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Estimation of the Quantity of Donkeys in Turkey via Artificial Neural Network and Time-Series Analysis

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Abstract: *The purpose of this study is to make a production plan by using artificial neural networks (ANN) and time series analysis (ARIMA and moving average) for establishing appropriate models and forecasting the asses population in Turkey over the years.*
The year parameter was used as an input parameter in the development of time series analysis and artificial neural network, and the number of asses was used as an output parameter. Mean square error (MSE) and Mean Absolute Error (MAE) statistics were used to calculate the efficiency of the suitable model. Among the established models, simple moving average (SMA) and artificial neural network methods were found to be suitable and give good results.
Keywords: *Artificial neural network, moving average, forecasting, asses.*

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I. INTRODUCTION

The natural range of the donkey is North Africa and the Arabian Peninsula. However, domestic, and wild donkeys have sprawled around the globe due to human intervention (Clutton-Brock, 1992).

Donkeys have played a significant role in agronomic practices until recently and are still utilized for carriage and transportation purposes in all countries, especially in the countryside, where their breeding remains present (Yilmaz and Wilson, 2013; Cozzi and et al., 2018). The majority of the donkey population in the world is situated in developing countries and China, to be taken advantage of their workforce and interbreeding with horses to produce mules. Their population in developed countries is rapidly decreasing due to agricultural and transportation mechanization (Anonymous, 2019).

Conveined management of donkeys requires the ability to match the animals' live weight to draft tasks required. However, most smallholder farmers have no access to a livestock scale (Pearson and Ouassat, 1996).

Historically, mules and donkeys showed enormous contribution to the development of civilizations, with extensive use in various tasks (Clutton-Brock et al., 1992). With the evolution of mechanical engineering the equide was directed to leisure and competition, and horses began to have enormous economic value (Grosenbaugh et al., 2011). Scientific research was mainly directed to horses and often extrapolating for other species such as mules and donkeys, which can often be a mistake (Senior, 2013; Burnham, 2002).

Totally 16551 base pair mitochondrial genomes of the Turkish Anatolian Donkey have been obtained, and a new mitogenome haplotype was confirmed, while they are found to be reasonably similar to the mitogenomes of existing donkey and Equidae by means of form, organisation, and composition. Genetic diversity and phylogenetic analysis suggest that the Turkish Anatolian donkey is notably similar to the Chinese domestic donkey. It has been determined that the domestic donkeys were domesticated from the African wild donkey (Somalian wild donkey or African wild donkey) (Ibiş, 2019).

The present study targets to model the number of asses in Turkey using ARIMA, simple moving average and the artificial neural network methods and to make forecasting for the coming years.

II. MATERIAL VE METHOD

MATERIAL

The material of the research is 1961-2020 number of asses values supplied from the www.tuik.gov.tr web address of Turkish Statistical Institute (TSI, 2020) and Food and Agriculture Organization of the United Nations (FAO, 2019). The dependent variable was number of asses figures while the independent variable was year series. These variables were selected in order to be able to make reasonable estimations with the models to be performed using ANN and time series analysis methods.

METHOD

ARIMA Models

A pth-order autoregressive modelAR(p) model is point out as (Cooray, 2008).

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + e_t$$

AR(p) model uses a linear combination of past values of the target to make forecasts.A qth-order moving average process, expressed MA(q), is indicated by (Cryer, 1986).

$$y_t = -\theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-q} + e_t$$

ARMA(p,q) model composed of apth-order autoregressive andqth-order moving average process and it is showed by (Hamilton, 1994).

$$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-q}$$

In order for time series models to be applied, series must be stationary and white noise (Kadılar and Çekim, 2020).

SIMPLE MOVING AVERAGE (SMA) METHOD

Simple moving average (SMA) or centred moving average operations can be applied to eliminate or flatten seasonal, cyclical or irregular fluctuations (Kadılar and Çekim, 2020). At this point, the SMA method will be explained.
In SMA process the following formula will be used:

$$SMA = \frac{Y_t + Y_{t-1} + \cdots + Y_{t-(k-1)}}{k}$$

"K" refers to the number of stretches. Stretching is used to remove fluctuations gradually and flatten the graph of series. The process of determining the "k" depends on the researcher. If the "k" is large, the series will straighten. Generally, the value of "k" is the same size as the period. As "k" increases, the number of missing observations will also increase (Kadılar and Çekim, 2020).

$$\hat{Y}_{t+1} = \frac{Y_t + Y_{t-1} + Y_{t-2} \ldots + Y_{t+k-1}}{k}$$

The forecast model given as the k-period moving average model is called. While this model adds this new value to the average calculation when a new observation value is obtained, it deducts the oldest period value included in the previous average from the calculation. Thus, the average of the observation values of the last k periods is taken as the predictive value (Erdem, 2017).

Artificial neural networks (ANN)

An ANN is an information processing model that can possession of, store and use empirical information to simulate human brain function. The network learns the relationship between data sets and understands the details of the problem under investigation, and thus provides a comprehensive approach to solving nonlinear relationships and complex problems (Chen et al., 2021).

Inputs and outputs data is given to the network, processed, and then apattern that identifies the intrinsic relationship between inputs and outputs. First, input and output data from the previous well was entered into the ANN model, and the analyzed data was imported to the new ANN model for a new well. Next, analyzed data from the previous well and input data from the new well was entered into the new ANN model, and the results would be reported as output parameter for a new well (Al-Kaabi, 1990).

One of the most common used type of ANN is the feedforward network. The architecture of a feedforward neural network is nonlinear. Therefore, the output is obtained from the input through a feedforward arrangement. The multilayer perceptron (MLP) is a type of feedforward neural network, consisting of input, hidden and output layers (Beale et al., 2011; Moghaddam et al., 2016).

The used activation function in configuration of ANNs in the study is Hyperbolic tangent sigmoid function (Bouabaz and Hamami, 2008).

$$f = \frac{2}{1 + e^{-net_j}} - 1$$

Normalization method standardizes the values of the input variables. Min Max normalization: Implements a linear transformation on the actual data. It normalizes the data in the range 0 to 1 by the formula (Öztemel, 2012):

$$X' = \frac{X_i - X_{max}}{X_{max} - X_{min}}$$

Where, X_i: Data value to be normalized, X': Normalized value of X_i, X_{min} : Minimum value, X_{max} : Maximum value.

To evaluate the precision of the predicted discharge volume, Mean Square Error (MSE) and Mean Absolute Error (MAE) were used (Eyduran*et al.*, 2019; Wang and Lu, 2018):

$$MSE = \frac{\sum_{i=1}^{n}(y_i - y_{ip})^2}{n}$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|(y_i - y_{ip})\right|$$

Here, y_i is the real value of the dependent variable (number of asses), y_{ip} is the predicted value of the dependent variable (number of asses) and n is the number of samples.

III. RESULTS AND DISCUSSIONS

The time series graph of number of asses between the years 1961-2020 was indicated in Figure 1.

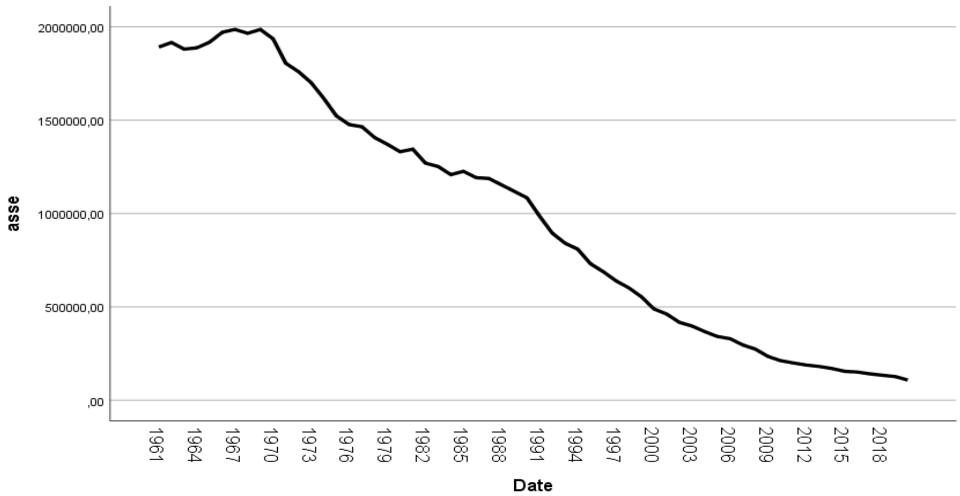

Figure 1. Time series graph for asses population

It was firstly examined whether ARIMA modelling among time sequences was constant. An autocorrelation (AFC) graph is given in Figure 2, and partial autocorrelation (PACF) graph is given in Figure 3.

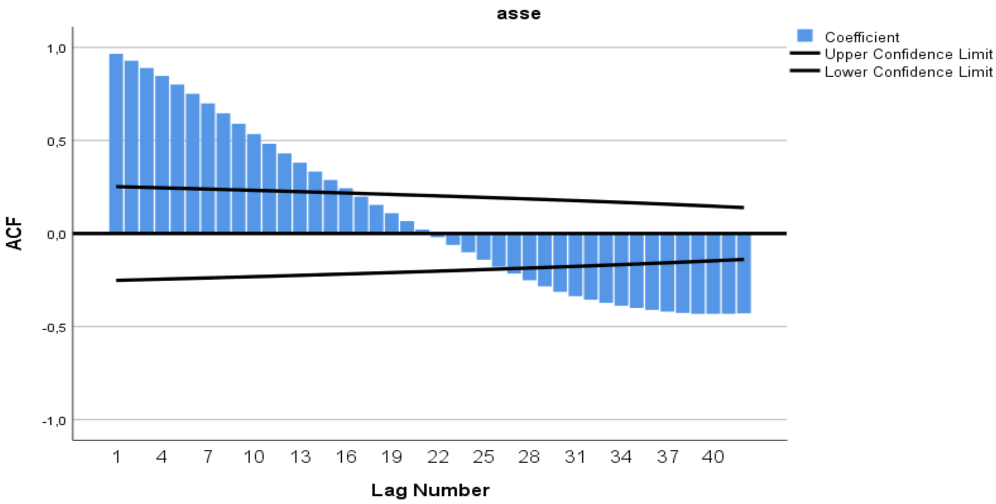

Figure 2. ACF graph of series

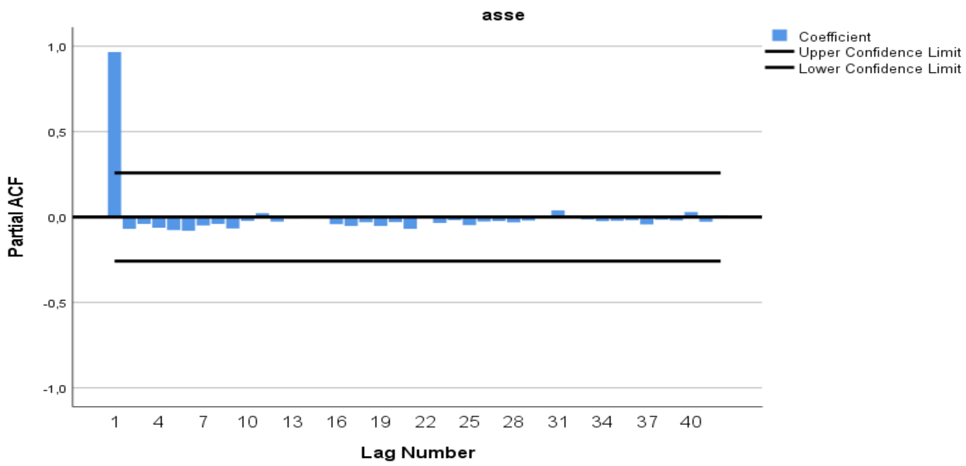

Figure 3. PACF graph of series

When Figure 2 is examined, it has been detected that there is a trend in the series and that it is not constant. The first difference of the series was calculated in order to make the series constant. ACF and PACF graphs of the series with its first difference calculated are shown in Figure 4 and Figure 5, respectively.

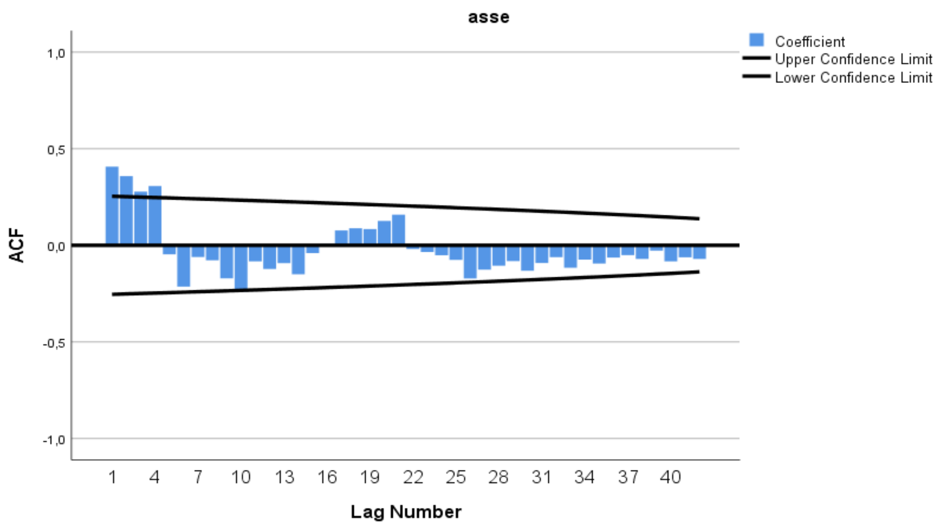

Figure 4. ACF plot of the first difference of the series

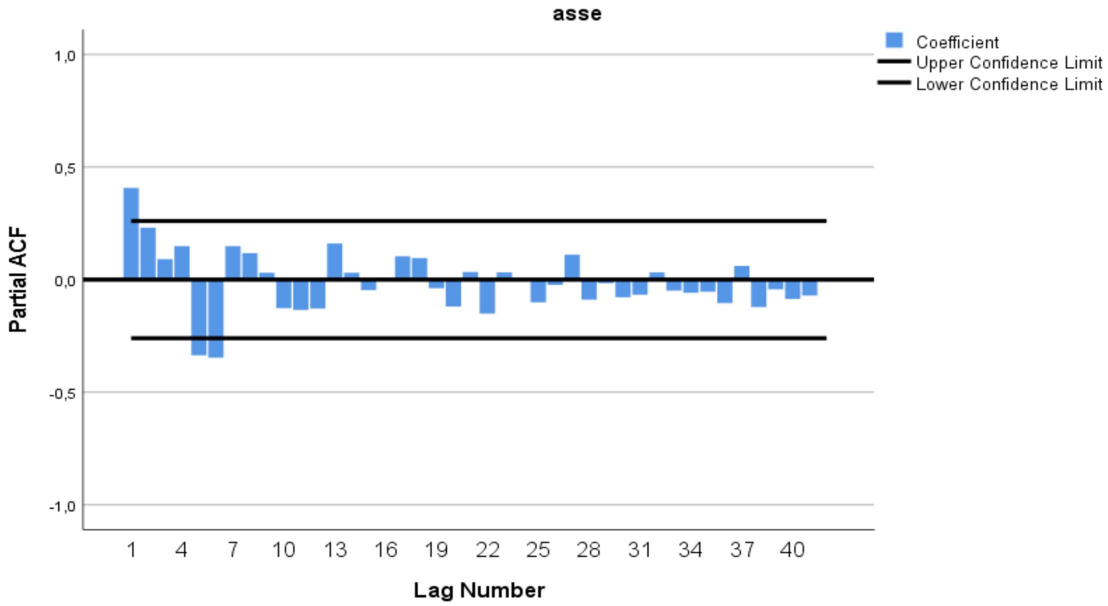

Figure 5. PACF plot of the first difference of the series

The first 4 lag values in the ACF graph of the first difference of the series exceeded the confidence limit. After the fourth lag, it quickly approached zero (Figure 4). As for Figure 4, while the first lag is significant, it has approached zero rapidly after the first lag. As the approach to zero is even faster in the AFC graph, the estimated model is ARIMA(0,1,4). When analysed according to the ARIMA(0,1,4) model, MAPE, MAE, and BIC (Bayesian Information Criterion) values were 3.523, 20872.576, and 20.817, respectively. As the degree of the model is q=4, it has 4 parameters. The coefficients of these parameters are calculated as -0.165, -0.546, -0.397, and -0.646, respectively. When the model's parameter estimates were examined, the coefficients of the 2nd, 3rd, and 4th parameters are found to be statistically outstanding, while the coefficient of the first parameter was found to be insignificant. Therefore, the model is not suitable. It is advised to test alternative models. Forecasting, using the simple moving average method, was required. Real values, estimated values, and error terms are presented in Table 1 when the simple moving average method with a stress coefficient of 5 is applied.

Table 1. Actual, predicted and residual values

Years	Actual	Single MA	Double MA	Predicted	Residual
1961	1891800	NaN	NaN	NaN	NaN
1962	1916000	NaN	NaN	NaN	NaN
1963	1880400	NaN	NaN	NaN	NaN
1964	1887672	NaN	NaN	NaN	NaN
1965	1918000	1898774	NaN	NaN	NaN
1966	1971000	1914614	NaN	NaN	NaN
1967	1986000	1928614	NaN	NaN	NaN
1968	1965000	1945534	NaN	NaN	NaN
1969	1986000	1965200	1930548	NaN	NaN
1970	1936000	1968800	1944553	2017179	-81178.7
1971	1805000	1935600	1948750	2005171	-200171
1972	1760000	1890400	1941107	1915875	-155875
1973	1701000	1837600	1919520	1814340	-113340
1974	1616000	1763600	1879200	1714720	-98720
1975	1522000	1680800	1821600	1590200	-68200
1976	1476000	1615000	1757480	1469600	6400

1977	1465000	1556000	1690600	1401280	63720
1978	1407000	1497200	1622520	1354100	52900
1979	1371000	1448200	1559440	1309220	61780
1980	1331000	1410000	1505280	1281340	49660
1981	1345000	1383800	1459040	1267080	77920
1982	1270000	1344800	1416800	1270940	-940
1983	1252000	1313800	1380120	1236800	15200
1984	1208000	1281200	1346720	1214320	-6320
1985	1226000	1260200	1316760	1182920	43080
1986	1192000	1229600	1285920	1175360	16640
1987	1188000	1213200	1259600	1145120	42880
1988	1153000	1193400	1235520	1143600	9400
1989	1119000	1175600	1214400	1130220	-11220
1990	1084000	1147200	1191800	1117400	-33400
1991	985000	1105800	1167040	1080300	-95300
1992	894445	1047089	1133818	1013940	-119495
1993	841000	984689	1092076	916995.8	-75995.8
1994	809000	922689	1041493	823609.1	-14609.1
1995	731000	852089	982471.2	744482.4	-13482.4
1996	689000	792889	919889	656515.7	32484.3
1997	640000	742000	858871.2	602389	37611
1998	603000	694400	800813.4	566693.2	36306.8
1999	555000	643600	744995.6	534779.9	20220.1
2000	489000	595200	693617.8	491506.6	-2506.6
2001	462000	549800	645000	447573.3	14426.7
2002	417214	505242.8	597648.6	407000	10214
2003	397540	464150.8	551598.7	366634.2	30905.84
2004	367739	426698.6	508218.4	332978.9	34760.08
2005	341377	397174	468613.2	304418.8	36958.16
2006	329475	370669	432787	290015.1	39459.86
2007	296114	346449	401028.3	277491.9	18622.06
2008	273520	321645	372527.1	264580.1	8939.92
2009	234182	294933.6	346174.1	245321.8	-11139.8
2010	211529	268964	320532.1	218072.8	-6543.82
2011	199496	242968.2	294992	191611.8	7884.18
2012	188789	221503.2	270002.8	164932.6	23856.44
2013	181422	203083.6	246290.5	148753.8	32668.2
2014	170503	190347.8	225373.4	138273.2	32229.78
2015	155158	179073.6	207395.3	137809.5	17348.54
2016	151439	169462.2	192694.1	136591.1	14847.92
2017	141375	159979.4	180389.3	134614.4	6760.62
2018	133953	150485.6	169869.7	129364.5	4588.48
2019	126912	141767.4	160153.6	121409.4	5502.58
2020	108304	132396.6	150818.2	114188	-5884.04

MSE and MAE values calculated with the simple moving average method are found to be 3 257 709 330 and 39617.587, respectively.

The graph of the observed and estimated values obtained with simple moving average method is given in Figure 6.

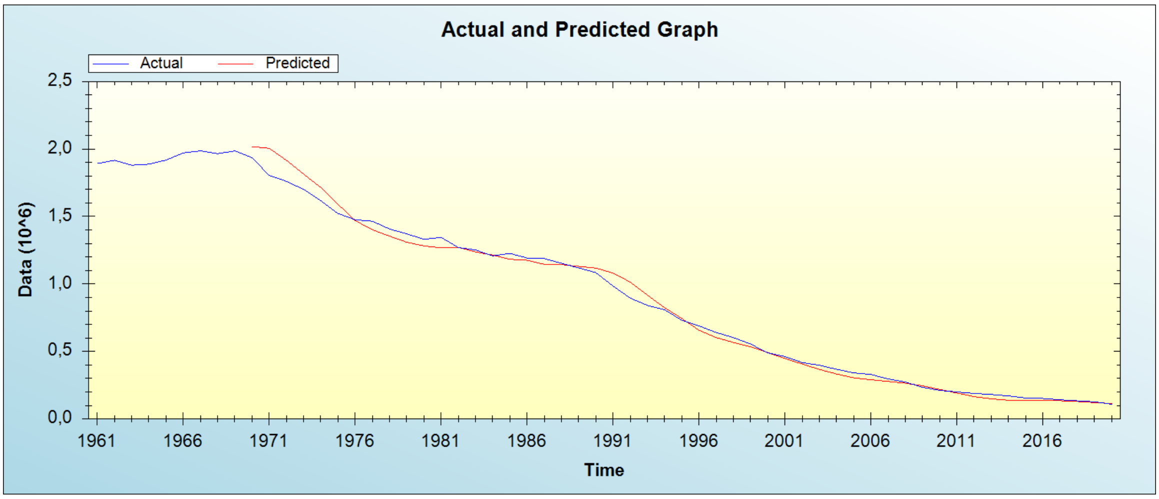

Figure 6. The combined graph of observed and predicted values for number of asses

In Figure 7, meantime the joint graph of actual and residual values was displayed, residual and observed values were found to be scattered free from each other and randomly. This situation shows that important hypotheses regarding the model are provided.

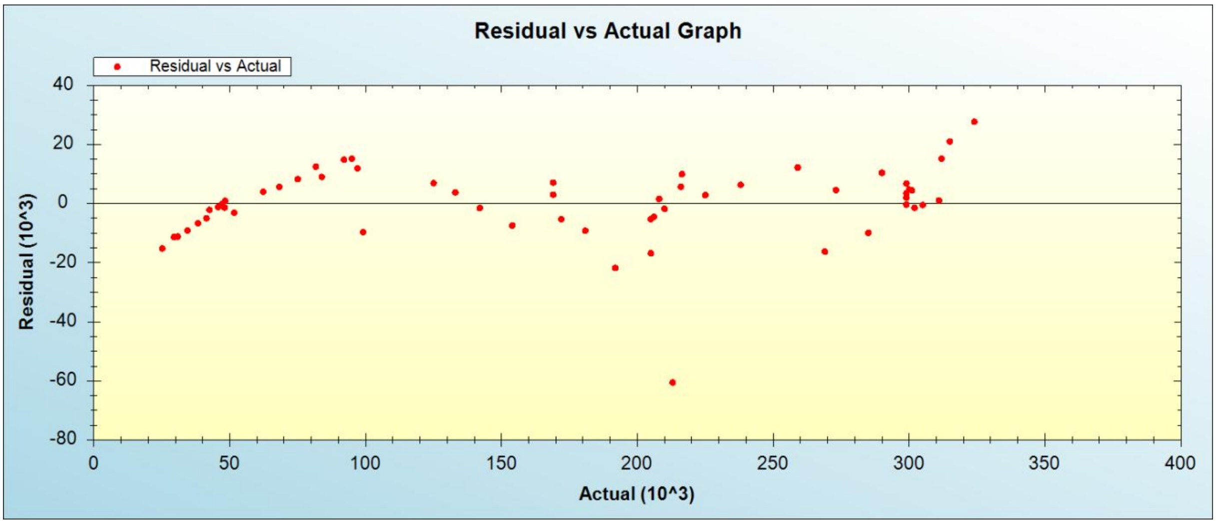

Figure 7. Joint graph of actual and residual values

In Figure 8, the graph of real values and smoothed values are presented.

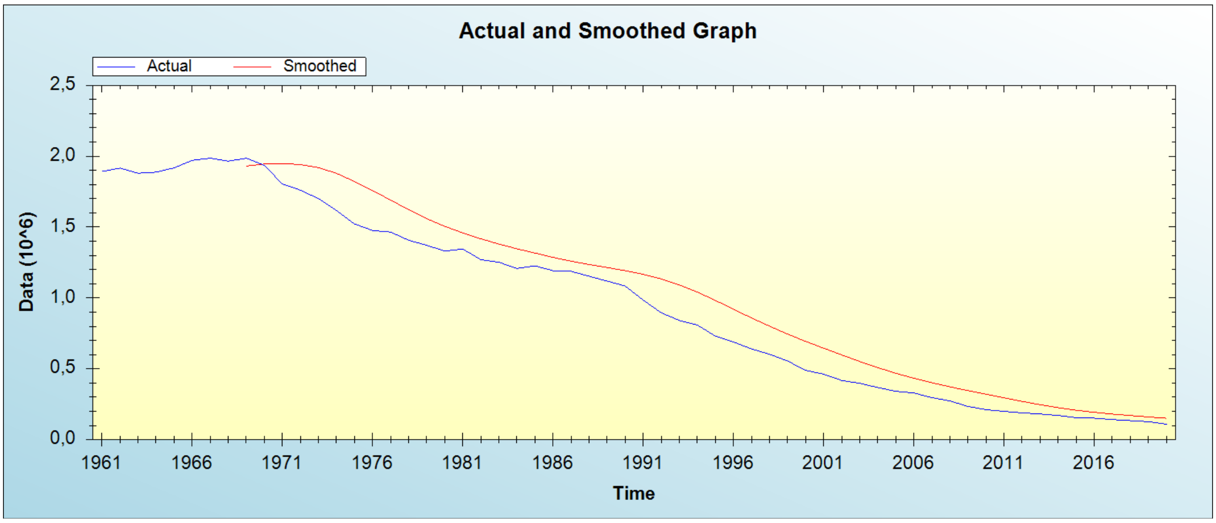

Figure 8. Joint graph of actual and smoothed values

The graph of the estimated values alongside the actual values is given in Figure 9, the graph of the error terms is given in Figure 10, the graph of the error terms along with the real values is given in Figure 11, and the graph of the estimated values with the error terms is given in Figure 12.

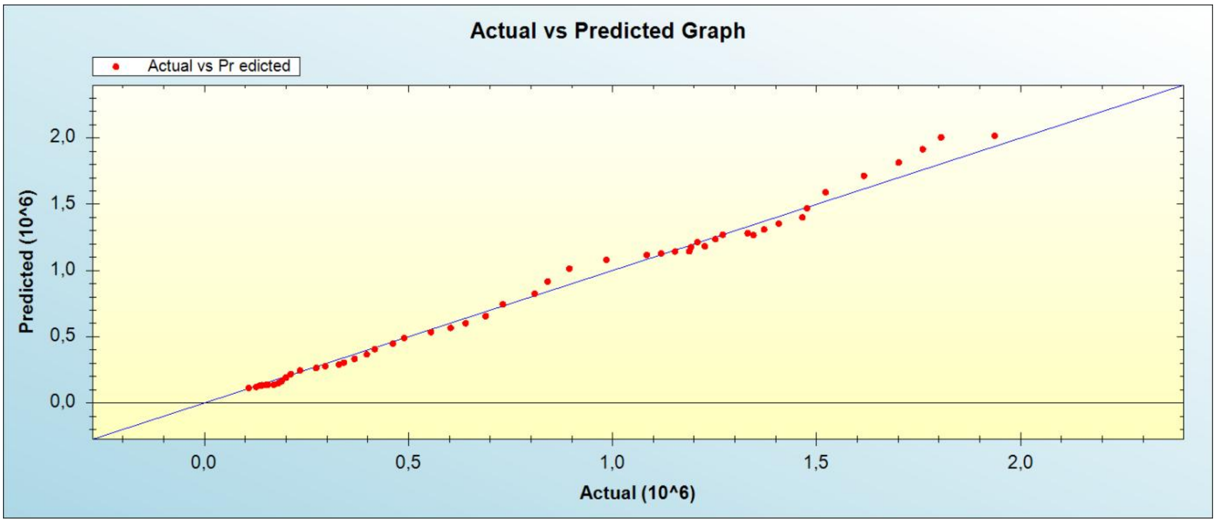

Figure 9. Joint graph of actual and predicted values

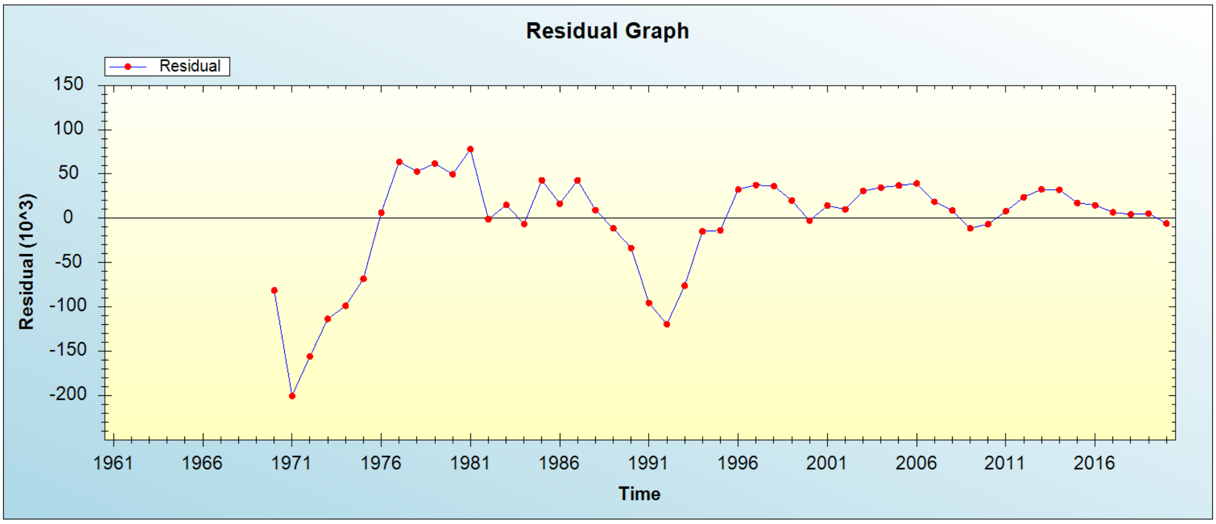

Figure 10. Graph of residual values

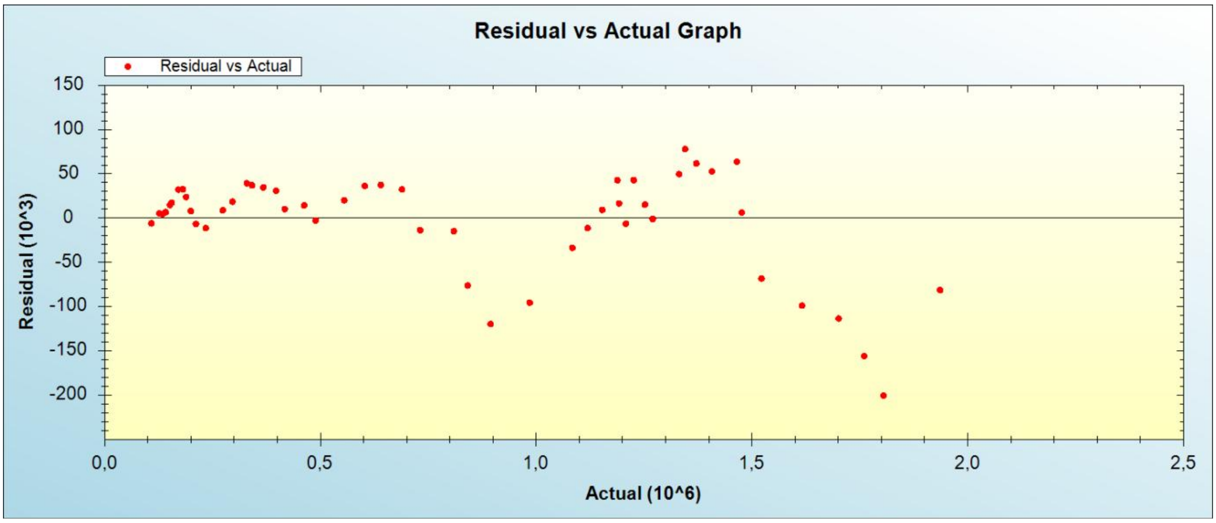

Figure 11. Joint graph of actual and residual values

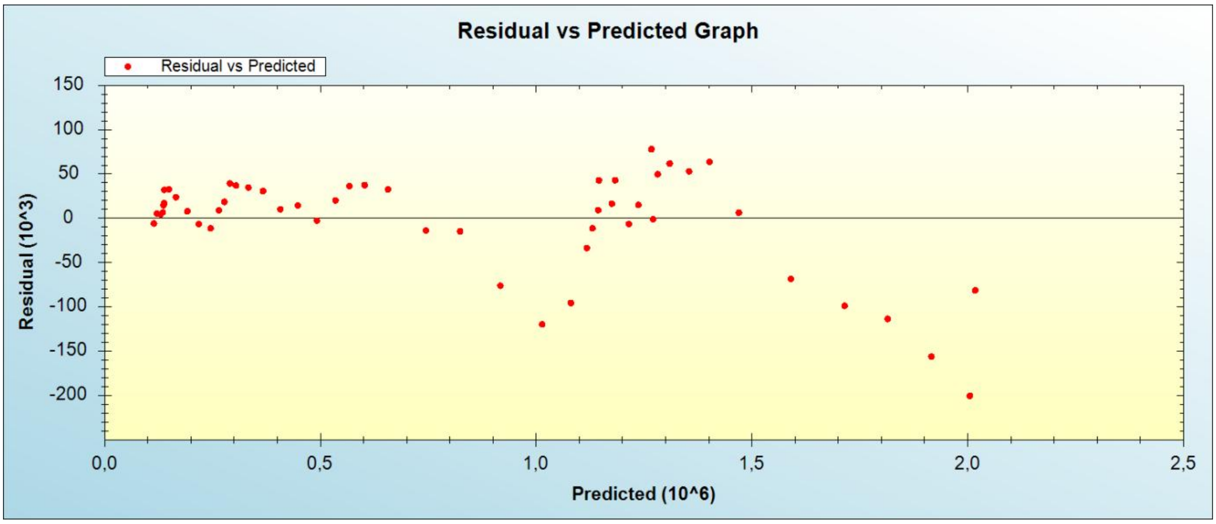

Figure 12. Joint graph of predicted and residual values

The possible 2021-2025 number of asses forecasted simple moving average method is presented in Table 2.

Table 2. Number of asses forecasting according to simple moving average (SMA) method

Years	Forecasting
2021	104764
2022	95553
2023	86343
2024	77132
2025	67921

In the 2021-2025 period, it is expected that there will be a decrease in the number of asses as a result of the moving average method (Table 2). The graph showing the actual and predicted values of the number of asses is shown in Figure 13.

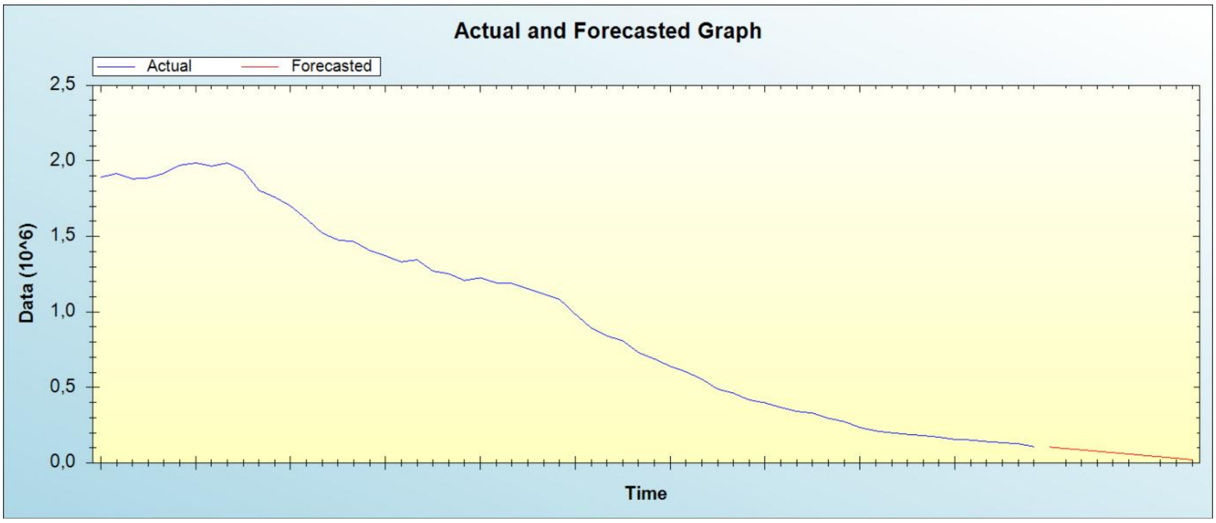

Figure 13. The joint graph of observed and estimated values

When analyzed with artificial neural networks (ANN), MSE and MAE values (MSE=4 070 846 083 and MAE=52743.563) as were calculated. The hyperbolic tangent function was used as activation function when creating a model with the ANN method. The number of neurons in the input layer, the hidden layer and the output layer was determined as 3-12-1 each. 1000 iterations were used for the ANN method in the data series consisting of 60 observations between 1961-2020. The estimated and residual values are given in Table 3 together with the real values of the ANN method for 1961-2020 period.

Table 3. Observed, predicted and residual values

Years	Actual	Predicted	Residual
1961	1891800	NaN	NaN
1962	1916000	NaN	NaN
1963	1880400	NaN	NaN
1964	1887672	1823045.48	64626.5174
1965	1918000	1833759.83	84240.1723
1966	1971000	1830235.89	140764.1052
1967	1986000	1847742.21	138257.7873
1968	1965000	1861486.79	103513.2092
1969	1986000	1871963.73	114036.2732
1970	1936000	1881303.66	54696.3433
1971	1805000	1862712.92	-57712.923
1972	1760000	1833657.52	-73657.5245
1973	1701000	1803839.23	-102839.226
1974	1616000	1729821.68	-113821.679
1975	1522000	1677684.08	-155684.075
1976	1476000	1611923.07	-135923.069
1977	1465000	1544350.92	-79350.9199
1978	1407000	1473292.86	-66292.8622
1979	1371000	1410657.72	-39657.7196
1980	1331000	1393888.51	-62888.5149
1981	1345000	1329410.39	15589.6116
1982	1270000	1308079.69	-38079.6874

1983	1252000	1232546.08	19453.9222
1984	1208000	1254732.46	-46732.4587
1985	1226000	1162357.61	63642.3931
1986	1192000	1160531.73	31468.2654
1987	1188000	1093893.94	94106.0623
1988	1153000	1120523.63	32476.374
1989	1119000	1069649.64	49350.3613
1990	1084000	1060945.44	23054.5612
1991	985000	1017108.05	-32108.0524
1992	894445	952776.502	-58331.502
1993	841000	912256.395	-71256.3948
1994	809000	808977.877	22.1229
1995	731000	712683.866	18316.1337
1996	689000	642965.349	46034.651
1997	640000	621834.537	18165.463
1998	603000	541463.561	61536.4394
1999	555000	505929.503	49070.4969
2000	489000	460131.809	28868.1908
2001	462000	427795.526	34204.4739
2002	417214	398464.01	18749.99
2003	397540	344546.199	52993.8008
2004	367739	331496.074	36242.9256
2005	341377	299406.343	41970.6574
2006	329475	288911.237	40563.7635
2007	296114	273001.068	23112.9323
2008	273520	254960.625	18559.3754
2009	234182	251588.164	-17406.164
2010	211529	232069.722	-20540.7221
2011	199496	224041.298	-24545.2976
2012	188789	205642.624	-16853.6243
2013	181422	195200.162	-13778.1616
2014	170503	190359.506	-19856.5058
2015	155158	185488.49	-30330.4895
2016	151439	182450.366	-31011.3662
2017	141375	179338.281	-37963.2808
2018	133953	172230.022	-38277.0218
2019	126912	171438.755	-44526.7548
2020	108304	167573.739	-59269.7389

The graph of the observed and estimated values obtained with ANN method is presented in Figure 14.

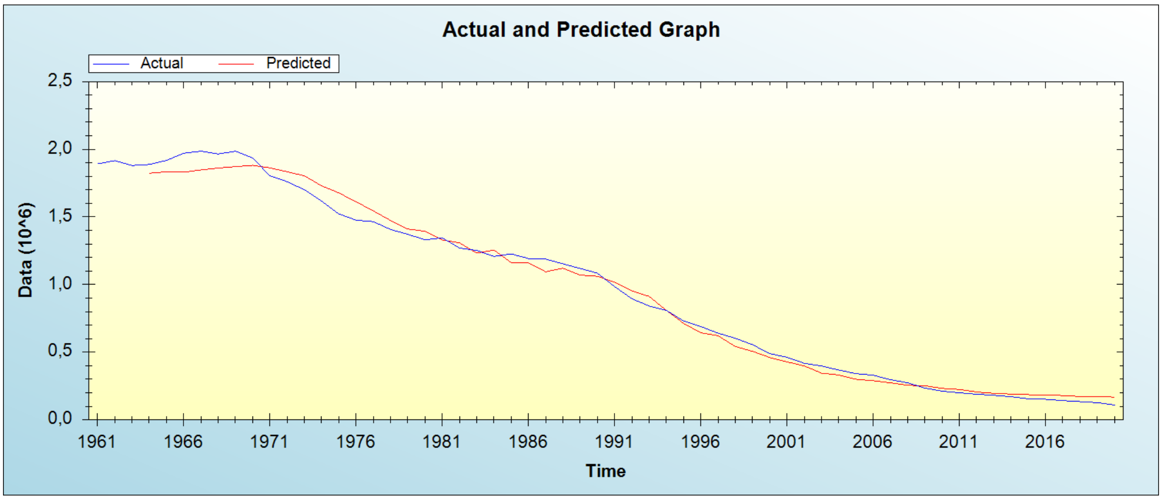

Figure 14. The combined graph of observed and predicted values for number of asses

In Figure 15, meantime the joint graph of observed and residual values was observed, residual and observed values were found to be scattered free from each other and randomly. This situation indicates that important hypotheses regarding the model are provided.

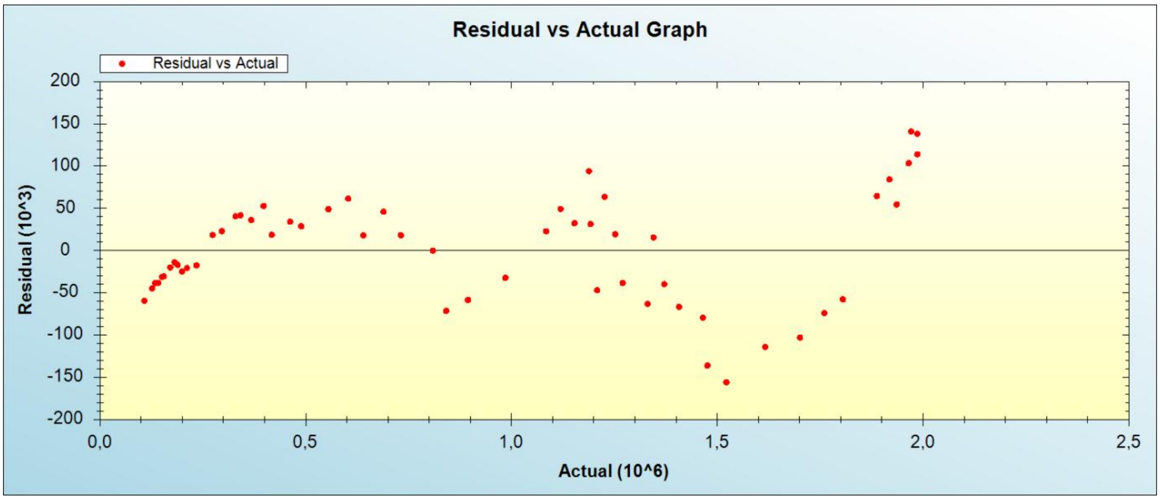

Figure 15. Joint graph of observed and residual values

Predicted and residual values are presented together in Figure 16.

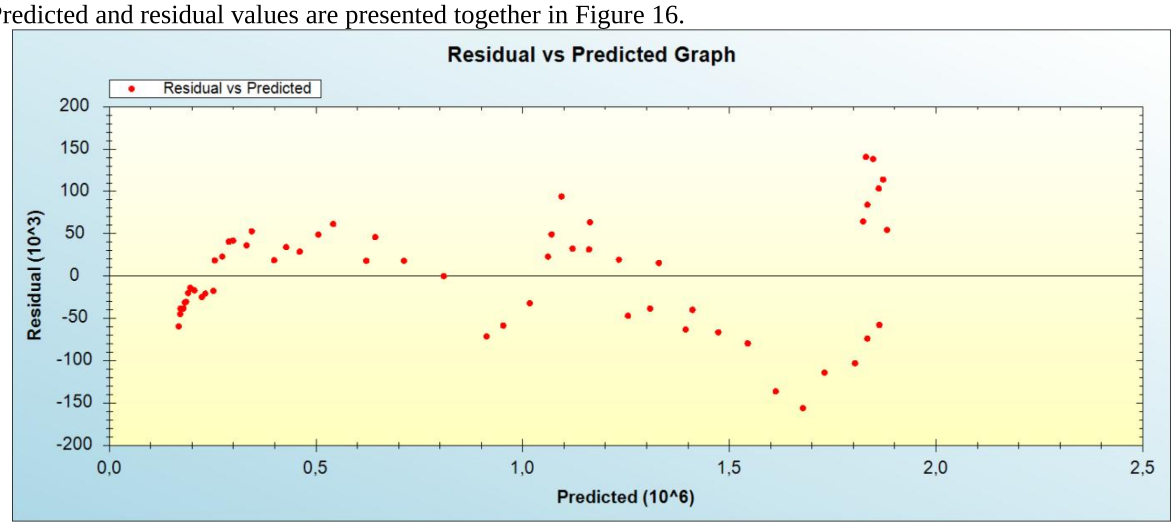

Figure 16. Joint graph of predicted and residual values

The possible 2021-2025 number of asses forecasted using ANN method is presented in Table 4.

Table 4. Number of asses forecasting

Years	Forecasting
2021	164054
2022	167464
2023	152852
2024	174798
2025	180044

In the 2021-2025 period, a fluctuation in the number of donkeys is expected as a result of the moving average method. Donkey numbers will continue to increase in the next 2 years. A decrease is expected in 2023. There will be an increase again in 2024 and 2025 (Table 4). The graph showing the actual and predicted values of the number of asses is shown in Figure 17.

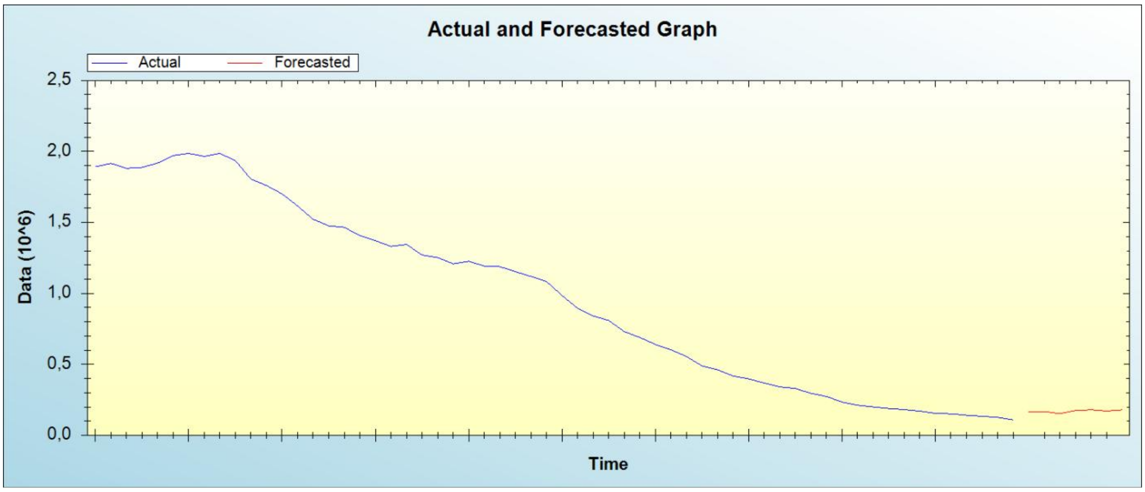

Figure 17. The joint plot of observed and forecasting values

Eyduran et al. (2020), used exponential smoothing methods with ARIMA (0,1,1), ARIMA (1,1,0) and ARIMA (1,1,1) for the modeling of banana production forecast in Turkey. Brown's approach was selected as the most appropriate method in the study of authors. As a result of time series analysis of the 1950-2010 period peanut production in Turkey, The ARIMA (0,1,1) model was obtained and the prediction between 2016-2030 was made according to this model. As a result of the foresight, it was estimated that the amount of peanut production will increase in the period (Çelik et al., 2017). ANN was applied to forecasting the number of pig, camel and mules (Çelik, 2021a; Celik, 2021b; Çelik, 2021c). In an other research related with donkeys in Turkey, by using Nei's genetic distance data, the Neighbor-Joining technique which was used to construct the phylogenetic trees have shown that all the studied populations were clustered in two different groups. In first cluster, Kütahya, Isparta, Amasya-Merzifon, Tekirdağ-Malkara, Kastamonu, Tokat, Konya, Antalya, Aydın, and Muğla populations were clustured. In second cluster, Kahramanmaraş, Mardin, Şanlıurfa, Kars, Kırklareli, and İstanbul-Çatalca populations were observed (Yatkın, 2019).

IV. CONCLUSION

This study estimated the number of donkeys in Turkey using artificial neural networks (ANN) with ARIMA model among time series methods and simple moving average method. None of the parameter coefficients were found to be statistically significant in ARIMA model. In the simple moving average method, stress coefficient was taken as k=5. As a result of the forecast, the number of donkeys for the 2021-2025 period is expected to be between 104764-67921, in a downward trend. In the estimation made with artificial neural networks, it is observed that the number of donkeys will range between 164054 and 180044. According to MSE and MAE statistics among the goodness of fit tests, it is seen that the simple moving average method is a better fit for the model. However, in the ANN method, if different iteration numbers are tested a larger amount of times with different neuron numbers in the input layer and different activation functions, different results are obtained at the end of each test. Therefore, various assessments can be conducted.

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