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Estimating Milk Production in Ardahan Province with ARIMA (Box-Jenkins) Model

Özlem EŞTÜRK[1]*

[1] Asst. Prof. Dr., Ardahan University, Faculty of Economics and Administrative Sciences, Department of Economics, Ardahan, Turkey

ABSTRACT

Economy of Ardahan province on a large scale depends on stock farming since a significant part of the population is employed in the livestock sector. For this reason, milk and dairy products have an important place in Ardahan's economy. The increasing demand for milk in Turkey and in the World brings the issue of sustainability of milk supply. Therefore, it is important to estimate the proceeding course of milk production to adapt increasing milk demand and to determine effective policies. In the study, Ardahan province milk production data was obtained from Turkish Statistical Institute (TUIK) for the period of 1995-2019 in order to estimate the milk production. Box-Jenkin's methodology was used to predict milk production of Ardahan province for the years of 2020-2025. A suitable ARIMA (0,0,1) model was proposed to forecast estimate milk production of Ardahan province. According to this model, the milk production in Ardahan province was estimated as 414, 439 and 557 thousand tons in 2020, 2021 2025, respectively.

Keywords: Milk Production, ARIMA, Estimate.

Ardahan İli Süt Üretiminin ARIMA (Box-Jenkins) Modeli ile Tahmini

ÖZET

Nüfusun önemli bir kısmının hayvancılık sektöründe istihdam edildiği Ardahan'da ekonomi, büyük ölçüde büyükbaş hayvancılığa dayanmaktadır. Bu nedenle Ardahan ekonomisinde süt ve süt ürünleri önemli bir yere sahiptir. Türkiye ve dünyada süte olan talebin, her geçen gün artması, süt arzının sürdürülebilirliği konusunu gündeme getirmektedir. Dolayısıyla artan talep

* Sorumlu yazar/Corresponding author
E-mail/e-ileti: ozlemesturk@ardahan.edu.tr

artışına uyum sağlanması ve etkin politikaların belirlenmesinde, gelecekteki süt üretiminin nasıl bir seyir göstereceğine ilişkin tahminler önem taşımaktadır. Çalışmada, Ardahan ilinin süt üretiminin tahmin edilmesi amacıyla Türkiye İstatistik Kurumu'ndan (TÜİK) 1995-2019 yılları için süt üretim verileri alınmıştır. Ardahan ili süt üretiminin tahmininde 2020-2025 yılları için Box-Jenkins yöntemi kullanılmış ve ARIMA (0,0,1) modelinin uygun olduğu görülmüştür. Bu modele göre, Ardahan ili süt üretiminin 2020 yılında 414 bin ton, 2021 yılında 439 bin ton, 2025 yılında ise 557 bin ton olacağı tahmin edilmiştir.

Anahtar kelimeler: Süt Üretimi, ARIMA, Tahmin.

1. INTRODUCTION

TRA2 region (Ardahan, Ağrı, Iğdır and Kars) is the least developed and industrialized region in Turkey. Share of industry in gross domestic product (GDP) is low for this region due to its remote geographical location, the absence of qualified workforce, insufficient capital accumulation, distance to the market, and harsh climatic conditions. Economy of this region and Ardahan is predominantly based on the livestock sector. Therefore, livestock sector is important at the strategic level for this region. The livestock sector is the locomotive of rural development since it provides high added value per unit investment and creates employment opportunities with low capital investments (Kutlu et al., 2003).

Milk is one of the most important products of cattle farming. In addition to providing income support to farmers, it creates an important source of income by creating employment opportunities for farmers who have no land. As milk production is a strategic product in terms of both supply and demand, future projections are important in policy makers' short and long-term planning (Ahmed et al., 2011).

Milk production in Ardahan province is 425 thousand tons in 2019 (Turkish Statistical Institute [TÜİK], 2020), having an important share in milk production of the TRA2 region. Average milk yield from cattle is low in the TRA2 region due to poor care and feeding conditions. Cattle spend less time in the pastures due to harsh climatic conditions which in turn increases the staying time in the barn and consumption of more feed. The main problems of stock farmers are high feed costs and decrease in the forage plant production capacity of pastures as a result of climate change. The presence of native breeds in the region is among the factors reducing milk yield (Bakır & Kibar, 2019; Şeker et al., 2012).

Stock farming is still carried out with traditional methods in Ardahan province and TRA2 region. This situation adversely affects milk quality and the fight against animal diseases. Therefore, establishment of modern infrastructure and application of modern techniques are necessary for the production at international standards.
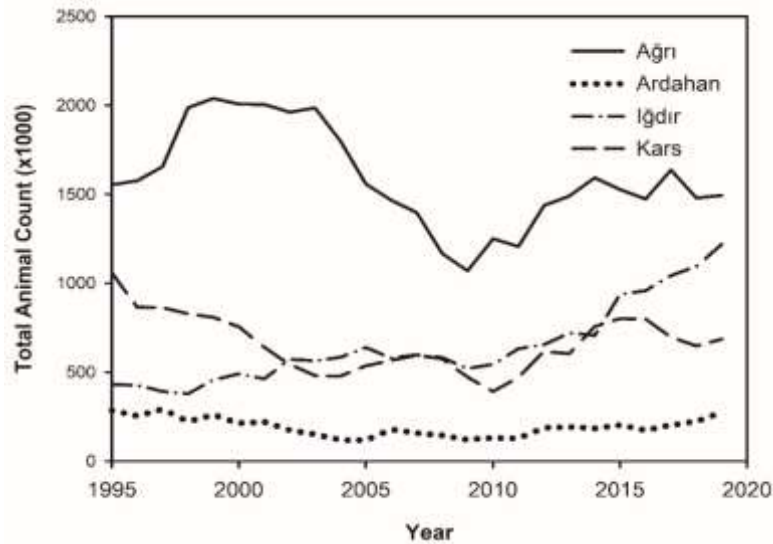

Figure 1. TRA2 Total number of milker animals in the region (TÜİK, 2020)

Figure 1 shows the number of milker animals in the TRA2 Region. While Ardahan province ranks last in the TRA2 region in milker animals, it ranks second in milk production (Figure 2) and first in milk productivity (Figure 3).

Milk production is increased over the years in the TRA2 region even though the number of milker animals have not been increased. The sustainability of increase in milk production depends on the income increase of stock farmers. In this context, it is important for the stock farmers to obtain a satisfactory profit from milk production and to transform milk into high added value products.
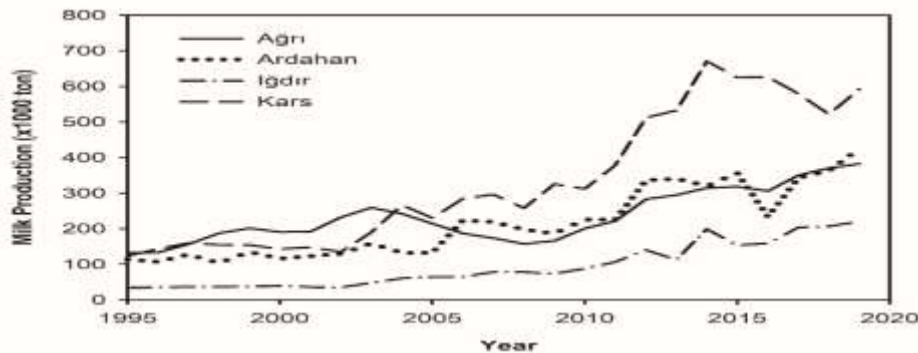

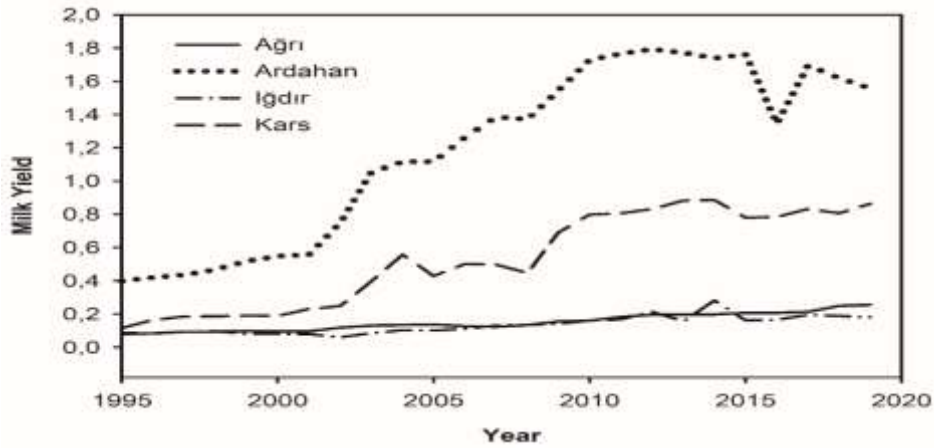**Figure 2.** Milk production in the TRA2 region (TÜİK, 2020)

Figure 3. Efficiency in total milk production (TÜİK, 2020)

In terms of milk productivity Ardahan ranks first in the TRA2 Region (Figure 3). Ardahan has a high milk production potential due to its fertile and broad pastures.

Although the number of cattle has decreased in recent years, there has been a limited increase in milk yield throughout Turkey. It is due to the success of breeding animal imports and breeding practices (İçöz, 2004).

Stock farming has an important place in the provincial economy. Approximately 34% of the GDP of Ardahan province was provided by the agricultural sector, the second income generating sector after the service sector (Figure 3). The low level of agricultural industry prevents the animal products turned into value added products.
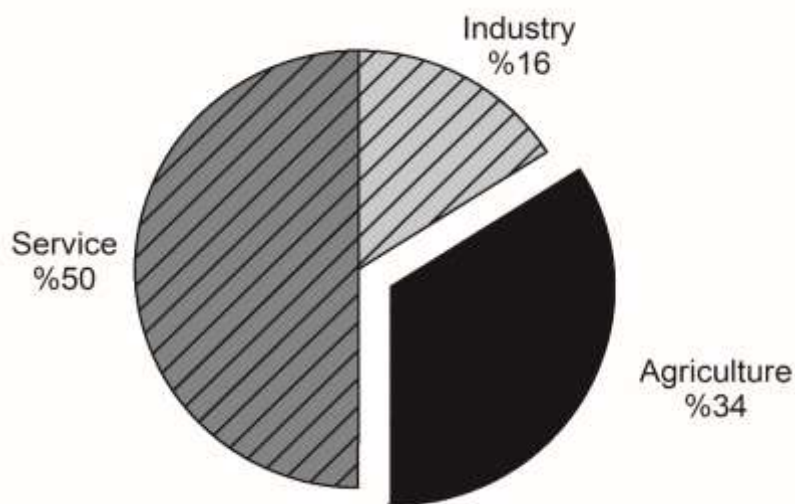

Figure 4. Economic activity sectoral distribution of GDP in Ardahan province (TÜİK, 2020).
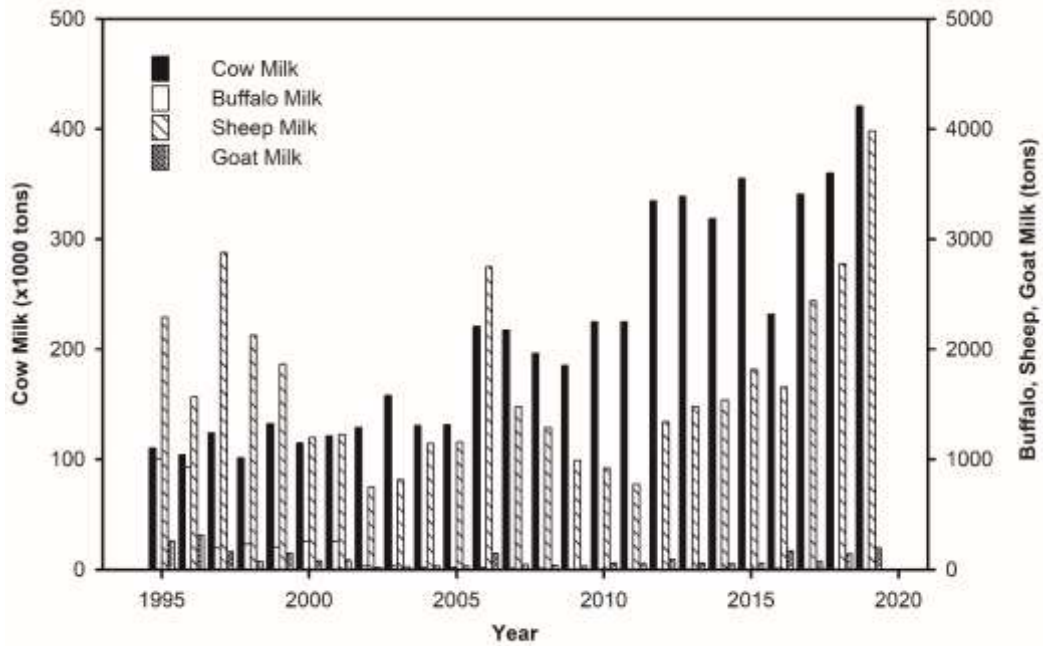
Figure 5. Milk production in Ardahan from different animal species (TÜİK, 2020)

The share of milk production in Ardahan province from different animal species is shown in Figure 5. Cow milk production was much higher than other animal species. Even though there were some fluctuations, cow milk production increased steadily from 1995 to 2019.

In this study, it is aimed to estimate the milk production of Ardahan province until 2025 with the help of ARIMA model. Such studies will reveal beneficial results for other stakeholders in the sector, especially milk producers.

2. LITERATURE REVIEW

Başaran and Engindeniz (2020) studied the fiber cotton production in Turkey for the years 1991-2018 and estimated cotton production for the next five years using ARIMA (4,1,4) model. Özen et al. (2019) studied meat consumption per capita by Box Jenkins and exponential smoothing models for the years from 1993 to 2017. Estimation was made according to ARIMA (0,1,0) and Brown models, it was concluded that the demand for meat consumption was going to increase in Turkey.

Kurt and Karayılmazlar (2018) estimated the mushroom production in Turkey with the ARIMA (3,2,1) model based on the 1985-2016 period. They concluded that mushroom production would follow an increasing trend. Bars et al. (2018) estimated hazelnut production

in Turkey with ARIMA and they concluded that the best model was ARIMA (1,2,2) model and predicted a fluctuating production for hazelnut. Celik et al. (2017) used ARIMA to estimate peanut production in Turkey for the period of 1950-2015 and stated that the best fit model was ARIMA (0,1,1). In the study of Mgaya (2019), animal product consumption in Tanzania for the years 1961-2013 was estimated by ARIMA and Brown exponential smoothing model.

3. DATA SET AND METHOD
3.1. Data Set

ARIMA model was used to estimate the milk production of Ardahan province, milk production data of the annual data set from 1995 to 2019. The data set was obtained from the regional statistics database of the Turkish Statistical Institute (TÜİK, 2020).

3.2. Method

Box Jenkins ARIMA (p,d,q) model proposed by Box and Jenkins (Box et al., 2015), is one of the common methods used to create the univariate time series forecasting model (Mensah, 2015). The ARIMA model, a mathematical approach to predict a process, was developed by George Box and Gwilym Jenkins in the 1970s. Box-Jenkins modeling involves completing an appropriate ARIMA process, fitting it to the data, and then using the appropriate model for prediction. One of the advantages of this model is that ARIMA operations contain numerous models and generally provide sufficient explanation for the data (Hyndman, 2001).

A non-seasonal ARIMA model is denoted by ARIMA (p,d,q), which is a combination of autoregressive (AR) and moving average (MA) and the order of integration or differentiation. Here, d represents the difference, p correlation and q moving average coefficients (Dasyam et al., 2015).

Autoregressive models are models in which the value of a variable in one period is related to its value in previous periods. The autoregressive process at the p level is expressed by AR(p) and is expressed as in equation 1.

$$AR(p): Y_t = \beta_0 + \Sigma \beta_i Y_{t-i} \quad pi=1 + \epsilon_t \tag{1}$$

Moving average models, on the other hand, are models in which there is a relationship between a variable and residuals from the previous period. The moving average model at the p level is expressed as MA(p) and shown as in equation 2.

$$MA(q): Yt = \alpha 0 + \epsilon t + \Sigma \alpha i \epsilon t - iqi = 1 \tag{2}$$

ARMA models are the combination of the two processes mentioned above. A process consisting of autoregressive term (p) and moving average term (q) is shown in equation 3 as ARMA (p, q).

$$ARMA(p, q): Yt = \beta 0 + \Sigma \beta i Yt - ipi = 1 + \epsilon t + \Sigma \alpha i \epsilon t - iqi = 1 \tag{3}$$

Time series should be stationarity to use these models for an estimation. There is no trend in stationary processes since mean and variance do not change over time. In the process of estimating ARMA (p, q) models, non-stationary series mathematically transformed into stationary series by taking the difference. A series that becomes stationary when its first difference is taken, denoted by I (1). The combination of all these processes creates integrated moving average (ARIMA) models.

3.3. Testing the Stationarity of the Series

The stationarity of the series was tested first to conduct the time series analysis. The unit root test results of the series are given in Table 1.

Table 1. ADF unit root test results

Test		t- Statistics	Significance
ADF Statistics		-6.557295	0.0000
Critical Values	%1	-2.669359	
	%5	-1.956406	
	%10	-1.608495	

To determine the best fitting model for estimating of the amount of milk production, various models were tested. The best model explaining the series was chosen for having Theil equality coefficient below 1 and the lowest Mean Absolute Percent Error (MAPE), Akaike Criterion, Hannan-Qinn and Schwarz Criterion values among the models (Başaran & Engindeniz, 2020; Güler et al., 2017). These values of the predicted models were shown in Table 2. Among these models, ARIMA (0,0,1) model was chosen for having the lowest AIC, BIC and HQ values. Statistical values for ARIMA (0,0,1) model were given in Table 3.

Table 2. ARIMA models statistics for milk production

Model	LogL	AIC*	BIC	HQ
(0,0,1)	69.481059	-5.540088	-5.392832	-5.501021
(1,0,1)	69.613348	-5.467779	-5.271437	-5.415689
(0,0,2)	69.612362	-5.467697	-5.271355	-5.415607
(0,0,3)	69.625054	-5.385421	-5.139993	-5.320309
(2,0,1)	69.618779	-5.384898	-5.139470	-5.319786
(1,0,2)	69.614565	-5.384547	-5.139119	-5.319435
(3,0,1)	70.075264	-5.339605	-5.045092	-5.261471
(0,0,4)	70.029227	-5.335769	-5.041255	-5.257634
(2,0,2)	69.649218	-5.304102	-5.009588	-5.225967
(1,0,3)	69.635580	-5.302965	-5.008452	-5.224831
(1,0,4)	70.354728	-5.279561	-4.935962	-5.188404
(1,0,0)	66.186886	-5.265574	-5.118317	-5.226507

Table 3. Estimation of the selected model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.290466	0.049456	106.9741	0.0000
MA(1)	0.741596	0.268968	2.757191	0.0115
SIGMASQ	0.019749	0.007680	2.571528	0.0174
R-squared	0.487952	Mean dependent var		5.283835
Adjusted R-squared	0.441403	S.D. dependent var		0.200439
S.E. of regression	0.149807	Akaike info criterion		-0.814834
Sum squared residual	0.493727	Schwarz criterion		-0.668569
Log likelihood	13.18543	Hannan-Quinn criter.		-0.774267
F-statistic	10.48238	Durbin-Watson stat		1.125543
Prob(F-statistic)	0.000634			

The results of unit root test applied to error terms of the ARIMA (0,0,1) showed that model he suitable according to ADF and Phillips and Perron tests (Table 4).

Theil inequality coefficient was calculated as 0.308 in the ARIMA (0,0,1) model indicating that the estimation error rate is low and it fits the model well.

Table 4. ADF and Phillips-Perron test

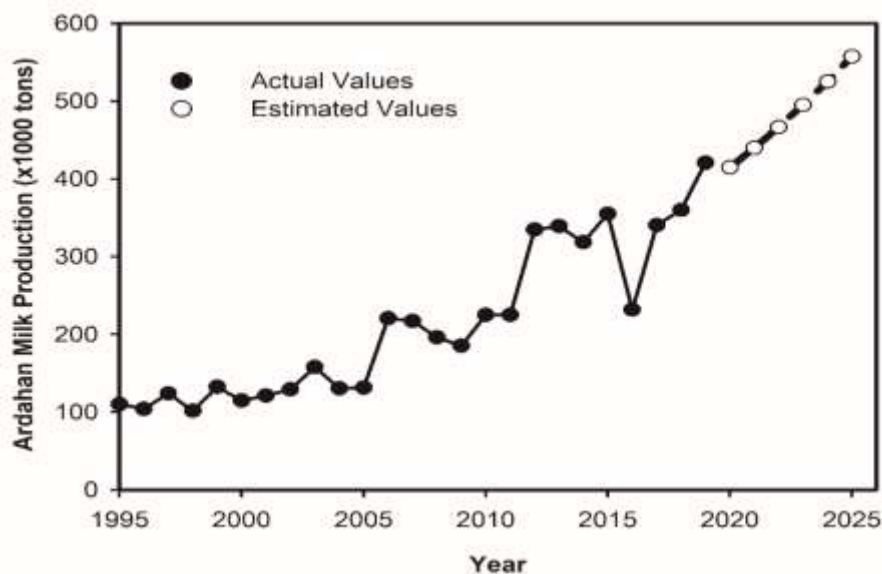|		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.715792	0.0000
Test critical values:	1% level	-4.394309	
	5% level	-3.612199	
	10% level	-3.243079	
		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.758205	0.0000
Test critical values:	1% level	-4.394309	
	5% level	-3.612199	
	10% level	-3.243079	

Figure 6. Milk production trend of Ardahan province for the period of 1995-2025

After the conducting compliance, milk production amount was estimated for Ardahan province. According to the ARIMA (0,0,1) model, it is estimated that milk production in Ardahan will increase over the years. Milk production in Ardahan province was estimated as

414 thousand tons in 2020 and 557 thousand tons in 2025, an increase of 31.05% compared to 2019.

4. CONLUSION

In this study, milk production of Ardahan province was estimated using the ARIMA model for the period 1995-2019. The data set was obtained from the regional statistics database of the Turkish Statistical Institute (TUIK). ARIMA (0,0,1) model was used to estimate the milk production of Ardahan province for the years of 2020-2025. Milk production in Ardahan was estimated as 414, 439, 466, 495, 525, 557 thousand tons for 2020, 2021 2022, 2023, 2024 and 2025, respectively.

Projected increase in the amount of milk production in Ardahan province would affect milk and cheese producers. Forecasting milk production in Ardahan may help in production and future investment planning of the Kashar cheese producers, which are prominent in dairy sector. Increases in milk production would increase capacity utilization of enterprises producing Kashar cheese, where a significant part of them works under their capacity. The spread of studies on the estimation of milk production, a strategic product for the Ardahan economy, is important for the future of the sector.

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