Research Paper

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# Forecasting Numbers of Poultry in Turkey Using Exponential Smoothing Techniques

Agricultural Science

**KEYWORDS :** Exponential Smoothing, forecasting, poultry

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## ABSTRACT

*In this study, forecast number of poultry carried out. Hens-cocks and turkey was estimated from the period 2016 to 2025 by means of annual of the animal number in Turkey. For this purpose, Holt, Brown and Damped Trend smoothing methods were worked to forecasting the time series data. Goodness of fit criteria kind of R2, RMSE and BIC criteria were compared exponential smoothing methods in the coverage of the number of poultry in the study. Number of hens-cocks in Turkey from the period 2016 to 2025 were forecasted by using Holt exponential smoothing method. Number of turkey in Turkey from the period 2016 to 2025 were forecasted by using Damped exponential smoothing method. Number of hens-cocks and turkey were forecasted from the period 2016 to 2025 ranged 315 994 000 to 349 641 000 and 2 917 000 to 3 098 000 respectively. As a result, increase number of poultry will has been expected in Turkey by 2025.*

**Introduction**

Poultry are necessary in order to the people's white meat and eggs needs. Besides, poultry producers plays an important role in both animal food and poultry using its international technology and they contribute to the country economy.

The National Research Council's (1994) nutrient recommendations for broiler chickens are based upon feeding a starter diet for 21 days, followed by a grower diet until 42 days of age, and a finisher diet from 42 to 56 days. The role of most interest to poultry nutritionists is the interconversion between Gly and Ser (Coon and Couch, 1975; Featherston, 1975; Ngo and Coon; 1976)

According to FAO (2014) statistics, the greatest hens-cocks have been performed China in the world with number of 4 632 640 000. USA is in second rank after China with hens-cocks number of 1 982 900 000. Indonesia is in third number of 1 923 068 000 and Turkey is 11th ranknumber of 293 728 000 in the world. The greatest turkey have been performed USA in the world with number of 237 500 000. Chile is in second rank after USA with turkey number of 32 000 000. Brazil is in third number of 28 900 000 and Turkey is 17th rank number of 2 990 000 in the world. According to the TSI statistics, the number of hens-cocks is 312 256 000, the number of turkey is 2 828 000 in Turkey in 2015.

Gürcan and Cenan (2011), determined the time series data number of cattle and small ruminant from period 1936-2005 in Turkey using Box-Jenkins methods. Inci et al. (2013) reported, since the 1980 shave been evaluated the current condition of turkey farming, problems encountered by farmers, improvement opportunities, solutions, turkey meat demand and consumption in Turkey and in Bingol. Çelik (2015), fasten down number of small ruminant model and forecastingfrom period 1930-2014 in Turkey by ARIMA models.

The purpose of this study, is made to forecast number of hens-cocks and turkey from 2016 to 2025 to using Holt, Brown and Damped Trend exponential smoothing methods.

**Statistical Methodology and Data:**

The agricultural data on the numbers of poultry from the period 1936 to 2015 evaluated in the study were supplied from "Statistical Indicators" book published by TUIK 2014. Likewise, the data of the subsection "Poultry Production" of Livestock Statistics in TUIK database were also utilized (TUIK, 2015).

In this section a review of exponential smoothing techniques have been carried out, since to find the model that returns the smallest error in observations, an extensive search is required.

Exponential smoothing techniques are techniques updating the estimates by taking account of the last change and spikes in the time series data. These spikes are occurred by random changes, the unexplained effects, or the unpredictable developments ignored (Kadilar, 2009).

To fit and forecast series with only level and trend pattern, Charles C. Holt developed the Holt's Linear Trend method, that now involves a forecast equation and two smoothing equations, one for the level and one for the trend (Holt, 2004).

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1})$$
$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$
$$\hat{y}_{t+p} = L_t + pT_t$$

Here, : New smoothed value,: Smoothing coefficient, (0<α<1), : Actual value at t. period, : Smoothing coefficient for trend estimation, (0<), : Trend predicted value, p:Number of forecasting periods, : Forecasting value after p period.

Gardner and Mckenzie(1985) introduced a parameter that dampens the trend to a flat line sometime in the future being known as Additive Damped Trend method. Thus, the equations of this method have, in addition to the terms of smoothing (α,γ), a damping parameter φ.

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + \varphi T_{t-1})$$
$$T_t = \gamma(L_t - L_{t-1}) + (1-\gamma)\varphi T_{t-1}$$
$$\hat{Y}_{t+h/m} = L_t + T_t \sum_{i=1}^{h} \varphi^i$$

If 0<<1, the trend is damped, if = 1, the equations become identical to the Holt's Linear Trend method. Tashman and Kruk (1996) defined that there may be value in allocating , if applied in series with a strong tendency, with exponential trend. Nevertheless, Taylor (2003) expressed that if the process is exponential, then a suitable method would be one that actually model such trend, as the method Stan-

dard Pegels. So Taylor introduced a damping parameter to the Exponential Trend method resulting to a Multiplicative Damped Trend method. The equations are presented below.

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1}T_{t-1}{}^{\varphi})$$
$$T_t = \gamma(L_t - L_{t-1}) + (1-\gamma)\varphi T_{t-1})$$
$$\hat{Y}_{t+h/m} = L_t + T_t \sum_{i=1}^{h} \varphi^i$$

The R-squared, BIC (Bayesian information criterion) and RMSE (root mean square error) from goodness of fit criteria can available.

Bayesian information criterion (BIC) was developed by Gideon E. Schwarz (1978), who gave a Bayesian argument for adopting it.

In the statistical comparison of the models, it is meaningful to use statistics like BIC (Pektas, 2013).

RMSE is that the errors are unbiased and follow a normal distribution. The RMSE is calculated for the data set as (Willmott and Matsuura, 2005; Willmott et al., 2009)

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_t - \hat{Y}_t)^2}$$

wheren is the observation number of particles, the exact solution of objective function, the predictive value of objective function.

**Result of the study:**

**The number of hens and cocks**

In this research has been analyzed the poultry number series in Turkey. The historical data is annual, between 1936 and 2015 (Figure 1). It could be seen that a stochastic trend was obtained by the series in the Figure 1. In order to infer the trend more precisely, autocorrelation (ACF) and partial autocorrelation functions (PACF) of the time series are examined.

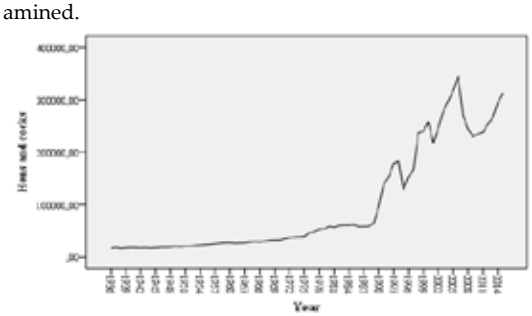
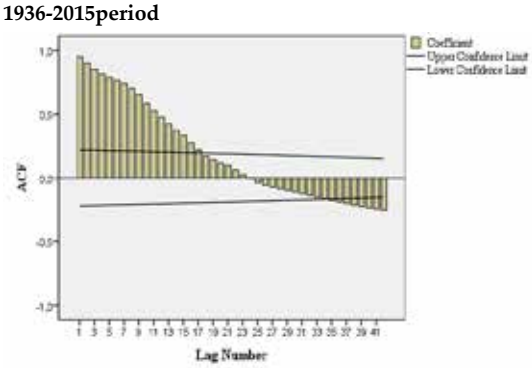



**Figure 1.The graph of the number of hens and cocks from 1936-2015period**



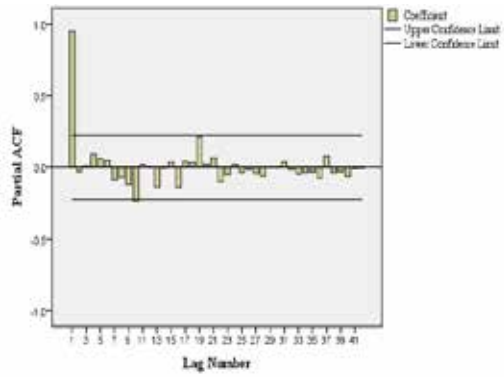




**Figure 2. ACF and PCF graphs of the series of number of hens-cocks and turkey.**

ACF and PACF graphs of the number of hens and cocks are exhibited in Figure 2. Due to the fact that a vast number of terms of the series in ACF graph exceeded confidence limits, a trend is available in the series. For become stationary state of the series, the difference of the series is taken at the first degree. ACF and PACF graphs of the first difference series created for providing the stationary state are showed in Figure 3, and produced evidence of the stationary state.

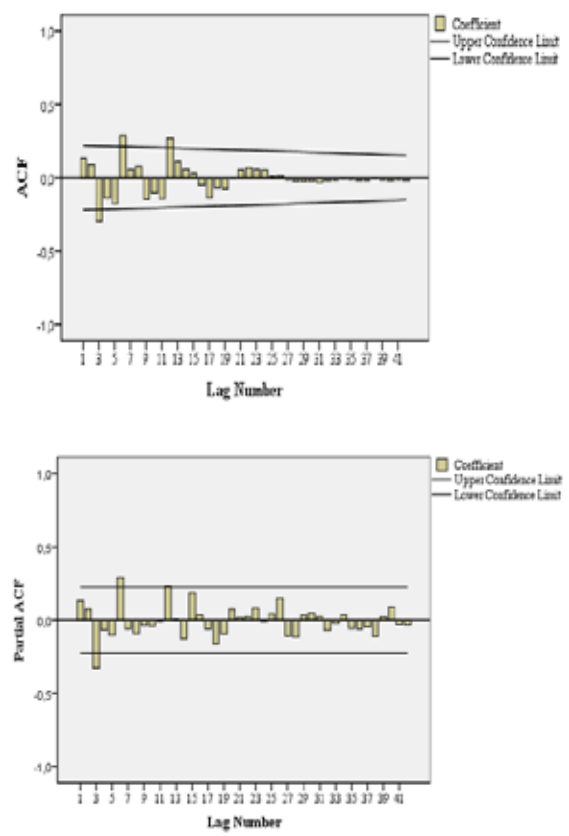



**Figure3.ACF and PACF graphs of the first differences of number of hens-cocks and turkey.**

Following these results, results of model fit statistics such as $R^2$, RMSE and BIC criteria which were evaluated by using Holt, Brown and Damped Trend smoothing methods are presented in Table 1.

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**Table1. Model fitstatistics**

| | Models | | |
|---|---|---|---|
| Criteria | Holt | Brown | Damped Trend |
| R-squared | 0.968 | 0.960 | 0.968 |
| RMSE | 17901.594 | 20072.770 | 18026.256 |
| BIC | 19.695 | 19.869 | 19.763 |

In Table 1, $R^2$ values are 0.968, 0.960 and 0.968 according to Holt, Brown and Damped trend methods, respectively. RMSE values are 17901.594, 20072.770and 18026.256according to Holt, Brown and Damped trend methods, respectively. BIC values are 19.695, 19.869 and 19.763 according to Holt, Brown and Damped trend methods, respectively. From Table 1, it is well understood that Holt smoothing method that value the lowest BIC value and the highest were the best method. Coefficients of Holt smoothing method were determined as and, respectively (Table 2). ACF and PACF graphs of the residuals are presented in Figure 4.

**Tablo 2. Holt Exponential Smoothing Model Parameters**

| Parameters | Estimate | SE | t | Sig. |
|---|---|---|---|---|
| Alpha (Level) | 1.000 | 0.114 | 8.755 | 0.000 |
| Gamma (Trend) | 0.001 | 0.022 | 0.039 | 0.969 |

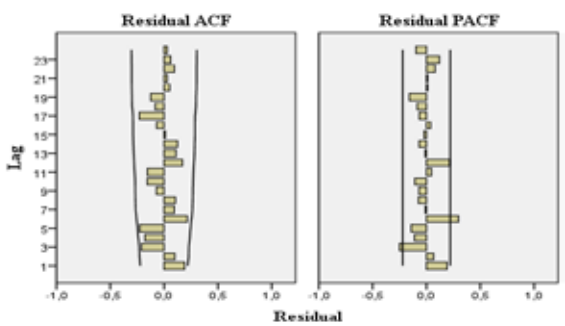



**Figure 4. ACF and PACF graphs of residuals number of hens-cocks and turkey**

From Figure 4, it is seen that relationship amount of sixth lag in the ACF and PACF graphs slightly exceeded confidence limit. Thus, results of Box-Ljung test used to find out whether the residuals have white noise or not are given in Table 3. In the examination of the test results for the first 10 lags, the residuals comprised white noise since significance levels for all lags were greater than 0.05.

**Table 3. Box-Ljung statistics for the residuals**

| Series: Noise residual | | | | | |
|---|---|---|---|---|---|
| | | | Box-Ljung Statistic | | |
| Lag | Autocorrelation | Std. Error[a] | Value | df | Sig.[b] |
| 1 | -0.024 | 0.110 | 0.048 | 1 | 0.826 |
| 2 | -0.032 | 0.109 | 0.133 | 2 | 0.936 |
| 3 | -0.017 | 0.108 | 0.157 | 3 | 0.984 |
| 4 | -0.095 | 0.108 | 0.930 | 4 | 0.920 |
| 5 | 0.008 | 0.107 | 0.936 | 5 | 0.968 |
| 6 | 0.195 | 0.106 | 4.317 | 6 | 0.634 |
| 7 | 0.065 | 0.105 | 4.701 | 7 | 0.696 |
| 8 | 0.036 | 0.105 | 4.821 | 8 | 0.777 |
| 9 | -0.064 | 0.104 | 5.195 | 9 | 0.817 |
| 10 | -0.197 | 0.103 | 8.838 | 10 | 0.548 |
| a. The underlying process assumed is independence (white noise). | | | | | |
| b. Based on the asymptotic chi-square approximation. | | | | | |

At next stage, the forecasting series were graphed together with observation values of the reel series. The obtained graph is depicted in Figure 5, showing that the reel series was compatible with the forecasting series.

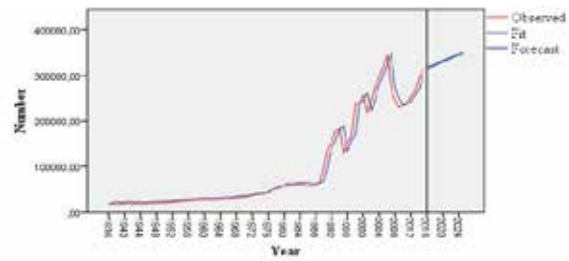



**Figure 5. The graph of number of hens and cocks forecasting series**

After the results obtained above, number of hens and cockscan be forecasted. Forecasting results, lower and upper limits are given in Table 4. An increase in number of hens and cocks from the between 2016-2025 years is estimated.

**Table 4. Forecasting results of between the years 2016-2025 (Hens and cocks)**

| Year | Forecast | LCL | UCL |
|---|---|---|---|
| 2016 | 315994000 | 280355000 | 351633000 |
| 2017 | 319733000 | 269310000 | 370155000 |
| 2018 | 323471000 | 261690000 | 385253000 |
| 2019 | 327210000 | 255840000 | 398579000 |
| 2020 | 330948000 | 251120000 | 410776000 |
| 2021 | 334687000 | 247201000 | 422172000 |
| 2022 | 338425000 | 243889000 | 432961000 |
| 2023 | 342164000 | 241057000 | 443270000 |
| 2024 | 345902000 | 238616000 | 453188000 |
| 2025 | 349641000 | 236502000 | 462779000 |

LCL: Lower confidence limit, UCL: Upper confidence limit

**Number of Turkey**

From Figure 6, which presents the number of turkey in Turkey, an approximately stochastic trend is noticed and a sudden change in 2001.

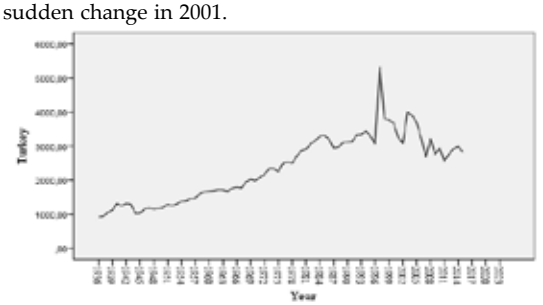
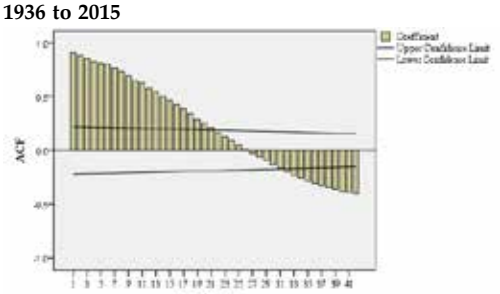



**Figure 6. Graph of number of turkey data from the period 1936 to 2015**



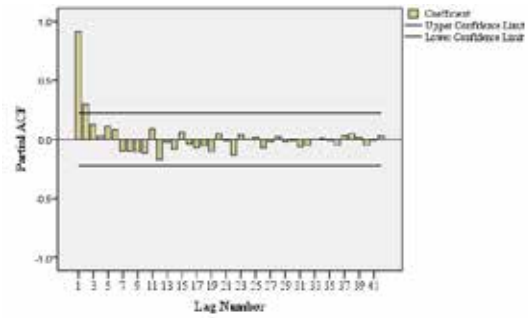



**Figure 7. ACF and PACF graphs of number o turkey data**

When ACF and PACF graphs are analyzed in Figure 7, many terms of the series in ACF graph surpassed confidence limits, and thus the series formed a trend. The first degree difference of the series was taken and ACF and PACF graphs of the first degree series are reported in Figure 8.

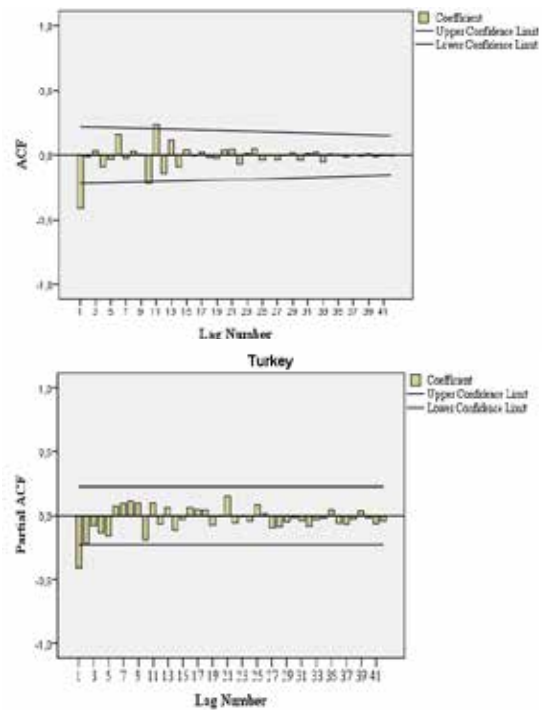



**Figure 8. ACF and PACF graphs of the first differences of number of turkey of number.**

When Figure 8 was view, terms of ACF and PACF graphs for the first difference time series were within confidence limits due to being produced the stationary time series. In the light of this information, the best smoothing one among Holt, Brown and Damped Trend smoothing methods was selected by using $R^2$, RMSE and BIC.

**Table 5. Model fit statistics**

| Criteria | Holt | Brown | Damped Trend |
|---|---|---|---|
| R-squared | 0.886 | 0.882 | 0.887 |
| RMSE | 324.181 | 327.44 | 324.899 |
| BIC | 11.672 | 11.637 | 11.731 |

In Table 5, $R^2$ values are 0.886, 0.882 and 0.987 according to Holt, Brown and Damped trend methods, respectively. RMSE values are 324.181, 327.44 and 324.899 according to Holt, Brown and Damped trend methods, respectively. BIC values are 11.672, 11.637 and 11.731 according to Holt, Brown and Damped trend methods, respectively. According to Table 5, the most appropriate method was Damped smoothing method which yielded the lowest normalized BIC and value. Coefficient of Damped smoothing method is given in Table 6 and were estimated as alpha and. The ACF and PACF graphs of the residuals for turkey numbers are depicted in Figure 9.

**Tablo 6. Damped Exponential Smoothing Model Parameters (Number of turkey)**

| | Coefficient | SE | t | Sig. |
|---|---|---|---|---|
| Alpha (Level) | 0.454 | 0.096 | 4.705 | 0.000 |
| Gamma (Trend) | 0.000068 | 0.037 | 0.002 | 0.999 |
| Phi (Trend damping factor) | 0.996 | 0.006 | 165.396 | 0.000 |

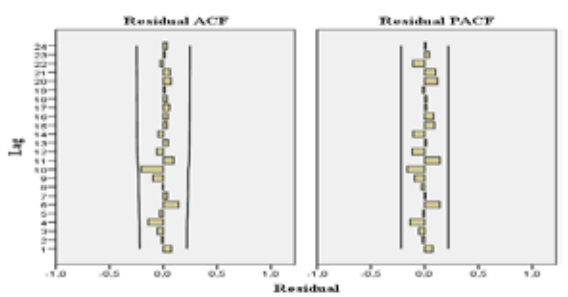



**Figure 9.The ACF and PACF graphs of the residuals for number of turkey**

Figure 9 is examined, the relationship amounts of the residuals in ACF and PACF graphs were found within confidence limits. Thus, the series is White-Noise. The joint graph of the original series and forecasting series is shown in Figure 10.

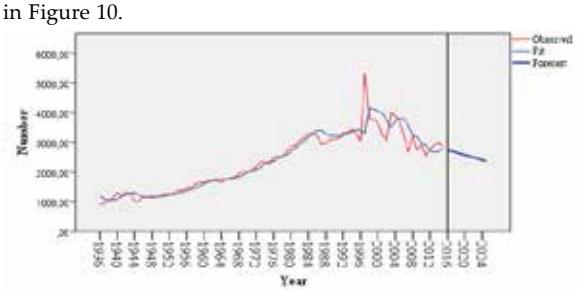



**Figure 10. The joint graph of the original series and forecasting series in number of Turkey**

Consequently, forecasting results of number of turkey data from the period 2016 to 2025 are given in Table 7. An improvement in the forecasting results of number of turkey was exhibited in Table 7. It has been expected decrease in the number of turkeys the period up to 2025.

**Tablo 7. Forecasting results from the period 2016 to 2025 (Number of turkey)**

| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|
| Forecast | 2917000 | 2938000 | 2958000 | 2978000 | 2998000 | 3018000 | 3038000 | 3058000 | 3078000 | 3098000 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LCL | 2270000 | 2227000 | 2189000 | 2155000 | 2125000 | 2097000 | 2071000 | 2047000 | 2025000 | 2005000 |
| UCL | 3564000 | 3648000 | 3727000 | 3801000 | 3872000 | 3940000 | 4006000 | 4069000 | 4131000 | 4191000 |

**Conclusion:**

In this research, number of poultry were forecasted by using exponential smoothing methods.In a first moment were applied Holt's linear trend method, Brown lineartrend and Damped trend to fit the best model in observed and then generate projections up to 2025. For the best model determined the one that produce $R^2$, RMSE and BIC criteria.

When performing the prediction with these models period from 2016 to 2025, Holt's linear trend method proved to be a good approximation on the number of hens and cocks. Number of the turkey was forecasted by Damped exponential smoothing method from the period 2016 to 2025. In forecasting period from 2016 to 2025, number o hens and cocks ranged from 315 994 000 to 349 641 000, whereas number of turkey varied from 2 917 000 to 3 098 000.

The forecasts for the number of hens-cocks and turkey mean that they will increase in number of poultry in the following years, which will be important for Turkish economy. Increasing production amounts of the number o poultry is important advantage in terms of meeting domestic demands and to meet the needs of white meat and eggs.

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