Veterinary Journal of Kastamonu University (2024): 3(2) Research Article
DOI: 10.61262/vetjku.1579424

Forecasting of Bull Carcasses Prices for the Future with Box-Jenkins Models: The Case of Tokat Province

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**This study was produced from the master's thesis prepared by the first author under the supervision of the second author.

Received 05.11.2024 **Accepted** 15.12.2024 **Published** 31.12.2024

Abstract
Aim to study: The purpose of this study is to make future forecast of bull carcass meat prices in Tokat province using econometric methods. It is aimed to analyze bull carcass prices in Tokat province with time series analysis and estimate these prices for 2025.
Material and methods: The data set of the study consists of monthly bull carcass prices slaughtered between June 2018 and May 2024. The estimates were made with the Box-Jenkins method, one of the econometric analysis methods.
Results: As a result of the time series analysis, the most suitable model for bull carcass prices was determined as Auto Regressive Integrated Moving Average (ARIMA) (0,1,0) (1,1,0). The estimation results from the determined ARIMA models predict that the average bull carcass price in Turkey will reach 550.37 TL/kg (16,98 US$) in May 2025.
Conclusion: In conclusion, time series analysis can be utilized to forecast future bull carcass prices, though these estimates should be regularly updated. This approach can support the future planning efforts of both producers and consumers.
Keywords: Box-Jenkins, bull, carcass, forecast, price, Tokat.

Tosun Karkas Fiyatlarının Box-Jenkins Modeller ile Geleceğe Yönelik Kestirimleri: Tokat İli Örneği

Öz
Çalışmanın amacı: Bu çalışmanın amacı; Tokat ilinde tosun karkas et fiyatlarının ekonometrik yöntemlerle geleceğe yönelik tahminlerinin yapılmasıdır. Tokat ilinde tosun karkas fiyatlarının zaman serisi analizi ile çözümlenerek, bu fiyatların 2025 yılı için tahmin edilmesi amaçlanmıştır.
Materyal ve yöntemler: Çalışmanın veri seti; 2018 Haziran ve 2024 Mayıs ayları arasında kesilen aylık tosun karkas fiyatlarından oluşmuştur. Tahminler ekonometrik analiz yöntemlerinden Box-Jenkins yöntemi ile yapılmıştır.
Bulgular: Yapılan zaman serisi analizi sonucunda tosun karkas fiyatları için en uygun model Otoregresif Bütünleşik Hareketli Ortalama (ARIMA) (0,1,0) (1,1,0) olarak tespit edilmiştir. Model doğrultusunda tosun karkas fiyatlarının kestirim sonuçlarına göre Türkiye'de Mayıs 2025 döneminde tosun karkas fiyatının ortalama 550,37 TL/kg (16,98 US$) ulaşacağı tahmin edilmiştir.
Sonuç: Sonuç olarak, zaman serisi analizi gelecekteki tosun karkas fiyatlarını tahmin etmek için kullanılabileceği, ancak bu tahminlerin düzenli olarak güncellenmesi gerekmektedir. Bu yaklaşım, hem üreticilerin hem de tüketicilerin ileriye yönelik yapacağı planlamalara katkı sağlayabileceği sonucuna varılmıştır.
Anahtar kelimeler: Box-Jenkins, tosun, fiyat, karkas, tahmin, Tokat.

To cite this article; Çelik, M., & Arıkan.,M.S,(2024). Forecasting of Bull Carcasses Prices for the Future with Box-Jenkins Models: The Case of Tokat Province *Veterinary Journal of Kastamonu University*, 3(2), 1-10.

Introduction

With the increase in the world population and the development of socio-economic conditions of consumers, the need for animal protein, in other words, the amount of meat consumed per person, has increased. Increasing the production of animal products to meet the demands of the increasing world population has become the primary goal of states (Sakarya & Aydın, 2011).

According to the data of the Turkish Statistical Institute (TurkStat), the number of slaughtered cattle increased by 6% in 2023 compared to the previous year and reached 5 million 811 thousand, and cattle meat production increased by 6% and reached 1 million 670 thousand tons (TurkStat, 2024).

In meat production, the choice of cattle breed affects unit costs and sales income, while knowing the fattening performance of cattle breeds improves the ability of producers to make economically sound decisions (Arıkan & Gökhan, 2018). The most suitable animal material for fattening activities in Turkey is generally Brown Swiss, Holstein, and Simmental breeds and their crossbreeds with local animal breeds (Çiçek, 2002). However, today, in order to close the red meat gap, different beef cattle breeds such as Angus, Hereford, Charolais and Limousin are also imported (Arıkan & Gökhan, 2018).

Time series is a method that uses econometric methods to estimate future prices using past and present data sets (Matta et al., 2021).

When producers fatten their butchered animals, they have no prediction about how much the carcass meat they obtain will be traded at the market when the fattening process is over. Time series analyses accept the prices that have occurred in a market before as data and make estimates about the price of that product in that market in the future (Montgomery et al., 2015).

The future course of carcass prices is of great importance for producers and consumers. By knowing the prices, breeders can predict the estimated price range of the carcasses they obtain at the end of the fattening process in the market they are in. On the other hand, industrialists who want to buy carcass meat can have a forecast on which price range the carcass meat will be in which time period.

This study was conducted to make future carcass price estimates by analyzing the time series of bull carcass prices in Tokat province using the Box-Jenkins method.

Material and Methods

Data Set

The data set of the study consisted of the prices (TL/kg) of 2,359 bull carcasses slaughtered in the slaughterhouses located in the center and districts of Tokat province between June 2018 and May 2024 (TOB, 2024). In the study, the average bull carcass price of each month was calculated to be used in the time series analysis and a 72-month data set was obtained. In the analysis of the data, trend analysis was performed in order to obtain and estimate the series value under the influence of only long-term movements by purifying the time series from the effects of irregular fluctuations. Within the scope of this study, the ARIMA model from the Box-Jenkins models was used in the time series analysis. Descriptive statistics of the data were performed and the parameters of the model with high goodness of fit in price estimation were estimated and price estimation was made. SPSS, version 25.0 (IBM Corporation, 2018) program was used for the analysis of the time series.

Time Series Analysis

In the study, ARIMA (0,1,0) (1,1,0) model was used for future predictions of beef carcass prices. When the autocorrelation function graph of the

series was examined, it was determined that the series was not stationary. The first difference was taken in order to make the series stationary. In order to determine the appropriate ARIMA (p,d,q) model for the predictions of beef carcass prices, the autocorrelation and partial autocorrelation functions of the series were examined, p and q levels were determined and the significance of the parameters was checked.

In the models (Wickramarachchi et al., 2017);

p: Autoregressive model degree,

q: Moving average model degree,

d: Non-seasonal difference degree.

The ARIMA (p, d, q) model is expressed as shown in Equation [1].

$$Z_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \ldots\ldots\ldots\ldots + \phi_P Z_{t-P} + a_t - \theta_1 a_{t-1} - a_t - \theta_2 a_{t-2} - \ldots\ldots\ldots\ldots - a_q - \theta_q a_{t-q}$$

[1] Here:

ϕ_P: Parameter values for the autoregressive operator, a_t: Error term coefficients, θ_q: Parameter values for the moving average operator, Z_t: Time series with d degree difference taken from the original series, That is, $W_t = Y_t - Y_{t-1}$, t = 1,2,…,t [2]

and the first difference series is defined as shown in equation [2] Here:

W_t = First difference series,

Y_t = Set of random variables of the original time series.

If the first difference series is not stationary; stationarity control is performed by taking the difference of the first difference series again. This is also modeled as given in the equation [3].

$Z_t = W_t W_{t-1}$ t = 1,2,…,t [3]

When the differencing degree d=0 (indicating that the original series is stationary), the ARIMA model reduces to an AR, MA, or ARMA model. This characteristic means that ARIMA models encompass all Box-Jenkins models.

Box-Jenkins ARIMA models include four basic steps in the establishment phase. In the first step, it is generally determined which class the model is in.

The autocorrelation and partial autocorrelation function graphs are used in selecting the general model. Considering both functions, the properties of theoretical functions are utilized for ARIMA models (Box et al., 2015).

In the second step, a temporary model that fits the data is established. Autocorrelation and partial autocorrelation functions are utilized in establishing this model. In determining the model, a model such as AR, MA, ARMA, ARIMA or SARIMA is decided (Tekindal et al., 2016).

In the third step, the parameters of the temporary model are estimated using statistical methods and their significance is determined by considering the standard errors of the coefficients. In the last step, the suitability of the decided model for estimation is determined. To evaluate this, the autocorrelation function is analyzed using the graph of autocorrelation coefficients for the residuals of the provisional model. If a specific pattern appears, it suggests that the residuals are not randomly distributed, indicating that the provisional model is unsuitable. In this case, the process returns to the second step, and a new provisional model is tested until an appropriate one is identified. Once a model passes this suitability check, it can be used for predictions or estimations (Yenice & Tekindal, 2015; Tekin & Tekindal, 2019; Kaymaz, 2018).

In evaluating the estimation consistency of the model; Forecast Error, Mean Forecast Error, Mean Absolute Deviation, Mean Absolute Percentage Error and Mean Square Error parameters were used (Arıkan et al., 2018).

Results

Within the scope of the research, a price series was created for bull carcasses with a total of 72 months of data between 2018/10-2024/5. Average beef carcass prices (TL/kg) in Tokat province between 2018-2024 are presented in Table 1.

When the table is examined, the bull carcass price increased between 2018/10-2024/5. The highest increase in the bull carcass price occurred in December 2023. Compared to the previous month, the bull carcass price increased by 23.36% in February 2024. Future estimates of bull carcass prices in Tokat province were made with time series analysis using price data between 2018/10-2024/5. The time series graph indicating the bull carcass prices is presented in Figure 1.

Table 1. Average bull carcass prices in Tokat province between 2018/10-2024/5 (TL/kg)

Years/Months	2018	2019	2020	2021	2022	2023	2024
January	-	28,79	31,50	35,00	65,00	127,71	280,50
February	-	28,55	32,17	35,22	67,56	160,33	296,11
March	-	29,00	33,57	39,08	73,38	186,47	335,31
April	-	29,56	34,33	39,57	85,00	209,69	361,67
May	-	30,85	35,60	40,00	95,00	224,12	361,67
June	-	30,92	37,29	43,63	94,20	227,78	-
July	-	31,00	37,52	44,20	96,50	233,89	-
August	-	31,23	37,77	45,50	96,78	234,50	-
September	-	31,47	37,90	45,00	96,91	240,75	-
October	29,80	32,80	35,67	44,67	100,83	245,29	-
November	29,00	30,27	35,40	51,36	102,92	218,88	-
December	28,33	30,83	35,42	57,33	107,63	270,00	-

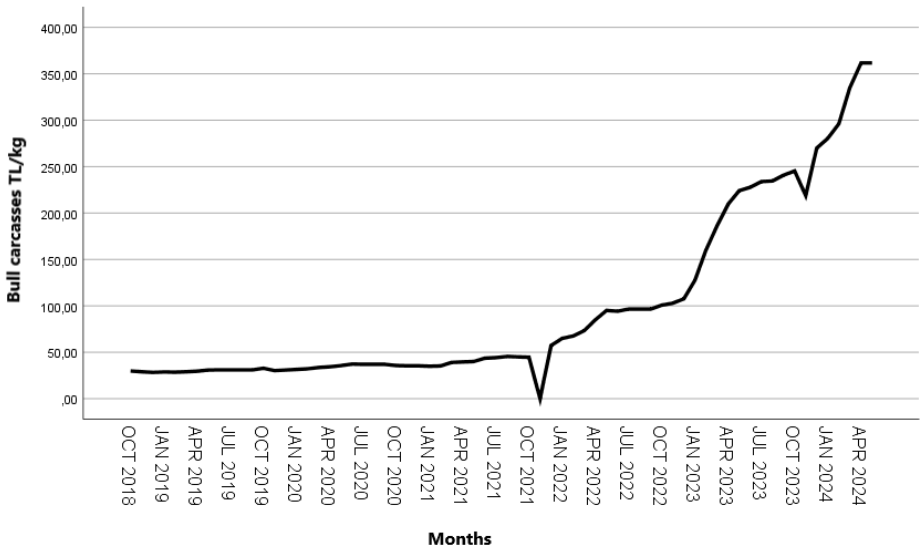

Figure 1. Time series graph of bull carcass prices (TL/month)

When Figure 1 is examined, it can be said that the time series increases with a trend along with fluctuations. The presence of a certain trend in the series shows that the time series of bull carcass prices is not stationary. In order to determine the stationarity of the time series of bull carcass prices, the autocorrelation function (ACF) and partial autocorrelation function (PACF) graphs of the series are presented in Figure 2.

When Figure 2 is examined, it can be stated that the series is not stationary because multiple lags in the time series are outside the confidence limits. In order to partially stationarize the series, the logarithm of the series was first taken and thus the differences between the values were reduced. However, since the series was still not stationary, the difference was taken until the series became stationary. Once the difference was taken, it was seen that Figure 3 the trend of the time series became stationary.

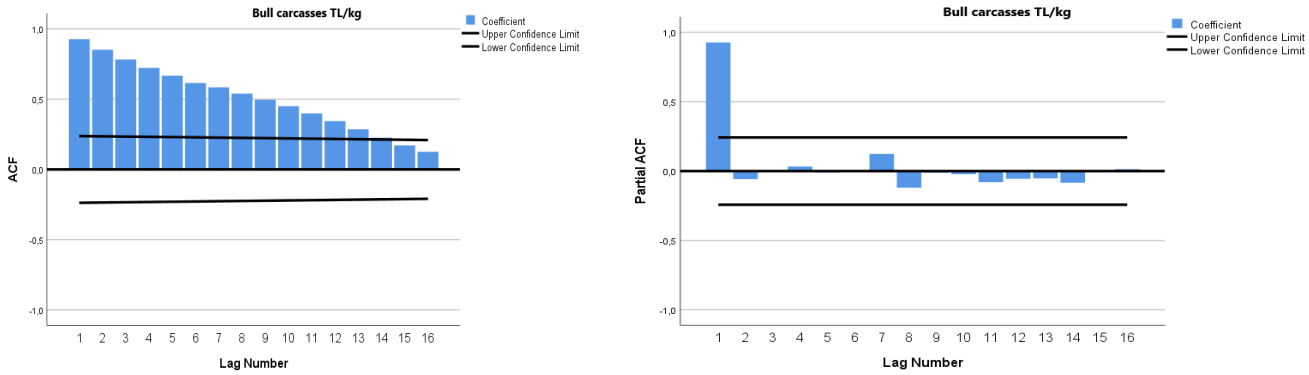

Figure 2. ACF and PACF graph of the series of bull carcass prices

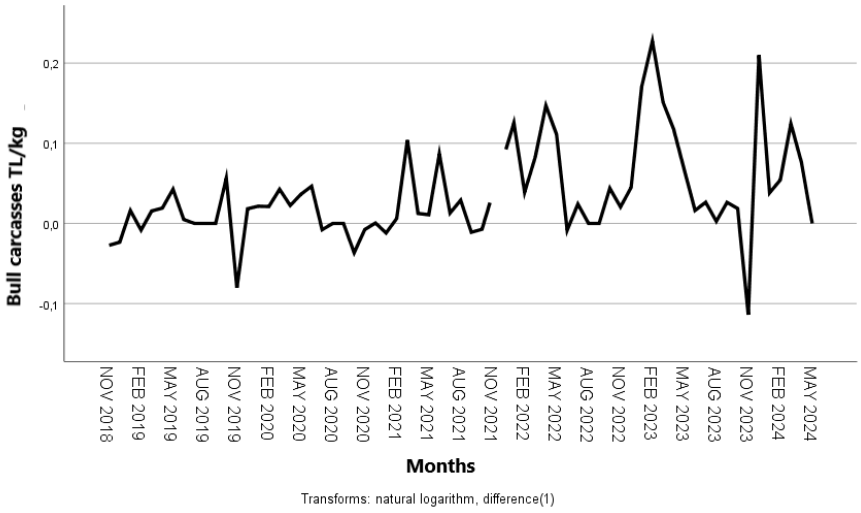

Figure 3. Graph of the series with bull carcass price difference

ACF and PACF graphs of bullock carcass prices (TL/kg) as a result of the difference process are given in Figure 4.

Examining the ACF and PACF graphs in Figure 4 reveals that the values exceed the confidence limit for the first three lags but remain below it from the fourth lag onward, suggesting that the time series is stationary. Several models were tested to identify the most suitable model for the time series, and it was determined that the ARIMA(0,1,0)(1,1,0) model is the best fit for forecasting beef carcass prices.

The predictions created by the selected model for the bull carcass prices in the following months are presented in Table 2.

When Table 2 is examined, in the analysis made on beef carcass price values, the Mean Absolute Percentage Error (MAPE) value was obtained as 8.624 and the R^2 value as 0.984. The ARIMA (0,1,0) (1,1,0) model gives the optimum result.

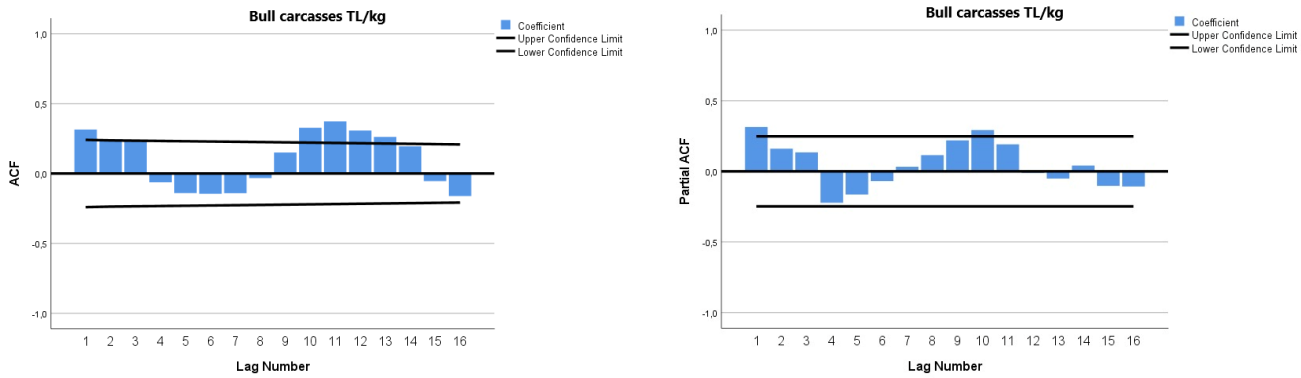

Figure 4. ACF and PACF graph of the series with bull carcass price difference

Table 2. Estimation of bull carcass price values for the future

Period	Forecast	UCL	LCL	MAPE	R^2	Model
June 2024	367.19	392.50	341.89			
July 2024	375.58	411.36	339.80			
August 2024	380.51	424.34	336.69			
September 2024	387.49	438.09	336.88			
October 2024	396.60	453.18	340.03			
November 2024	393.09	455.07	331.12			
December 2024	419.30	486.25	352.36	8.624	0.984	ARIMA (0,1,0) (1,1,0)
January 2025	440.63	512.19	369.06			
February 2025	471.80	547.71	395.90			
March 2025	507.38	587.39	427.37			
April 2025	536.45	620.36	452.53			
May 2025	550.37	638.01	462.72			

When Figure 5 is examined, it is estimated that carcass prices will decrease in November 2024, increase again from December, and the average beef carcass price will be 550.37 TL/kg in May 2025.

The compliance criteria for the price prediction models used in the time series analysis are presented in Table 3.

The goodness-of-fit criteria for the obtained models are evaluated in comparison with one another. R^2, often referred to as the coefficient of determination, is a widely used criterion that measures the goodness of fit for linear models. This coefficient ranges from 0 to 1, with lower values indicating a poor fit to the data. Stationary R^2 is another criterion that compares the stationary component of the model with the baseline model, making it useful when a trend or seasonal pattern is present. The Root Mean Squared Error (RMSE) is the root mean square error and indicates how much the model's estimates deviate from the dependent series; low values indicate better model estimates.

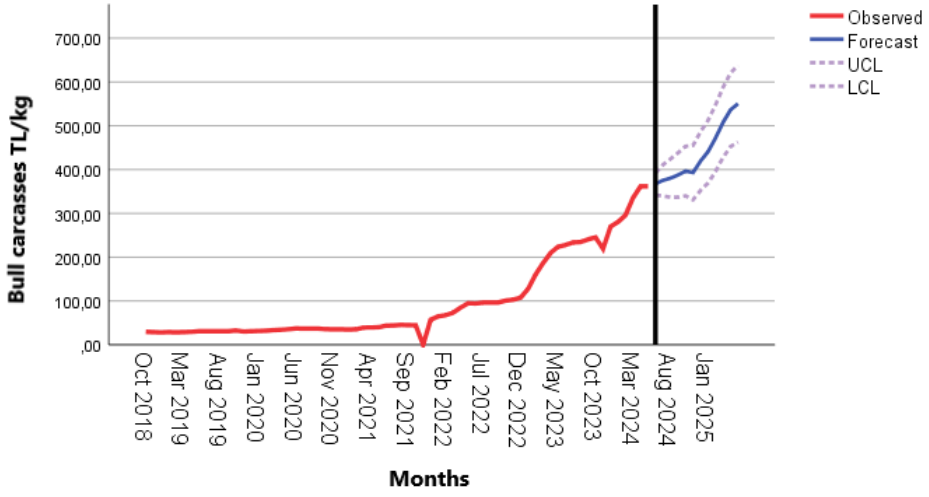

Figure 5. Bull carcass price value prediction graph for the future

Table 3. Fit criteria for bull carcasses price prediction models

Fit Criteria	ARIMA (0,1,0) (1,1,0)
Stationary R-squared	0.459
R-squared	0.984
RMSE	12.651
MAPE	8.624
MaxAPE	91.148
MAE	7.438
MaxAE	52.255
Normalized BIC	5.221
Statistics	17.977
DF	17
Sig.	<0.001

MAPE shows the average absolute percentage error and is used in comparing different series since it is independent of the units of the series. Models with this value below 10 are considered to be “very good”, models between 10 and 20 are considered to be “good”, models between 20 and 50 are considered to be “acceptable” and models above 50 are considered to be “incorrect and faulty”.

Mean Absolute Error (MAE) represents the average absolute error and is expressed in the units of the series. Maximum Absolute Percentage Error (MaxAPE) measures the highest percentage error between the estimated values and actual values, making it unit-independent and useful for analyzing worst-case scenarios in forecasts. Maximum Absolute Error (MaxAE) indicates the largest absolute error and is presented in the same units as the dependent series. The Normalized Bayesian Information Criterion (BIC) assesses the overall model fit, aiding in model comparison for the same series, with lower values indicating a more effective model.In our study, the Box-Jenkins models created for beef carcass prices are statistically significant ($p<0.001$). The MAPE value shows that the series of prices contain quite usable estimates.

Discussion

In Turkey, 2,384,047 tons of red meat will be produced in 2023, with 70.07% of the production coming from cattle, 23.87% from sheep, 5.41% from goats and 0.65% from buffalo, and the demand for beef is increasing every year (TurkStat, 2024). Red meat production in Turkey, at 1,651,650 tons, is insufficient to meet the consumption of 2,146,000 tons, causing a supply deficit of approximately 490,255 tons (TEPGE, 2023). The supply deficit in red meat in Turkey is met through imports. Although attempts are made to balance prices by increasing supply in the domestic market through carcass meat import decisions, these decisions put pressure on local producers and are not a sustainable solution in the long term in stabilizing prices (Akın et al., 2020). However, studies indicate that increasing the supply of red meat through imports is insufficient to regulate red meat prices in domestic markets (Aktaş, 2020). On the other hand, it has been reported that state interventions in the red meat market have been insufficient to stabilize prices (Arıkan et al., 2019).

In this study, price data of bull carcasses slaughtered in slaughterhouses and combined in Tokat province in Turkey between 2018 and 2024 were used. Since the time series created using the price data did not show stationarity, they were made stationary after taking their first differences. As a result of the time series analysis, it was determined that the most suitable ARIMA (0,1,0) (1,1,0) model for bull carcass prices.

In line with the determined ARIMA models, carcass prices were estimated until May 2025. According to the estimation results, it was estimated that bull carcass prices in Turkey would reach an average of 550.37 TL/kg in the May 2025 period.

It has been stated that red meat prices in Turkey have experienced mild price fluctuations in the long term (Ayyıldız, 2017). In order to protect consumers from these fluctuations, products are sold below market prices through the Meat and Milk Board. However, it has been stated that the primary purpose of this practice is to meet the demand for red meat by low-income

consumers rather than ensuring price stability and that it does not have an increasing effect on the market for red meat (Çiçek et al., 2020).

Conclusion

In conclusion, time series analysis is used as an effective tool for predicting future trends in carcass meat prices. In the case study conducted on bullock meat prices in Tokat province, results obtained through ARIMA models revealed that prices follow a particular trend and exhibit seasonal fluctuations. This analysis method provides forecasts on how prices may change in the future by considering trends, seasonality, and other patterns within the time series of past data, thereby increasing price predictability in the short term. As a result, both red meat producers and consumers can be better prepared for market uncertainties and engage in strategic planning. Particularly in countries like Turkey, where inflationary pressures are high, the findings of this study contribute to the development of policy recommendations aimed at stabilizing the red meat market and provide crucial insights for determining strategies to minimize price fluctuations.

Financial Support

This study did not receive a grant by any financial institution/sector.

Ethical Statement

This study was approved by the Fırat University Non-Interventional Research Ethics Committee (27.07.2023/10-35).

Author Contributions

Investigation: M.Ç. and M.S.A; Material and Methodology: M.Ç. and M.S.A; Supervision: M.Ç. and M.S.A; Visualization: M.Ç and M.S.A; Writing-Original Draft: M.Ç. and M.S.A; Writing-review & Editing: M.Ç. and M.S.A.

Conflict of Interest

The authors declared that there is no conflict of interest.

Data Availabilty Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgements

This study was produced from the master's thesis prepared by the first author under the supervision of the second author.

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