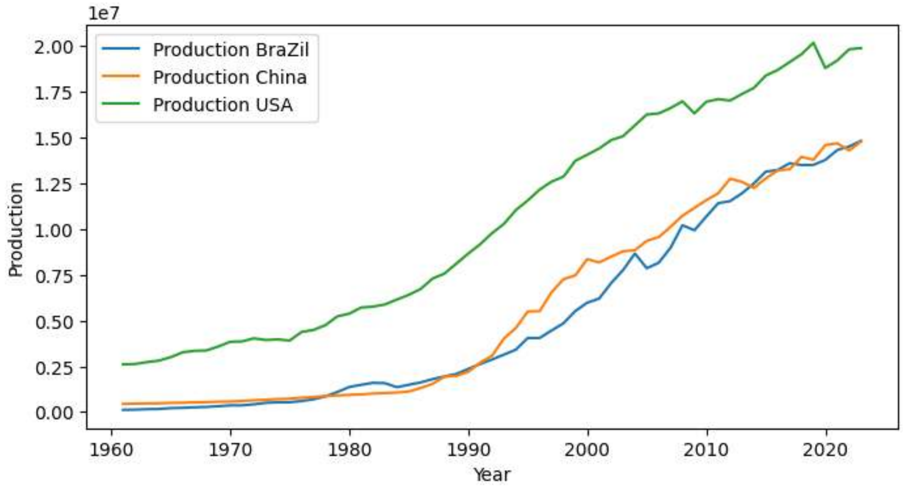


The descriptive statistics indicated relevant differences in the relative variability of chicken meat production among the analyzed countries. The coefficient of variation of Brazilian production was estimated at approximately 97.0%, slightly higher than that observed for China (≈92.4%), evidencing greater relative variability in the Brazilian series. Despite this, the maximum values recorded for Brazil and China were similar, remaining at comparable levels over the analyzed period. In contrast, U.S. production exhibited a substantially lower coefficient of variation, estimated at approximately 57.4%, associated with significantly higher mean and median values. This combination reflects lower relative variability in the U.S. series compared to those observed for Brazil and China, even in the presence of large absolute ranges.

Figure 4 presents the historical evolution of chicken meat production in the three main producing countries over the analyzed period. Production growth is observed in Brazil, China, and the United States, with differences in the temporal patterns of their trajectories. From the 1990s onward, the Brazilian and Chinese series began to show more pronounced growth, with convergence in production levels from the 2000s onward. In contrast, U.S. production exhibited a continuous upward trajectory throughout the entire period, starting in the 1960s, maintaining higher absolute levels than those observed for Brazil and China.

Figure 4

Evolution of chicken production



The analysis of Pearson correlation coefficients indicated a strong positive association among the chicken meat production time series of the analyzed countries. The correlation between Brazil and China was estimated at approximately 0.983, evidencing high similarity in the temporal behavior of the series over the analyzed period. Similarly, the correlation between Brazil and the United States showed an even higher value, approximately 0.991, indicating a very strong temporal association between their production trajectories. Despite absolute differences in production scale among the countries, the series exhibited similar patterns of temporal evolution. These results are consistent with the previously presented descriptive statistics, in which Brazil exhibited higher relative variability (CV ≈ 97.0%) compared to China (≈92.4%) and the United States (≈57.4%), while still maintaining strong temporal association with both.

3.2 BRAZIL–UNITED STATES–CHINA COMPARISON: DESCRIPTIVE ANALYSIS

The t-test between Brazil and China yielded a test statistic of $t = -0.501$ and a p-value of 0.618. Considering a significance level of 5%, no statistically significant difference was observed between the mean production levels of the two countries. This result is consistent with the descriptive statistics, in which Brazil and China exhibited similar mean and maximum values, although Brazil showed higher relative variability (CV ≈ 97.0% compared to 92.4% for China). In practical terms, this indicates that, despite fluctuations, the average Brazilian production does not differ consistently from that of China.

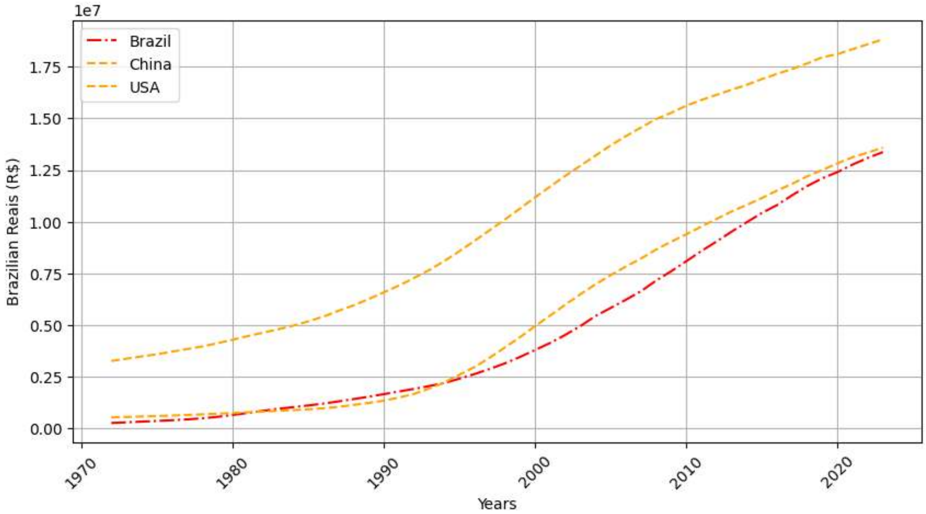
In contrast, the comparison between Brazil and the United States yielded different results, with a test statistic of $t = -5.391$ and a p-value of approximately 3.39×10^{-7}, indicating a highly significant difference between mean production levels. This finding corroborates the higher production levels of the United States previously evidenced by the descriptive measures and by the lower coefficient of variation (≈57.4%), reflecting not only a larger production scale but also greater stability over time. Therefore, the inferential tests reinforce the previously outlined scenario: Brazil and China exhibit statistically equivalent mean production levels, occupying similar positions in the global context, whereas the United States maintains a robust and statistically differentiated leadership, both in absolute scale and in production consistency.

3.3 BRAZIL–UNITED STATES–CHINA COMPARISON: PREDICTIVE ANALYSIS

The analysis of the moving average of chicken meat production in the three main global producers (Figure 5) highlights distinct trajectories in terms of production scale and consistency. The time series for Brazil and China reveal pronounced growth from the 1990s onward, showing parallel evolution and statistically equivalent mean values, as indicated by the t-test ($p > 0.05$). However, Brazilian production is characterized by higher relative variability (CV ≈ 97%), reflecting more intense fluctuations over time, whereas China exhibits greater stability (CV ≈ 92.4%). In contrast, the United States has maintained absolute leadership since the 1970s, with higher mean and median levels and a lower coefficient of variation (≈57.4%), resulting in a more stable and robust curve. These results are consistent with the previously observed descriptive and inferential measures, confirming that while Brazil and China show convergence in terms of productive capacity, the United States remains statistically superior both in scale and production consistency.

Figure 5

Moving average of production in the three countries over time



The seasonality analysis of production reveals temporal variation patterns that complement the descriptive and inferential measures previously discussed (Figure 6). The behavior of the series demonstrates that production exhibits cyclical fluctuations, reflecting both structural factors of the production chain and conjunctural shocks. It is observed that, particularly from the 1980s onward, fluctuations become more pronounced, indicating greater sensitivity of production to market and supply conditions. This instability manifests differently across countries: Brazil and China exhibit sharper peaks and troughs, consistent with the high coefficients of variation identified (97.0% and 92.4%, respectively), suggesting greater vulnerability to external and internal shocks. In contrast, the United States presents less intense and more regular oscillations, in line with its lower coefficient of variation (57.4%), which reinforces the robustness and consistency previously indicated by the moving average analysis. In summary, the seasonality assessment confirms that, although Brazil and China exhibit convergent growth trajectories, their production is marked by high volatility, whereas the United States sustains a more stable pattern over time, consolidating its position as a global reference in terms of production security and regularity.

Figure 6

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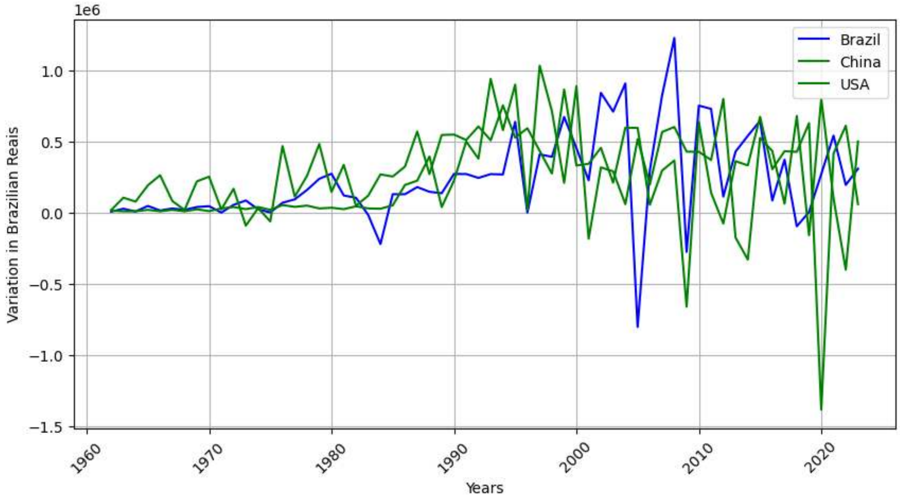
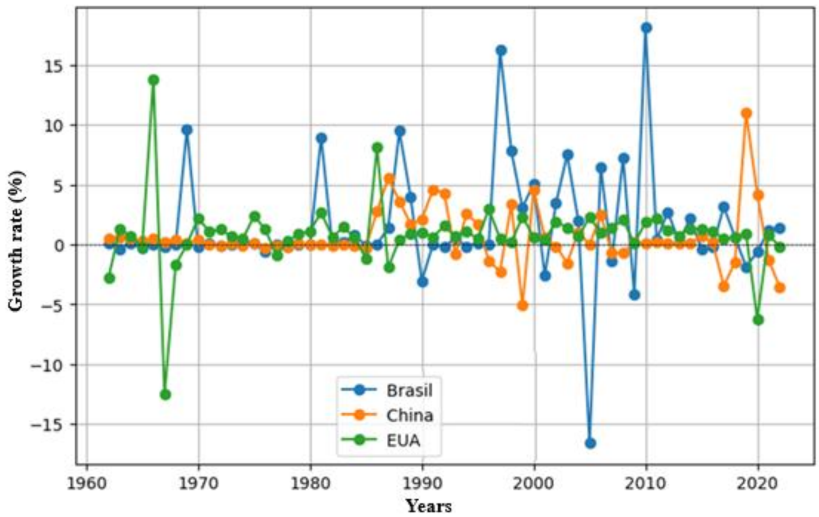
Seasonality of production in the three countries over time



The analysis of the monthly growth rate of chicken meat production among Brazil, China, and the United States reveals significant contrasts in terms of volatility and production stability (Figure 7). In the case of Brazil, the series exhibits more pronounced oscillations, with variations exceeding ±15% in some periods. This behavior reflects the high coefficient of variation (≈97%) previously identified, indicating strong instability. China, although showing consistent long-term growth, exhibits monthly peaks and declines of up to 10% after the 1990s, signaling greater sensitivity to internal factors such as sanitary outbreaks and changes in food safety policies. Chinese variability (CV ≈92.4%) reinforces this vulnerability, albeit to a lesser extent than that observed for Brazil. In contrast, the United States demonstrates smoother oscillations closer to the stability line, with variations predominantly concentrated between −5% and +5%. This pattern is consistent with the lower coefficient of variation (≈57.4%), confirming the structural robustness and resilience of the U.S. sector. In summary, the analysis of the monthly growth rate reinforces previous findings: Brazil and China exhibit accelerated growth accompanied by higher volatility, whereas the United States sustains not only leadership in absolute scale but also the highest relative stability, consolidating its position as a global benchmark for production consistency.

Figure 7

Growth rate of countries



The analysis of historical trends in chicken meat production among Brazil, China, and the United States reveals distinct dynamics of growth and market consolidation (Figure 9). Brazil exhibits a consistently upward trajectory from the 1980s onward, with a steeper growth rate compared to the other countries. The slope of the trend line confirms Brazil's role as an emerging power in the sector, corroborating the descriptive and inferential analyses that indicated statistical equivalence with China in terms of mean production, albeit with greater variability. China, in turn, shows strong expansion until the early 2000s, followed by deceleration and a tendency toward stabilization in more recent levels. The gentler slope of its trend line suggests sectoral maturity, with less accelerated growth compared to Brazil. Nevertheless, the results remain close to Brazilian maximum values, reinforcing the statistical equivalence between the two countries ($p > 0.05$). The United States displays the longest and most stable trajectory, with gradual growth since the 1960s and a robust linear trend. Although its expansion rate is less steep than Brazil's, the United States maintains consistently higher absolute levels, in line with its lower coefficient of variation (≈57.4%) and with the t-test result indicating a statistically significant difference relative to Brazil ($p < 0.001$). In summary, the trend analysis confirms that Brazil exhibits a more accelerated growth rate, gradually narrowing the gap with the United States; China shows stabilization at intermediate levels; and the United States consolidates its historical leadership, supported by greater scale and production stability.

The historical analysis of chicken meat production in the three main producing countries indicates that the expansion and contraction cycles observed in the series are strongly associated with conjunctural and structural events documented in the literature.

Among the most relevant factors are input cost shocks, particularly for corn and soybean meal, especially during the global commodity crisis of 2007–2008, when grain prices reached record levels, directly affecting poultry profitability and resulting in temporary production declines in countries such as Brazil and China (FAO, 2009). A similar episode occurred in 2012, when severe drought in the United States drastically reduced corn supply, increasing feed costs and negatively impacting the growth rate of U.S. poultry production (USDA-ERS, 2012).

In addition to input costs, sanitary events have also played a central role in explaining production fluctuations. China, for example, experienced recurrent outbreaks of highly pathogenic avian influenza (HPAI) between 2004 and 2012, leading to significant declines in chicken meat production and domestic consumption, with repercussions for international trade (Li, Tian, and Zhou, 2014). More recently, Brazil has also faced temporary embargoes and trade restrictions related to avian influenza, which explain part of the volatility observed in its historical series (USDA-FAS, 2023). In the United States, the COVID-19 pandemic in 2020 represented a simultaneous supply and demand shock, with bottlenecks in the processing industry and redistribution of consumption flows between foodservice and retail, resulting in temporary disruptions in the monthly growth rate (USDA-ERS, 2021).

In the long term, the United States has maintained a stable trajectory since the 1960s, consolidating itself as the most robust producer, as reflected by the lowest coefficient of variation identified (≈57.4%). This resilience derives from structural factors such as the consolidation of an integrated production chain, domestic availability of inputs, and stable public policies that dampen conjunctural shocks (OECD/FAO, 2021). In contrast, Brazil and China exhibit more volatile trajectories, with coefficients of variation of 97.0% and 92.4%, respectively, which can be attributed to greater sensitivity to exchange rate fluctuations, supply shocks, and vulnerability to sanitary crises (FAO, 2020). Nevertheless, Brazil stands out for the steeper slope of its trend, resulting from the adoption of producer–industry integration systems from the 1980s onward, which enhanced scale gains and international market insertion (Miele and Waquil, 2016).

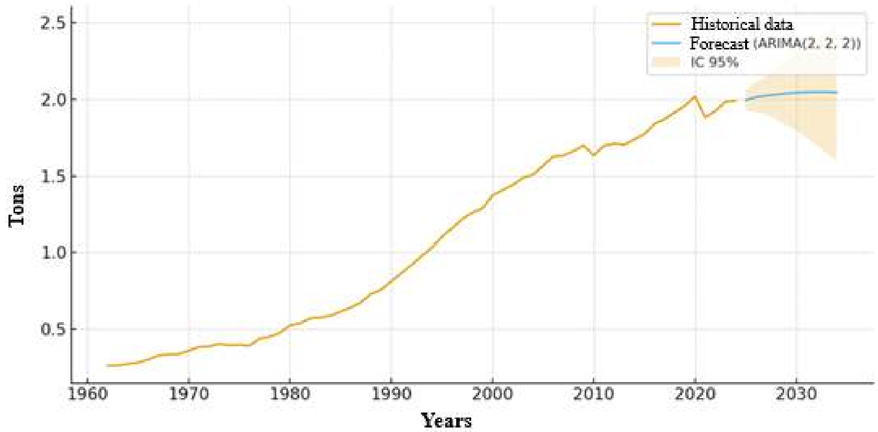
Thus, the more intense oscillations observed in the Brazilian and Chinese series can be explained by cost shocks and sanitary events, whereas the lower-intensity cycles in the United States reflect a more resilient production structure. These findings reinforce the previous statistical interpretation: although Brazil and China exhibit statistically equivalent mean production levels ($p > 0.05$), both are subject to greater instability, while the United States maintains superiority not only in absolute scale but also in production consistency.

Time-series modeling using the ARIMA (AutoRegressive Integrated Moving Average) method was applied to the annual chicken meat production series of Brazil, China, and the United States, with the objective of projecting future scenarios over a 10-year horizon. The models were individually fitted for each country using historical series from 1961 to 2023, allowing identification of the most appropriate orders of autoregression, differencing, and moving average according to the Akaike Information Criterion (AIC).

The results indicate that the United States presents the most parsimonious model, with low differencing requirements, consistent with the greater stability previously evidenced in the descriptive and inferential analyses (Figure 8). The forecast suggests the maintenance of continuous growth, albeit at a moderate pace, consolidating its leadership position with projected values exceeding 20 million tons in the final year of the projection.

Figure 8

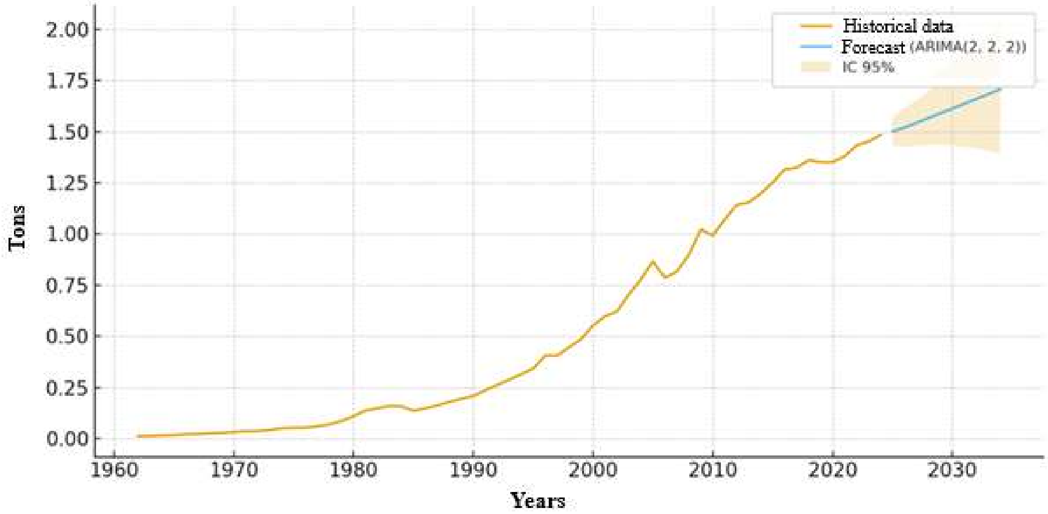
ARIMA forecast for the USA



For Brazil, the selected model required a higher degree of differencing, reflecting its historical variability (coefficient of variation ≈ 97%) (Figure 9). Nevertheless, the estimated trend remains upward, with projections exceeding 15 million tons over the 10-year horizon. This result reinforces the country's role as an emerging power, gradually reducing the relative gap with the United States, albeit accompanied by greater uncertainty, as evidenced by wider confidence intervals.

Figure 9

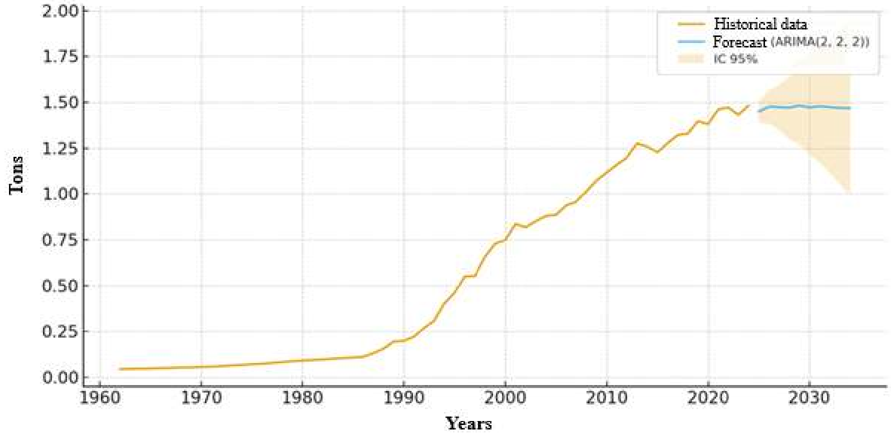
ARIMA forecast for Brazil



China exhibited an intermediate pattern: the fitted series also required differencing, but with greater stability compared to Brazil (coefficient of variation ≈ 92.4%) (Figure 10). The forecasts suggest a stabilization trajectory around levels close to 14 million tons, indicating maturity of the domestic market and a lower relative growth rate compared to that observed in previous decades.

Figure 10

ARIMA forecast for China



Overall, the prospective analysis using ARIMA corroborates the previous findings: (i) the United States remains a robust leader in terms of production scale and consistency; (ii) Brazil exhibits a more accelerated growth rate, albeit accompanied by higher volatility; and

(iii) China, despite maintaining high production levels, tends toward stabilization. These results indicate that, in the near future, the global poultry production landscape will continue to be characterized by U.S. leadership, Brazilian expansion, and the consolidation of the Chinese market at intermediate levels.

4 CONCLUSIONS

This study analyzed, under a statistical and predictive approach, the evolution of chicken meat production in the three largest producers worldwide—the United States, Brazil, and China—over the period from 1961 to 2022. Descriptive analysis revealed relevant differences in production levels and relative variability among countries. Historical average production values were approximately 10.53 million tonnes for the United States, 5.16 million tonnes for Brazil, and 5.62 million tonnes for China, with coefficients of variation of 57.4%, 97.0%, and 92.4%, respectively, indicating higher relative variability in the Brazilian and Chinese series compared to the U.S. series.

Inferential analysis confirmed these structural differences. The Student's t-test applied to the comparison between Brazil and China did not identify a statistically significant difference between mean production levels ($t = -0.501$; $p = 0.618$), whereas the comparison between Brazil and the United States indicated a highly significant difference ($t = -5.391$; $p \approx 3.39 \times 10^{-7}$). These results demonstrate that, although Brazil and China operate at statistically equivalent mean levels, the United States maintains significantly higher average production levels over the analyzed period.

Pearson correlation analysis revealed strong temporal association among the production series, with correlation coefficients of approximately 0.983 between Brazil and China and 0.991 between Brazil and the United States. These values indicate a high degree of similarity in growth patterns over time, despite absolute differences in production scale and relative variability among countries.

In the predictive domain, ARIMA models fitted to the historical series demonstrated the ability to adequately capture long-term trends in chicken meat production, enabling consistent short- and medium-term projections. Forecasts indicated continued production growth in all three countries, with distinct trajectories in terms of stability and volatility, reflecting patterns historically observed in the analyzed series. The hypothesis proposed in this study was partially confirmed, supporting the null hypothesis (H_0) for Brazil and China, but being rejected for the United States. Descriptive and inferential analyses revealed strong positive correlation between the Brazilian and Chinese series ($r \approx 0.983$), indicating that both countries expanded production in a parallel manner alongside population growth and export intensification in recent decades, particularly after the 1990s. This behavior reflects the pursuit of food self-sufficiency and competitiveness in international markets, confirming the influence of these factors on production expansion. In contrast, the United States exhibited stable and sustained growth, less dependent on population variations and more closely associated with the maturity of its domestic market and the structural consolidation of the poultry production chain. Thus, the results indicate that, although global chicken meat production is driven by population growth and international trade, the intensity and nature of this relationship vary according to the stage of development and production structure of each country, leading to partial acceptance of the null hypothesis (H_0) and its rejection with respect to the United States.

As the main contribution, this work presents an integrated comparative analysis—descriptive, inferential, and predictive—of chicken meat production on a global scale, supported by robust statistical evidence quantifying differences in mean level, variability, and temporal association among the main producing countries. The results provide relevant quantitative insights for understanding the historical behavior of broiler production and for prospective analyses based on time-series methods. However, some limitations should be considered. The study is based on aggregated annual data and univariate models, not incorporating exogenous variables or exploring causal relationships. Future research may extend this approach by incorporating multivariate models (e.g., ARIMAX) and economic, sanitary, and climatic indicators to deepen understanding of the determinants of global chicken meat production.

5 DATA AVAILABILITY

The data from this research, as well as all the mathematical modeling applied in the Python language, is available at: https://colab.research.google.com/drive/1FCZOgFiNJCsCBgbMOwgtTWbRntZNsVdW

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