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Time Series Analysis on Sales Quantity in an Automotive Company and Estimation by Artificial Neural Networks

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Abstract

The automotive sector, today, is a key sector for developed and developing countries. A powerful automotive sector is one of the common characteristics of industrialised countries. Two significant problems of a genuine production environment are unknown demand and unbalanced production times. These two parameters impact the semi-finished and finished product inventory levels which cause an increase in the total cost of production systems. Forecasting the possible demand for automobiles has gained importance in this sense in recent years. In one of Turkey's leading automobile companies operating in the provice of Sakarya, the number of orders for future months is estimated over the number of orders for past months while determining the number of automobile sales. In this study, it was aimed to determine this company's automobile sales by using demand forecasting methods. However, the company's managers do not want to depend on a single method while deciding on any issue. To this end, time series analysis, causal methods and artificial neural networks were used to chieve demand forecasting. The method that makes the best estimation will be used for this company by comparing these methods. Considering the forecasts to be made using this method, it was aimed to establish a firm base for the annual budgets and main production plan of the company. By using this method, the company will be able to better predict some of its policies and production plans about the automotive sector by predicting the numbers regarding sales in advance.

Keywords: automotive industry, demand forecast, time series analysis, causal methods, artificial neural networks

1. INTRODUCTION

The automotive sector is one of the developing sectors where the largest investments are made. It has a large business volume. It contributes significantly to the economic development of countries in the world [1]. Therefore, it is very important for companies in this sector to correctly manage their resources. To do that, companies should predict the future in the best possible way and anticipate possible issues.

Demand forecasting is extremely important for accurate planning and prediction for the future in the automotive sector, which is a critical sector for the economy [2]. Demand forecasting has a vital role for businesses. The reason for this is that knowing what service or product to produce helps to making decisions in several ways for the benefit of businesses.

Demand forecasting is strategically a very important issue for businesses and is used in many areas such as administrative science, and production planning and control. Since the 1960s, significant developments have been experienced in demand forecasting, and new methods are being tested every passing day. Many studies have been carried out on demand forecasting to the present day. We may summarize some of these studies as follows:

Carlson and Umble (1980) [3] used the multiple regression analysis method to determine the demand forecast in the US for the next five years for five different types of automobiles in the standard and luxury automobile categories. Gavcar et al. (1999) [4] identified the demand for 8 different paper products produced in SEKA paper mill by using multiple regression analysis. Zhoumcmahon et al. (2002) [5] used the time series analysis method to predict the

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prospective water demand of Melbourne city by using the city's six-year daily water consumption data. Cahow (2004) [6] used the data gathered through health and retirement questionnaires to determine the demand for nurses caring for patients who are treated at home, by using the multiple regression and the Monte Carlo simulation methods. Griffiths et al. (2010) [7] predicted local wheat productivity by using the regression model with the data collected from five different Western Australian states. Kılınç and Aydın (2016) [8] determined the demand that will emerge based on the prospective body sizes in garment enterprises by using the arithmetic average, moving average and weighted average methods.

There are various prediction studies on artificial neural networks in the literature. Prediction studies using artificial neural networks in businesses were carried out especially in the fields of economics and finance, and significant results were obtained. Hu (2002) [9] stated that the artificial neural networks method predicted domestic tourism demands better than other traditional methods. Tüzüntürk et al. (2016) [10] estimated the number of dispenser-size bottled water units that were sold by using the artificial neural network method.

There are many studies in the literature on the automotive sector which have been carried out through the artificial neural networks method. Hosoz and Ertunç (2006) [11] used artificial neural networks to predict automobile performances and decided that AAC was the most effective factor in performance. Asilkan and Irmak (2009) [12] predicted the prospective prices of second-hand automobiles by using artificial neural networks. In their study, the results obtained through artificial neural networks and the results obtained through time series analyses were compared. İşeri and Karlık (2009) [13] created an automobile pricing model by using the artificial neural networks method. Using the model that they proposed, they predicted the prices of automobiles based to the technical and physical characteristics of the automobiles. Kleyner and Sandborn (2005) [14] developed a prediction method for the warranty process of automobiles. Karaatlı et al. (2012) [15] estimated the total new car sales figures in Turkey by using artificial neural networks, and considering the monthly data regarding the sales of new cars from 2007 until 2011.

Based on the literature, it is seen that there are different factors influencing sales in different sectors while forecasting demand. Carlson and Umble (1980) [3] predicted the demand for five different types of cars in the standard and luxury car categories in the US for the next five years. While predicting demand, they considered the following as the influential factors: gasoline prices, impact of gasoline shortages in the market, automobile prices, consumer incomes, and strikes of American automotive industry workers. Gavcar et al. (1999) [4] used the following as the factors influencing paper demand, while predicting demand for 8 different paper products produced SEKA paper mill: the wholesale price index of paper products and printing industry, import and export quantities, gross national product (GNP), and population. Karaatlı et al. (2012) [15] used gross domestic product, real sector confidence index, investment expenditures, consumer expenditures, consumer confidence index, dollar exchange rate and time as independent variables in order to estimate the total new car sales in Turkey. They used the total number of cars sold as the dependent variable.

In this study, in order to determine the factors used in forecasting automobile sales, an expert team of five people was formed from the sales marketing, production planning and R&D departments within the company. This team, firstly, examined the factors used in studies in the literature. Then, by adding factors that were specific to the company, they determined the factors to be used in this study. These factors were the number of registered vehicles, gross domestic product, consumer price index, dollar exchange rate, real sector confidence index, consumer confidence index, monthly working hours and the number of models produced.

The second part of this article provides information about the techniques that were used in the study. In the third part, the time series analysis and the artificial neural network processes that were carried out for the sales forecast problem of a business in the automotive sector are explained, and these methods are compared. In the last part, the results of the study are discussed.

2. MATERIALS AND METHOD

In this study, it was aimed to determine automobile sales by using demand forecasting methods. To this end, moving average and simple exponential smoothing model of time series analysis, multiple regression analysis of causal methods, and artificial neural networks of artificial intelligence-based methods were used to carry out demand forecasting. This section explains the demand forecasting methods that were used in this study.

2.1. Demand Forecasting

Demand forecasting is the process of organizing and analysing data of an earlier period to determine and

anticipate a company's product sales for future periods [16].

The demand forecasting method may be a simple algorithm under any probabilistic model, while it may also be a data-specific model. Although there are different classification methods in the literature, they may be organized under two groups: quantitative and qualitative [17].

Demand forecasting methods are as in Figure 1.

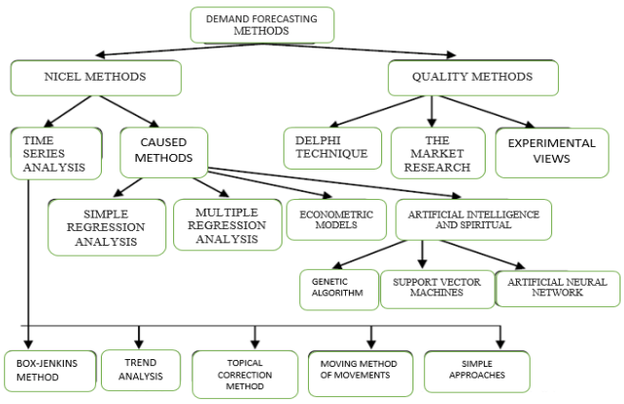

Figure 1. Demand Estimation Methods

2.1.1. Time Series Analysis

In the most general sense, time series are arrangements demonstrating the distribution of variables based on any unit of time such as a day, week, month, season or year. According to the number of variables, time series analyses are classified into two categories: with a single variable and with multiple variables, moving average methods and exponential smoothing methods.

a. Moving Average: The method by which future periods are forecast using the average of recent past data is called the moving average method [18]. In this method, the predicted value of the variable Y in the consequent period is found by calculating the average of that variable in the preceding period n. The mathematical expression of the method is shown in Equation 1.

$$F_{t+1} = \frac{Y_t + Y_{t-1} \ldots\ldots + Y_{t-k+1}}{k} \qquad (1)$$

b. Simple Exponential Smoothing Method: This method is one of the methods in which equal weights are not given to the data of earlier periods [19]. The method attributes the highest value to the last observation value in the data model, and it attributes a decreasing value to an earlier observation value. Equation 2 shows the formula of this method.

$$F_{t+1} = \alpha Y_t + (1-\alpha) F_t \qquad (2)$$

2.1.2. Causal Methods

Causal methods are methods that aim at forecasts depending on the changes in the factors that affect the predicted factor by associating the predicted factor with those factors. These are the regression analysis and correlation analysis method.

a. Multiple Regression Method: Multiple regression is used for dependent variables that cannot be explained by a single independent variable. The general purpose in multiple regression is to establish a linear relationship between a dependent variable and several independent variables [20].

The multiple regression equations for the main mass and the sample are shown in Equations (3) and (4)

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_n X_n + \varepsilon \qquad (3)$$

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_n X_n + \varepsilon \qquad (4)$$

2.1.3. Artificial Neural Networks

Artificial neural networks are a sub-discipline of artificial intelligence which is used to imitate the working mechanism of an actual biological nervous system of humans in computer systems and perform functions such as learning, prediction, and classification just like humans [21]. The field of usege and prevalence of artificial neural networks have increased especially due to the successful results they have provided for solution of nonlinear problems. Artificial neural networks are based on the logic of being able to make predictions about new instances using the instances that have already happened regarding an event. Figure 2 shows the components of a simple neuron.

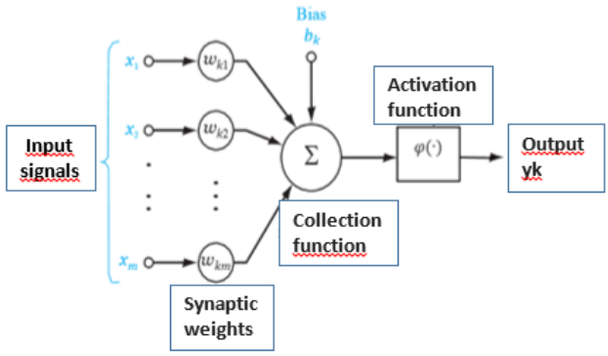

Figure 2. Components of a simple neuron

Inputs supplied to the neuron to train the network are multiplied by the weights found in each neuron. The resulting products, and if used, the weighing value of the bias neuron are fed into the addition function to obtain the total value. The total value is transmitted to the next nerve cell or to the output layer by subjecting it to an activation function, rather than as usual [22]. The output layer calculates the difference between the target value that the network has to reach and the value that the network produces, that is, the error of the network.

3. IMPLEMENTATION

In one of Turkey's leading automobile companies operating in the province Sakarya, the number of orders for future months was estimated over the number of orders for the past months while carrying out a current demand forecasting. In this study, time series analysis — a demand forecasting method — causal methods and artificial neural networks were used to forecast the demand. Considering these forecasts, it was aimed to establish a firm base for annual budgets and the main production plan of the company. The demand forecasting study was carried out in the Excel software through a regression analysis, and the demand forecasting study through time series was carried out in the Minitab software. The artificial neural networks were run on the MATLAB R2015A software.

In this study, while automobile sales were estimated, the experts determined the factors to be the number of registered vehicles, gross domestic product, consumer price index, dollar exchange rate, real sector confidence index, consumer confidence index, monthly working hours and the number of models produced. From among these specified factors, the data for the independent variables were taken from the Central Bank's website (www.tcmb.gov.tr), and the data for the dependent variable were taken from the production data of Turkey's leading automotive companies. These factors were as follows:

1. Number of Vehicles Registered: shows the monthly variation in the number of vehicles registered in Turkey between 2011 and 2016

2. Gross Domestic Product (GDP): shows the variation in GDP between 2011 and 2016

3. Consumer Price Index (CPI) This is the index that measures variations in prices of goods and services purchased by consumers

4. Dollar Exchange Rate: shows the monthly variation in the exchange rate between the dollar and the Turkish lira between 2011 and 2016.

5. Reel Sector Confidence Index***:*** shows the monthly variation in the Real Sector Confidence Index between 2011 and 2016.

6. Consumer Confidence: Index shows the monthly variation in the Consumer Confidence Index between 2011 and 2016.

7. Monthly Working Hours: shows the monthly variation in the monthly working hours between 2011 and 2016.

8. Number of Models Produced***:*** shows the monthly variation in the number of models produced between 2011 and 2016

Graphical representation of monthly variations in the factors affecting the sales of companies in Turkey between 2011 and 2016 are shows as in Figure 3. Figures 3a, 3b, 3c, 3d, 3e, 3f, 3g and 3h show the variations in the number of registered vehicles, gross domestic product, consumer price index, dollar exchange rate, real sector confidence index, consumer confidence index, monthly working hours, and the number of models produced, respectively.

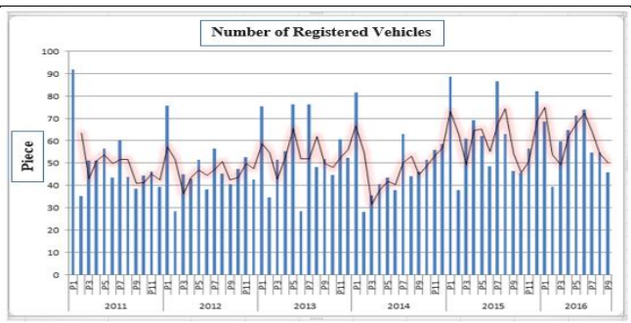

Figure 3a. The variation of the number of vehicles registered in Turkey between 2011 and 2016

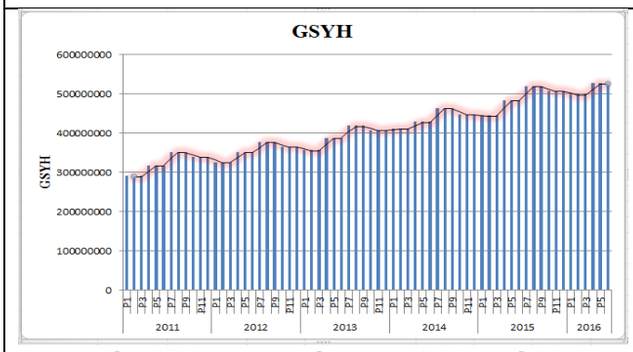

Figure 3b. GDP variation between 2011 and 2016

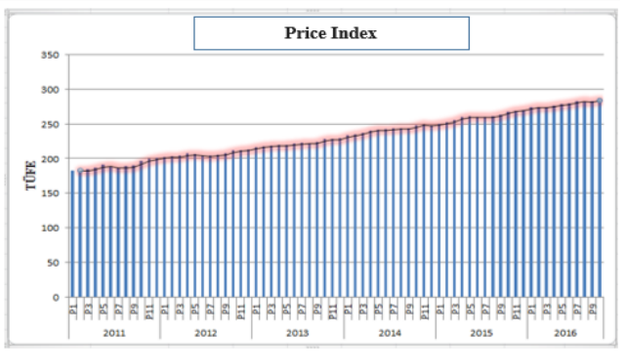

Figure 3c. CPI variation between 2011 and 2016

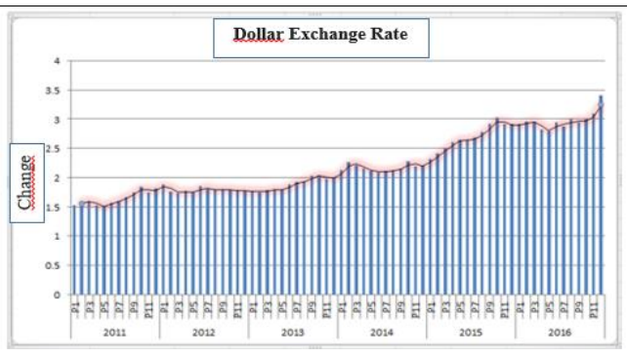

Figure 3d. Variation in the exchange rate of the dollar between 2011 and 2016

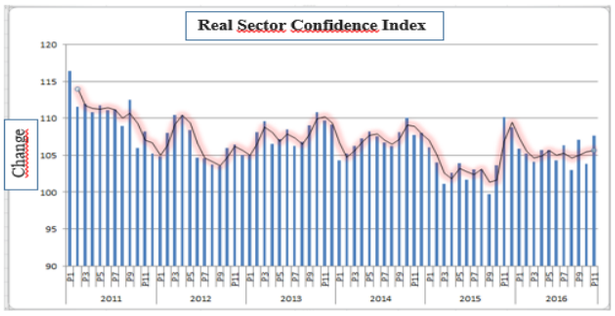

Figure 3e. Variation in the Real Sector Confidence Index between 2011 and 2016

Figure 3f. Variation in the Consumer Confidence Index between 2011 and 2016

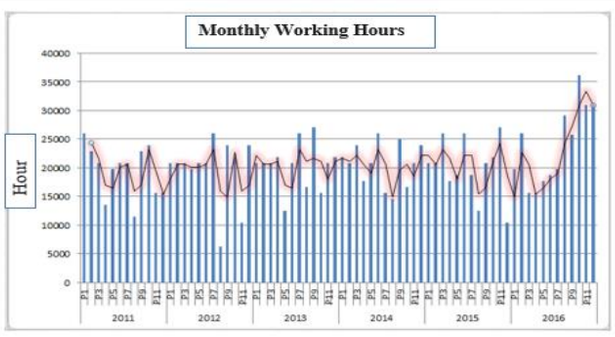

Figure 3g. Variation in the Monthly Working Hours between 2011 and 2016

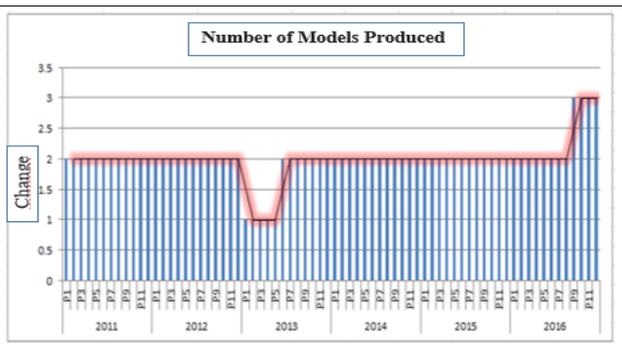

Figure 3h. Variation in the number of models produced between 2011 and 2016

Figure 3. Monthly changes in factors affecting demand for sales

The output of the multiple regression analysis, which was carried out in Excel, is as follows. The multiple regression coefficient was found to be 0.87. The independent variables, which are introduced above, affected the number of sales by 87%. Figure 4 shows the results of the regression analysis.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,874221559
R Square	0,764263334
Adjusted R Square	0,731177487
Standard Error	1579,793073
Observations	66

ANOVA

	df	SS	MS	F	Significance F
Regression	8	461201971	57650246,37	23,09940307	2,83052E-15
Residual	57	142257530,8	2495746,154		
Total	65	603459501,8			

	Coefficient	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-31728,7127	9416,23809	-3,369574176	0,001355808	-50584,40423	-12873,02117	-50584,40423	-12873,02117
X Variable 1	-5,078037794	13,82093437	-0,367416389	0,714669149	-32,75398148	22,59790589	-32,75398148	22,59790589
X Variable 2	2,44496E-05	1,23241E-05	1,983883143	0,052092121	-2,29011E-07	4,91283E-05	-2,29011E-07	4,91283E-05
X Variable 3	18,02832465	40,50945245	0,445039949	0,657976395	-63,09045466	99,14710396	-63,09045466	99,14710396
X Variable 4	-2427,243805	1879,524294	-1,291413903	0,201772717	-6190,926284	1336,438674	-6190,926284	1336,438674
X Variable 5	121,573666	83,40451923	1,457638832	0,150427912	-45,44100295	288,5883349	-45,44100295	288,5883349
X Variable 6	10,46318695	64,87244866	0,161288608	0,87243642	-119,4416508	140,3680247	-119,4416508	140,3680247
X Variable 7	0,455044078	0,04540067	10,02284934	3,45845E-14	0,364130804	0,545957353	0,364130804	0,545957353
X Variable 8	4861,795524	837,9602247	5,801940689	3,02886E-07	3183,809118	6539,78193	3183,809118	6539,78193

Figure 4. Regression statistics in Excel

In this study, the multiple regression equation was calculated to be as in Equation 5. As seen in Figure 4, the number of registered vehicles and the dollar exchange rate affected sales negatively.

Y = -31728.7127 - Number of Registered Vehicles * 5.07 + GDP * 0.244 + CPI * 18.0283 - Dollar Exchange Rate * 2427.243 + Real Sector Confidence Index * 121.573 + Consumer Confidence Index * 10.4631 + Monthly Working Hours * 0.455 + Number of Models * 4861.7955 (5)

Table 1 shows the monthly car sales volumes and a part of the sales estimated through the multiple regression analysis.

Table 1. Estimated output values of test inputs based on the multiple regression equation

Actual Values	Estimated Values	Actual Values	Estimated Values
3337	3408.32	8654	8704.82
3541	4044.78	10557	10451.14
3525	4085.84	11876	11834.19
3589	4914.13	10535	9767.37
3162	700.91	10560	9588.42
9200	9546.94	13176	11307.25
12875	12052.03	8952	8422.00
10337	7983.14	9504	9014.33
12602	12732.51	13174	12097.67
9067	7600.71	9504	9613.72
11845	9874.85	6182	6678.59
11846	10258.08	10369	9838.89
12143	9451.64	10927	10283.09
10778	9022.25	14303	13721.65
12595	10693.94	5280	5857.55
9283	8584.39	7477	9696.54
10964	10246.23	10771	12469.83
14220	12578.13	6608	7506.37
8345	8438.78	7710	8745.26
7524	7969.29	6836	9727.61
13386	12886.12	8564	9687.17

Based on the study, the total estimated value of the test data and the deviation of the total actual values were calculated to be 3.43%. The MAPE value was 12.66%.

3.1. Demand Forecasting using Time Series Analysis

A time series analysis was carried out to examine the data of earlier periods to determine whether there is a certain tendency and make predictions for the future.

3.1.1. Moving Average Method

The forecast for the next period was found by averaging the demands for the last n periods. In this study, the average of the number of sales for the last three periods was taken as the sales value of the next period. Table 3 shows the estimated values and the error values of the last 42 months. The MAPE value was found to be 23.08%.

Table 2. Estimated values found based on the moving average method

Nu	Sales	Guess	Mape	Nu	Sales	Guess	Mape
1	3337	4704.333	0.409	22	8654	9751.667	0.126
2	3541	3288.667	0.071	23	10557	9854.667	0.066
3	3525	3835	0.087	24	11876	10865.67	0.085
4	3589	3467.667	0.033	25	10535	10362.33	0.016
5	3162	3551.667	0.123	26	10560	10989.33	0.040
6	9200	3425.333	0.627	27	13176	10990.33	0.165
7	12875	5317	0.587	28	8952	11423.67	0.276
8	10337	8412.333	0.186	29	9504	10896	0.146
9	12602	10804	0.142	30	13174	10544	0.199
10	9067	11938	0.316	31	9504	10543.33	0.109
11	11845	10668.67	0.099	32	6182	10727.33	0.735
12	11846	11171.33	0.057	33	10369	9620	0.072
13	12143	10919.33	0.100	34	10927	8685	0.205
14	10778	11944.67	0.108	35	14303	9159.333	0.359
15	12595	11589	0.079	36	5280	11866.33	1.247
16	9283	11838.67	0.275	37	7477	10170	0.360
17	10964	10885.33	0.007	38	10771	9020	0.162
18	14220	10947.33	0.230	39	6608	7842.667	0.186
19	8345	11489	0.376	40	7710	8285.333	0.074
20	7524	11176.33	0.485	41	6836	8363	0.223
21	13386	10029.67	0.250	42	8564	7051.333	0.176

Figure 5 shows a graphical representation of the estimated values based on the moving average method and the actual values. The MAPE, MAD and MSE values shown here represent the average error values of 66 units of data between 2011 and 2016.

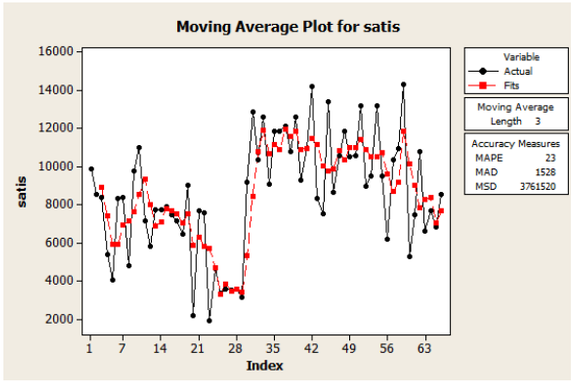

Figure 5. Representation of estimated and actual values based on the moving average method

3.1.2. Simple Exponential Smoothing Method

Table 3 shows the estimated values and error values based on the simple exponential smoothing method. The value recommended by the Minitab software was taken as the smoothing coefficient. This value was $\alpha = .334395$. The MAPE value was found to be 24.2%.

Table 3. Estimated values found using the simple exponential smoothing method

Nu	Sales	Guess	Mape	Nu	Sales	Guess	Mape
1	3337	4627	0.386	22	8654	10925.4	0.262
2	3541	4195.28	0.184	23	10557	10165.2	0.037
3	3525	3976.32	0.128	24	11876	10296.3	0.133
4	3589	3825.28	0.065	25	10535	10825.0	0.027
5	3162	3746.20	0.184	26	10560	10727.9	0.015
6	9200	3550.69	0.614	27	13176	10671.7	0.190
7	12875	5441.30	0.577	28	8952	11509.8	0.285
8	10337	7929.07	0.232	29	9504	10653.8	0.121
9	12602	8734.91	0.306	30	13174	10269.0	0.220
10	9067	10029.0	0.106	31	9504	11241.2	0.182
11	11845	9707,11	0.180	32	6182	10659.8	0.724
12	11846	10422.5	0.120	33	10369	9161.26	0.116

13	12143	10898.9	0.102	34	10927	9565.45	0.124
14	10778	11315.2	0.049	35	14303	10021.1	0.299
15	12595	11135.4	0.115	36	5280	11454.1	1.169
16	9283	11623.9	0.252	37	7477	9387.86	0.255
17	10964	10840.5	0.011	38	10771	8748.36	0.187
18	14220	10881.83	0.234	39	6608	9425.26	0.4263
19	8345	11998.9	0.4379	40	7710	8482.43	0.100
20	7524	10776.1	0.432	41	6836	8223.93	0.203
21	13386	9687.77	0.276	42	8564	7759.442	0.093

Figure 6 shows a graphical representation of the estimated values and the actual values based on the simple exponential smoothing method.

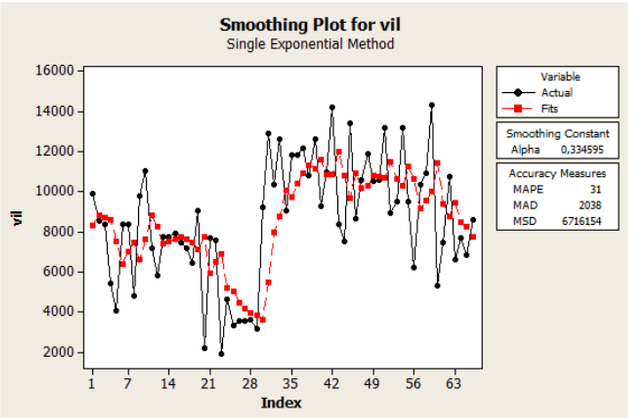

Figure 6. Representation of estimated and actual values based on the simple exponential smoothing method

3.2. Artificial Neural Network MATLAB Applications

The most commonly-used method for demand forecasting is the backpropagation algorithm. For this reason, the multi-layered feed-forward backpropagation algorithm was used in this study. As the normalisation technique, the most commonly used the D_Min_Max method was used to normalise all the data between 0.1 and 0.9, and then, these data were transferred to the software. All the models that were created within the study consisted of an input layer, an output layer and a hidden layer. The input layer consisted of eight cells, and the output layer consisted of one cell.

In this study, first of all, the number of cycles was kept constant, and an attempt was made to find the most suitable value for the coefficients of momentum and learning. To do this, the coefficients of momentum and learning were modified while holding the number of cycles constant at 1000, and the most suitable values were determined. Variations in the number of cells, momentum coefficient and learning coefficient affected the results of forecasting. So, a considerable number of attempts were made, and the results were compared.

In this study, the neural network code of the MATLAB R2015A software was used to train the network. Figure 7 shows the artificial neural network model that was created. The MAPE value was found to be 7.44%.

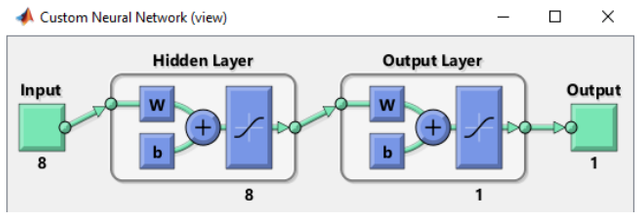

Figure 7. Representation of ANN

Figure 8 shows the regression graph obtained after the learning operation in MATLAB. According to this plot, the lowest value belonged to the test set that had an R value of 0.91525. In other words, the learning operation was a big success. The factors we identified as the independent variables affected the sales by a rate of at least 0.91.

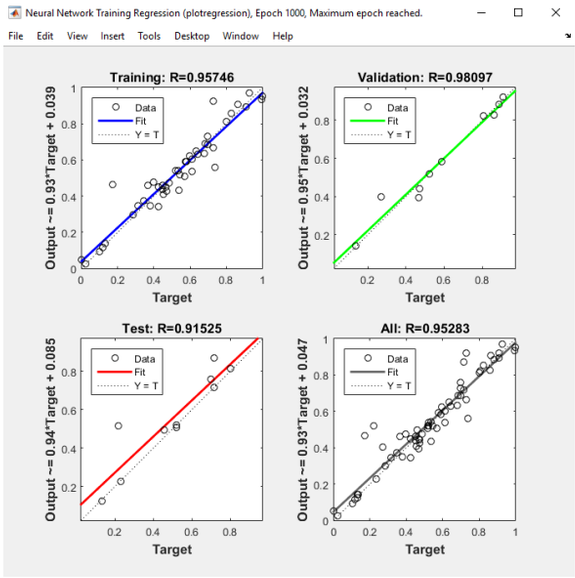

Figure 8. Regression plot regarding the learning, validation and test sets in MATLAB

During the test stage, 42 units of data, which the network had not seen while being trained, were used. After the test operation, it was necessary to compare the test output data provided by the network as an estimation of the actual data. Table 4 shows this comparison.

Table 4. Comparison of estimated values found through ANN with actual values

Sales	Guess	Sales	Guess
0.1157	0.1139	0.5445	0.5198
0.1322	0.1229	0.6979	0.7292
0.1309	0.1401	0.8043	0.8211
0.1360	0.1404	0.6962	0.6851
0.1016	0.0940	0.6982	0.7586
0.5885	0.5841	0.9091	0.8940
0.8848	0.8843	0.5685	0.5071
0.6802	0.6344	0.6130	0.5378
0.8628	0.9063	0.9090	0.9200
0.5778	0.5904	0.6130	0.6029
0.8018	0.8122	0.3451	0.3722
0.8019	0.8151	0.6828	0.6889
0.8258	0.8554	0.7278	0.6661
0.7157	0.7187	1.0000	0.9535
0.8623	0.8252	0.2724	0.4010
0.5952	0.6234	0.4496	0.4604
0.7307	0.9232	0.7152	0.8708
0.9933	0.9336	0.3795	0.3469
0.5196	0.5059	0.4683	0.3951
0.4534	0.4083	0.3979	0.4774
0.9261	0.9705	0.5372	0.4332

3.3. Comparison of the Estimation Methods

Table 5 shows a comparison of the estimation results based on ANN, multiple regression and time series nalyses. The average error value, MAPE, was taken as the performance function. As seen in Table 5, the best result was the estimated value found through the ANN.

Table 5. Comparison of the estimation methods

MAPE %	YSA	Regression	Moving Average	S. Exponential Correction
	7.44	12.66	23.08	24.2

4. CONCLUSION AND RECOMMENDATIONS

In this study, time series analysis method and artificial neural networks methods were used to estimate the number of sales for future months of one of the leading companies of the automotive industry in Turkey. The

study used monthly data between January 2011 and July 2016. The following were used as the independent variables: number of vehicles registered, gross domestic product, consumer price index, dollar exchange rate, real sector confidence index, consumer confidence index, monthly working hours of the company and the number of vehicle models produced by the company. The total number of vehicles sold was taken as the dependent variable. In order to measure the success of the forecasting operation, the estimation results obtained through the multiple regression model and the time series analysis were compared to the ANN estimation results. When the estimates were compared to the actual values, the predicted and actual values in the artificial neural network method were found to be closer to each other. The MAPE values found through the ANN, multiple regression, moving average, and simple exponential smoothing methods were 7.44%, 12.66%, 23.08%, and 24.2%, respectively. They are shown in Table 5. When the MAPE values were compared, the best result was obtained in the artificial neural networks method by 7.44%.

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