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Modeling and Forecasting Meat Consumption per Capita in Turkey

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Summary: The objective of this study is to model the per capita consumption of red meat in Turkey employing various time series methods, evaluate the forecasting capability of the developed models, and address the variables that may affect the per capital consumption of red meat using the cointegration method on a term basis (short/long). The material of the study consists of the per capita consumption of red meat, total annual population, feed prices, gross domestic product and share of agriculture in gross domestic product in Turkey between 1993 and 2017. ARIMA (0,1,0) and Brown's exponential smoothing method were employed to model the time series data for per capita consumption of red meat, and Johansen method was used to address the cointegration relationship between per capita consumption of red meat and the other variables. The results of the modelling work suggest that per capita consumption of red meat has an increasing trend. Additionally, a statistically significant short-term relationship was found between per capita consumption of red meat and the other variables. Given the relationship between consumption of red meat and level of economic development, the projections concerning red meat consumption are important from the viewpoint of the policies that will be formulated.
Key words: ARIMA, modeling, red meat consumption, time series

Türkiye'de Kişi Başına Düşen Et Tüketiminin Modellenmesi ve Geleceğe Yönelik Tahmini

Özet: Bu araştırmanın amacı Türkiye'de kişi başına düşen kırmızı et tüketiminin çeşitli zaman serisi yöntemleri ile modellenmesi, oluşturulan modellerin öngörü yeteneğinin değerlendirilmesi ve kişi başına düşen kırmızı et tüketim miktarına etki edebilecek değişkenlerin dönemsel bazda (kısa-uzun) kointegrasyon yöntemi ile incelenmesidir. Çalışmanın materyalini 1993-2017 yılları arasında Türkiye'de kişi başına düşen kırmızı et tüketimi, yıllık toplam nüfus, besi yemi fiyatları, gayri safi yurtiçi hasıladan tarım ve hayvancılık sektörünün payı ve toplam gayrisafi yurt içi hasıla bilgileri oluşturmaktadır. Kişi başına düşen kırmızı et tüketimi serisinin modellenmesi için ARIMA (0,1,0) ve Brown üstel düzgünleştirme yöntemleri kullanılmış olup, kişi başına düşen kırmızı et tüketimi ile elde edilen diğer değişkenler arasındaki koentegre ilişki Johansen yöntemi ile incelenmiştir. Modelleme sonuçlarına göre kişi başına düşen kırmızı et tüketiminde artan bir trend öngörülmektedir. Ayrıca kişi başına kırmız et tüketimi ile elde edilen tüm değişkenler arasında istatistiksel açıdan anlamlı kısa dönemli bir ilişki bulunmuştur. Kırmızı et tüketiminin ekonomik gelişmişlik ile olan ilişkisi düşünüldüğünde yapılan projeksiyonların, oluşturulacak politikalar açısından önemli olduğu düşünülmektedir.
Anahtar kelimeler: ARIMA, kırmızı et tüketimi, modelleme, zaman serisi

Introduction

As the world population is growing, the demand for meat and meat products that have an important place in human health and nutrition is steadily increasing. Consumption of red meat and meat products is crucial for ensuring healthy and balanced nutrition in Turkey where the population is increasing rapidly.

The average share of animal production in total agricultural production in Turkey in 2017 was 58%. About thirty seven percent of that was production of animal products. The share of red meat production in total production of animal products was 44.1%. Eighty seven percent (87.8%) of the total production of red meat was beef, 9% mutton and 3.1% goat meat (23).

One of the primary criteria used to determine the countries' level of development is the per capita consumption of meat and animal protein (27). The per capita consumption of red meat in Turkey is 14.6 kg, which is far below the average values in Europe and the US (19). The primary factor affecting the level of red meat consumption is the structure of the demand for red meat, and the two important factors that contribute to the formation of this demand are price of red meat and average income of consumers. Akbay et al. (1) note that the price elasticity and income elasticity of demand for red meat are -1.89 and 0.32, respectively. Some other studies in the literature report that the price elasticity of demand for red meat is -1.59 (4) and -1.22 (3).

The dynamic structure of consumption preferences and the socioeconomic changes affect consumption

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of foods, including red meat. Hence, the measuring of the level of red meat consumption in different periods and projections based on such data can provide valuable information that can be used to ensure efficient and sustainable production and formulate policies aimed at consumers.

The previous studies concerning red meat consumption in Turkey usually focused on the modelling of supply and demand in an econometric context, employing various statistical analysis methods such as linear approximated almost ideal demand system (LA/AIDS) (3,16,21), linear regression analysis (9), logistic regression (24), Bayesian MCMC (4), and ARIMA (8, 25, 26). However, no study that focuses specifically on the co-integration between various factors that may affect red meat consumption through modelling of per capita consumption of red meat using time series data could be found.

The objective of this study is (i) to model the per capita consumption of red meat in Turkey between 1993 and 2017 employing Box-Jenkins and Brown's Exponential Smoothing methods, (ii) to evaluate the forecasting capability of the developed models, and (iii) to address the variables that may affect the per capita consumption of red meat using the co-integration method on a term basis (short/long).

Material and Methods

Data collection tools and process

The data for the study consist of the total production of red meat (tons), total population (people), feed prices (annual average compound feed prices for growing and fattening), agricultural gross domestic product (share of agriculture, TURKSTAT - constant prices of 1998), total gross domestic product (USD$) and per capita consumption of red meat (kg/person) (14) (19,23,28).

Statistical analyses

Forecasts were made using the Box-Jenkins and Brown's exponential smoothing methods in the time series analyses. The Box-Jenkins method is composed of the combination of autoregressive model (AR) and moving average (MA) model of stationary time series. However, the Box-Jenkins method requires the time series to be stationary. In order to make the series stationary, *d* difference of the series is taken. Then, it is included in the ARMA model to obtain the ARIMA (autoregressive integrated moving average) model.

Such non-seasonal models are denoted by ARIMA (*p,d,q*). In an ARIMA model, *p* is the degree of the autoregressive model (AR), *q* is the degree of the moving average model (MA) and *d* is the degree of the non-seasonal differences taken. The ARMA model is as given in equation [1] (5,6).

$$Y_t = \sum_{i=1}^{q} \beta_i \, \varepsilon_{t-i} + \sum_{i=1}^{p} \alpha_i \, Y_{t-i} + \varepsilon_t \quad [1]$$

Equation (2) is obtained when the first difference of the nonstationary time series X_t is taken.

$$\nabla X_t = X_t - X_{t-1} = X_t' \quad [2]$$

If the time series X_t' is still not stationary, its second difference (d=2) is taken.

$$\nabla^2 X_t = \nabla(X_t') = X_t' - X_{t-1}' = X_t - 2X_{t-1} + X_{t-2} \quad [3]$$

If the series is still not stationary, the differencing is repeated until it becomes stationary. Thus, the ARIMA (p,d,g) model is obtained (7).

$$X_t = \nabla^d Y_t = (1 - B)^d Y_t \quad [4]$$

After testing the stationarity of the series using ADF (Dickey-Fuller) unit root test, the forecasts of each series for the period 2018-2023 were made using the ARIMA model. The autocorrelation and partial autocorrelation functions of each series were reviewed and the significance of the parameters were checked to determine the best ARMA (p,d,q) model. In selecting the optimum forecasting model that gives the best results for the period 2014-2017, the information criteria such as RMSE, MAE, MAPE, and SIC were used, and the forecasts were made using this model.

Another method employed to make forecasts in the study was Brown's exponential smoothing method, which is used when the series has a trend. In the exponential smoothing method, the additive model is as follows:

$$M_t = \frac{(x_t) + (x_{t-1}) + \cdots + (x_{t-N}) + 1}{N} \quad [5]$$

Where

$$x_t = a + b_t \quad [6]$$

$$x_t = a\varepsilon_t$$

$$M_t = k - period\ moving\ averages$$

The equation of the updated trend component is given in equation [7].

$$M_t = M_{t-1} \frac{(x_t) - (x_{t-N})}{N} \quad [7]$$

The equations for simple, double and triple exponential smoothing of the updated component are given in

[8], [9] and [10], respectively.

$$S_t(x) = \alpha(x_t) + (1-\alpha)S_{t-1}(x) \quad [8]$$

$$S_t(x) = \alpha(x_t) + (1-\alpha)[\alpha(x_{t-1}) + (1-\alpha)S_{t-2}(x) \quad [9]$$

$$S_t(x) = \alpha\sum_{k_0}^{t-1}(1-\alpha)^k(x_{t-k}) + (1-\alpha)^t(x_0) + (1-\alpha)[\alpha(x_{t-1}) + (1-\alpha)S_{t-2}(x) \quad [10]$$

In the formula, $S_t(x)$ denotes the forecast for the next period (t+1), S_{t-1} the forecast for the previous period and α the smoothing coefficient or weight.

Following the completion of the parameter forecasts of the models, the Q-statistic developed by Box-Pierce (Ljung-Box) was used to check the goodness of fit of the model to the data, employing the error terms.

Additionally, the relationships between the per capita consumption of red meat and the total production of red meat (tons), total population (people), feed prices, agricultural gross domestic product (share of agriculture) and gross domestic product (USD$) between 1993 and 2017 were tested by cointegration analysis technique. Prior to the cointegration test, the stationarity of the series was checked using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. After confirming that the series were integrated of the same order, the co-integration test was conducted using the Johansen method. The Johansen method uses the maximum likelihood approach to estimate the co-integration vector, and is basically a generalized version of the Dickey-Fuller method.

$$X_t = \Pi_1 X_{t-1} + ... + \Pi_k X_{t-k} + e_t, t = 1,2,..., \quad [11]$$

Here, X denotes the vector of the variables represented by past values. This denotation refers to the variables using the past model values in the VAR model. If we express the model in moving averages, we obtain the following equation.

$$A(e) = I - \Pi_1 e - ... - \Pi_k e_k \quad [12]$$

The rank r of matrix A gives the number of matched vectors, and in equations where r<p the variable with dimension p can be at most one less than the number of vectors. The error term has white noise process.

$$A(e)\big|_{e=1} = \Pi = I - \Pi_1 - ... - \Pi_k,$$
$$\Pi = \alpha\beta' \quad [13]$$

The coefficients matrix Π is the sum of the matrices α and β' with dimension (pxr). α denotes the adjustment rate, and β' denotes the matrix obtained by maximum likelihood method where the number of rows is equal to the number of cointegrating vectors.

Then, this method is used to evaluate the hypothesis that there is at most r cointegrating vectors through maximum likelihood estimation.

$$-2\ln(Q) = -T\sum_{i=r+1}^{p}\ln(1-\hat{\lambda}_i) \quad [14]$$

The critical values to which the statistical values of λ_{trace} and $\lambda_{\max}$, obtained from the tests, are highlighted in the study by Johansen and Juselius (18).

In order to determine the common lag length of the variables in the equation, the Final Prediction Error (FPE), Hannan-Quinn (HQ), Schwarz (SW), Likelihood Ratio (LR) and Akaike Information Criterion (AIC) were used. The short- and long-term relationships were determined using the Johansen method, and forecasts for per capita consumption of red meat were made using the optimum error correction model.

All analyses were conducted using Stata 12 MP4 (Licence: 9869264) and EViews 10 Enterprise Edition (Retrieved 17 June 2017).

Results

Time series graph of per capita consumption of red meat is given in Figure 1. The data for per capita consumption of red meat between 1993 and 2017 presents a plateau between 1993 and 2007, a decreasing trend between 2007 and 2009 and an increasing trend between 2009 and 2017 (Figure 1).

The results of the augmented Dickey-Fuller test conducted to check the stationarity of the series after its logarithmic transformation indicate that the series was not stationary before taking its difference (t=-1.254; P=0.758) and became stationary after taking its first difference (D1) (t=-11.258; P=0.001) (Figure 1). In addition to the stationarity tests for the series, the autocorrelation function (ACF) and partial autocorrelation function (PACF) coefficients were calculated and graphed (Figure 2) in an attempt to determine the AR(p) and MA(q) values required to develop a forecast model for red meat consumption.

The graphs of ACF and PACF coefficients indicate that none of the coefficients is outside the confidence

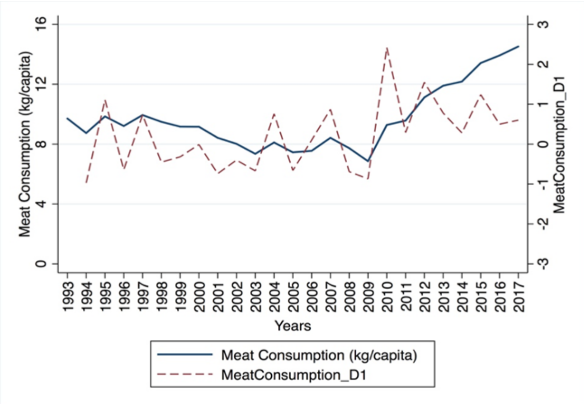

Figure 1. Per capita consumption of red meat between 1993 and 2017 (kg/person)

interval (Figure 2). This suggests that the optimum ARIMA model for forecasting the per capita consumption of red meat is (0,1,0) model.

Table 1 and Figure 3 give the forecast values of per capita consumption of red meat for the period 2018-2023. Accordingly, both the ARIMA and Brown models forecast that per capita consumption of red meat has an increasing trend (Table 1).

The results of the Q-test conducted to confirm the suitability of the models for forecasting indicate that both models are suitable (Q_{ARIMA}=18.51; P=0.423,

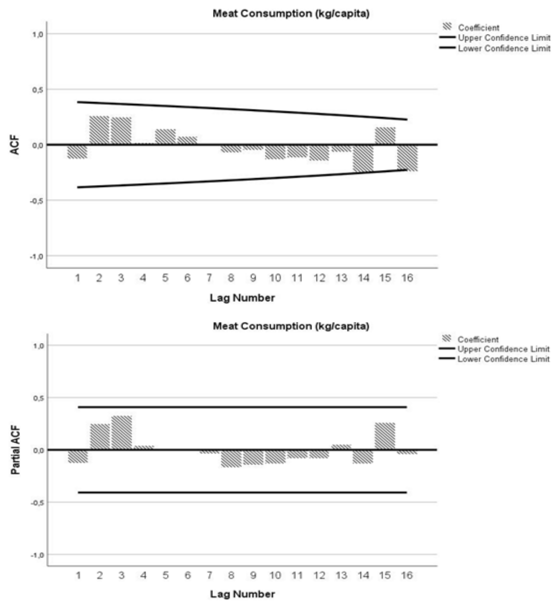

Figure 2. (a) Autocorrelation function (ACF) and (b) partial autocorrelation function (PACF) graphs for per capita consumption of red meat

Q_{Brown}=10.83; P=0.865). The goodness of fit criteria for both models are given in Table 2.

Although the values of the goodness of fit criteria for the models were quite close to each other, Brown model provided better results in all of the criteria, excluding maximum absolute error (MaxAE) and maximum absolute percentage error (MaxAPE). This suggests that Brown's exponential smoothing model can provide more consistent results than the ARIMA model, as shown by the calculations of the forecast values.

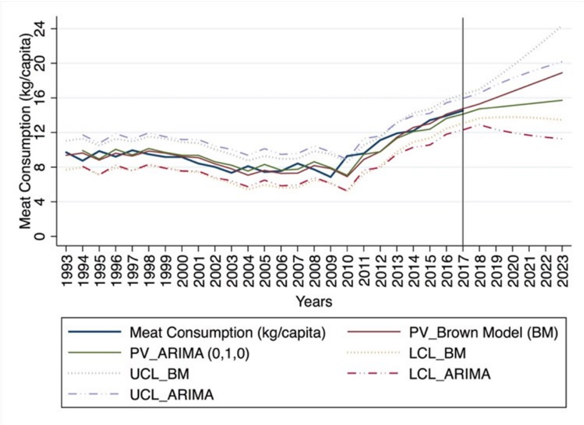

Figure 3. Forecast values for per capita consumption of red meat between 2018 and 2023, obtained from ARIMA and Brown models

Longitudinal price graphs of the variables are given in supplement data. Accordingly, the share of agriculture in gross domestic product has a decreasing trend, whereas the gross domestic product, feed prices, amount of red meat production and population have an increasing trend (Supplement data).

The series were checked for stationarity prior to the cointegration test. The results of the ADF and PP tests are given in Table 3. The results in Table 3 indicate that all of the variables have a unit root.

The coefficients of the Final Prediction Error (FPE), Hannan-Quinn (HQ), Schwarz (SW), Likelihood Ratio (LR) and Akaike Information Criterion (AIC) calculated to determine the common lag length of the variables in the equation are given in Table 4.

The results in Table 4 indicate that all criteria provide the same result as the optimum lag length. Hence, the necessary synchronization can be used as an optimal lag in a synchronicity study.

The test results obtained by the Johansen method in the co-integration study are given in Table 5. According to the results in Table 5, a statistically significant co-integration relationship was found between the variables (P<0.05). At an error margin of 5%, there is a quite short-term relationship between the variables.

Tablo 1. Forecast values of per capita consumption of red meat for the period 2018-2023

Year	Actual Value	ARIMA (0,1,0)			BROWN MODEL		
		Forecast	95 % CI		Forecast	95 % CI	
			L.B	U.B		L.B	U.B
2014	12.18	12.1	10.28	13.92	12.58	10.91	14.25
2015	13.42	12.38	10.56	14.2	13.02	11.35	14.69
2016	13.92	13.62	11.8	15.44	14.11	12.44	15.78
2017	14.52	14.12	12.3	15.94	14.74	13.07	16.41
2018		14.72	12.9	16.54	15.3	13.63	16.97
2019		14.92	12.35	17.49	16.02	13.75	18.3
2020		15.12	11.97	18.27	16.74	13.77	19.71
2021		15.32	11.68	18.96	17.46	13.73	21.2
2022		15.52	11.45	19.59	18.18	13.62	22.75
2023		15.72	11.26	20.18	18.9	13.45	24.35

CI: Confidence Interval, LB: Lower Bound, UB: Upper Bound

Tablo 2. Goodness of fit criterias for the models used for forecasting

Model Fit Criteria	ARIMA (0,1,0)	Brown Model
R-squared	0.833	0.851
RMSE	0.877	0.809
MAPE	7.904	6.915
MaxAPE	23.918	25.536
MAE	0.727	0.63
MaxAE	2.22	2.37
Normalized BIC	-0.124	-0.295

RMSE: Root mean square error, MAPE: Mean absolute percentage error, MaxAPE: Maximum absoulte percentage error, MAE: Mean absolute error, MaxAE: Maximum absolute error, BIC: Bayesian information criteria

Tablo 3. Results of ADF ve PP test statistics

Variables	ADF	PP
Δ Meat consumption (OECD), kg/capita	-5.381	-5.324
Δ GDP (current US $)	-4.747	-4.703
Δ Fixed capital investments on agricultural GDP) (TURKSTAT) - 1998 at fixed prices	-6.742	-9.576
Δ Price of fattening feed	-4.423	-4.723
ΔTotal population (person)	-4.428	-4.428
ΔTotal amount of red meat produced (tonnes)	-5.539	-5.551

Δ Meat Consumption (OECD), kg/capita
Δ GDP (current US$)
Δ Fixed capital investments on agricultural GDP) (TURKSTAT) - 1998 at fixed prices
Δ Price of fattening feed
ΔTotal population (person)
ΔTotal Amount of Red Meat Produced (tonnes), variables, first differences were taken, constant and trending were added to unit root research. Critical values for ADF and PP are -3.62% for 5%. ΔHBA variable was taken into regression analysis with first degree difference, not constant and without trend. The critical value for the 5% is 1.96

Tablo 4. Criterias used to determine lag levels for the variables

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1298.104	NA	7.15e+41	113.400	113.696	113.474
1	-1179.970	164.361	6.37e+38	106.258	108.331	106.779
2	-1117.100	54.669*	1.35e+38*	103.921*	107.772*	104.890*

* indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Tablo 5. Results of the Johansen cointegration test statistics testi sonuçları

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	P**
0.389	15.411	15.494	0.0515	0.0389
0.187	4.567	3.841	0.0326	0.0187

** Trace statistics and maximum eigenvalue statistics show that there is a cointegrated vector at 1% and 5% significance level. The cointegration test does not include linear deterministic constant constraint and trend

Discussion and Conclusion

One of the areas in which the agricultural production statistics are the most questionable is the forecast of red meat production. However, it is important to have almost accurate figures concerning red meat production and formulate production policies accordingly, because there is a significant positive relationship between red meat production and level of economic development (20). The forecasts for total and per capita consumption of red meat were made based on the actual data. This can be accounted for by the fact that unregistered slaughters are actually higher, as highlighted by Yavuz et al. (25), and by the difference of methods employed by national and international organizations such as TURKSTAT, FAO, Agricultural Economics Research Institute (TEAE), etc.

The time series for per capita consumption of red meat do not tend to move around a constant average over time, meaning that they are not stationary. The unit root tests also confirm this finding. The main reasons for the structural breaks in the trend of the series include abrupt changes in policy, economic fluctuations and crises, factors that cannot be predetermined such as import of carcass and livestock for slaughter and breeding, and other socioeconomic developments (22).

Considering the accuracy of the forecasts by the ARIMA and Brown models for the period 2014-2017, it can be said that both models are quite successful. For the period 2018-2023, the ARIMA model forecasts a horizontal trend, whereas the Brown model predicts that the increasing trend after 2009 will continue in the same way.

In order to make accurate forecasts, it is essential that the data are accurate and reliable. Additionally, we chose to look into the co-integration relationship between per capita consumption of red meat, GDP and agricultural GDP, as they are among the data taken into account concerning the countries' level of development, these figures are collected more reliably than many other data in Turkey, and they can be obtained retrospectively.

A significant portion of cointegration studies are rather based on hypothesis testing aimed at proving the existence of a cointegration relationship. Hence, such studies consider the purpose of forecasting more rarely. The reason for this is that the presence of long-term relationships between variables is usually a prediction of the theoretical model. The earliest studies concerning forecasting in cointegration systems were conducted by Engle and Yoo (11), Engle et al. (12), Fanchon and Wendel (13), Hall et al. (15), and Hoffman and Rasche (17). Duy and Thoma (10) scrutinized the relevant literature. The error correction models used to make forecasts in this study may not be considered favourable forecast models in every aspect. Thus, the analysis was conducted to show the presence of the cointegration relationship between only the relevant variables in accordance with the literature.

It was found that there was a short-term cointegration relationship between per capita consumption of red meat and real GDP per capita, prices, population, total red meat production. This short-term relationship should be addressed from two viewpoints. One of them is the factors affecting the organizations that produce red meat, and the other one is the factors affecting the consumers that buy the produced meat. An example of the major factors affecting the red meat producers in Turkey is the import of carcass and livestock for slaughter in various amount and subject to various customs duties since 2010 (2). Another major factor is the decreasing profitability of enterprises due to increasing cost of inputs (feed material, feed price, etc.) because of the fluctuations in the exchange rate, combined with the import of livestock for slaughter, and the subsequent failure to achieve the expected increase in the level of total red meat production, as they gave up the production process. The decreasing production, which is insufficient to meet the demand, brings with it price increases, thereby reducing the consumers' demand for red meat. The demand for red that increases again as a result of suppression of prices as a result of the import policy followed during various periods as a measure against the rising prices can account for this short-term relationship from the viewpoint of consumers. Among the short-term effects for consumers in Turkey is the falling demand for red meat due to the decreasing purchasing power of consumers as a result of increasing inflation recently. The abovementioned examples account for the upward and downward diversity of lower and upper limits of the forecast models in this study.

One of the major nutritional problems in Turkey is that people have an unbalanced and inadequate diet. This diet is predominantly composed of cereals and vegetables, and the level of consumption of animal products is below that in developed countries. Moreover, the gap between Turkey's and developed countries' per capita consumption of red meat is even larger.

The comparison of the forecasts and actual figures did not provide any clear information concerning the superiority of any of the models to the other one. In order to take right decisions regarding the food and agricultural policies to be followed, there is need for development of suited time series analysis models in the projections aimed at resolution of the sector's structural problems. It can be said that the structural problems have not been able to be resolved for long and that some political practices concerning the livestock sector are in a vicious circle.

Records should be kept reliably at both macro and micro (enterprise) level in the livestock sector so that time series models can be developed and similar studies can be conducted more soundly. Introduction of a reliable registration system involving the livestock sub-sectors in Turkey is of great importance. If a proper and reliable registration system is introduced to ensure better resolution of the long-standing problems in the livestock sector, more reliable forecasts can be made for the sub-sectors, thereby allowing long-lasting government policies to be implemented. This study will give ideas to future studies focusing on different livestock sub-sectors.

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