Car Sales Forecasting Using Artificial Neural Networks and Analytical Hierarchy Process

Case Study: Kia and Hyundai Corporations in the USA

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***Abstract* - In this study, we evaluate different effective factors related to marketing and sales and discuss the various prediction methods. The field of this study is the car industry and the tools used for classification, comparison and weight determination is the Analytical Hierarchy Process (AHP). Artificial Neural Networks are used for identifying the architecture and shaping the process of prediction. In order to do so, using a questionnaire presented to experts in the field, the factors affecting car sales in North America were identified and the processed weights obtained from these opinions were fed to the neural network as input, so that, ultimately, by teaching the network through different algorithms, the optimal solution can be obtained. The conceptual model of the research first identifies the factors affecting sales and then tries to determine the interconnection among the data. In order to compare the performance of this method, we needed a valid and established measure so that we can assess the methods based on it. Therefore, linear and exponential regression methods were selected to compare the degree of error and to obtain a more desirable final output which is closer to reality. The obtained result indicates the successful performance of the neural network compared to other selected methods and it was found that it has a lower Minimum Square Error (MSE) compared to others.**

Keywords- car sale prediction; analytical hierarchy process; artificial neural networks; feed forward network; multi-layer back propagation neural network; learning algorithm

I. INTRODUCTION

Management has always been significant for people, companies, and governments. Each one of these groups has dealt with this issue somehow and they try to maximize their wealth. Hence, they have to make the right decisions, one of which is the decision regarding (future) investments. This study evaluates the utilization of neural networks for predicting sales in the car industry and compares it with reality. It justifies the use of neural networks in this industry for the prediction process. Generally, car manufacturing industries include design, development, manufacturing, marketing and sale of different equipment for motor vehicles. The set of companies and factories involved in design, manufacturing, marketing, and sale of motor vehicles are a part of this industry. In 2008, more than 70 million motor vehicles including ordinary cars and commercial vehicles were manufactured around the world. In 2007, a total number of 71.9 million cars were sold in the world, with 22.9 million sold in Europe, 21.4 million sold in Asia and Pacific Region, 19.4 million sold in the US and Canada, 4.4 million sold in Latin America, 2.4 million sold in the Middle East, and 1.4 million sold in Africa. When the market was experiencing a recession in the US and Japan, Asia and South America significantly grew and got stronger. Moreover, it seems that large markets in Russia, Brazil, India and China have experienced a rapid growth. The car industry, as one of the largest industries in the world hosting a large amount of people, financial and time resources, is in dire need of accurate predictions of its future and its competitors in order to reach big and sensitive decisions. Perhaps one of the biggest concerns of the managers and manufacturers in the car industry and the investors in this field is the prediction of product sales and planning for the future manufacturing volume. If a manager can have a more accurate prediction regarding the future sales volume and car demand, they can absolutely optimize the investment volume, recruit workforce and optimally use time to reach optimal decisions and carry out macro strategies.

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II. The Conceptual Model of the Study

Five initial exogenous variables were used as the input for the neural network and the network was prepared for the entrance of the sixth variable; namely, the effect of season and month on buying behavior (see Figure 1). Then, the effect of the month was normalized and used as the main input for the network. Weights affecting the car sales were already extracted in previous studies; however, due to the specific geographical focus of this study, we needed to generate these effective weights. Therefore, the factors were extracted from electronic databases, particularly two prestigious studies in the car industry, and, after generating them and presenting questionnaires to experts in the same geographical region and integrating the sum of the weights, the viewpoints were ordered using analytical hierarchy process. In order to be used in other studies, the questionnaires were classified into sub-factors for each factor, too and the weights of the head factors were introduced into the system of the study. Regarding the introduction of seasonal and monthly effects, by identifying and analyzing high-sale and low-sale months and ranking these sites using the Excel software application, the months were ranked based on the sales volume from 2010 to 2015 and then they were normalized using Equation 1:

$$S_{iN} = \frac{S_i - S_{min}}{S_{max} - S_{min}} \qquad (1)$$

Where

S_{max}: Equals the maximum value for each entry;

S_{min}: Equals the minimum value for each entry;

S_i: Is the value of the i^{th} entry.

S_{iN}: Is the normalized value of the i^{th} entry.

Due to the stability of criteria selection for humans, the data arising from individual judgment and their taste in time have stability and solidity. For instance, an individual who cares about safety, based on personality stability theory and selection stability, is very likely not to change his mind about his choice in the next five years. Therefore, after using fixed weights, due to the dynamic nature of neural networks, this study requires a dynamic measure for better training the network. In order to reach this, the seasonal and monthly data are used as the sixth variable for making the entries dynamic. The method for extracting monthly data for each country is different, since the coefficients of the months are different in each country. In the following, the monthly weights extraction process for the USA and the normalization method for these weights are discussed in detail [2].

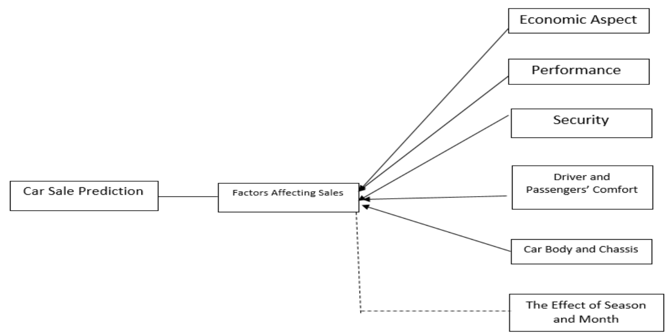

Figure 1: The Conceptual Model of the Study

The schematic conceptual model of the study is devised and presented for representation and simplification of the inputs and objectives framework. The conceptual model in this study is represented by expressing the factors affecting sales, categorization and the desired objective.

III. Methodology

Regarding objectives, this study searches for a scientific process for improving decision making about the future of the car industry, the time consumed, the energy, and the investment, as well as preventing the untimely manufacturing, which interferes with the economic cycle and leads to the loss of the industry. This can be used in governmental and non-governmental sectors, whether from the viewpoint of industrial policy making or the viewpoint of enterprise profitability. Regarding the type and nature, this study is a descriptive-analytical one since it evaluates and analyzes the current state of the market.

In this study, at first, the factors affecting car sales are identified based on previous studies and researches and then, these are presented to a panel of experts in order to be ranked.

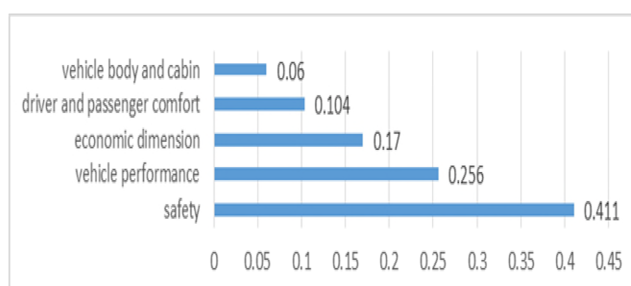

Figure 2: The Weights of the Factors Affecting Sales Obtained from the Software

Then, the semi-processed information is sent to the Expert Choice software application for final and ultimate processing and after obtaining the output as weights, they are presented along with the main input data to the neural network so that, while teaching the main data and using these weights, a better forecasting for the future can be obtained. Finally, the prediction data is compared to the real data so that the validity of the developed model can be measured. The statistical population of the study includes the market for the products of Kia and Hyundai corporations in the US and Canada from 2010 until 2015. This information is extracted from the formal electronic databases supervising the American industries as well as the databases of Kia and Hyundai corporations. In order to gather the required data for the theoretical sections (e.g. previous studies or introduction to artificial neural networks), the library method (using online databases, books, dissertations, and online articles) was used and for gathering the data related to the weights, the expert panel method was used and the opinions were integrated using the relevant software applications [8].

IV. DATA ANALYSIS

In this section, the multi-layer back propagation neural network is applied on the sales data for Kia and Hyundai corporations in the US and Canada from 2010 until 2015 in order to propose a model for predicting the car sales based on artificial intelligence. The 6 determining variables for car sales (economic, dimension, performance, safety, driver and passengers' comfort, dimensions, size, and the appearance of the car as well as the seasonal effects on sale) were used in two groups as the input for the network. In the first group, which includes the first five variables mentioned, the data was extracted using questionnaire from the expert panel and was fed into the group analytical hierarchy process. The cumulative results obtained from the Expert Choice software application were considered as the first group of inputs. The system was taught using these weights and was prepared for the second group of inputs, which include the seasonal effects on sale. The inputs of the artificial neural network have been normalized so that they can be between 0 and 1, and then they are fed into the neural network. In this study, a neural network with two hidden layers is used and the different network parameters (such as, the number of neurons, the type of network training algorithm, the fraction of the data tested by the network, and so on) were optimized using the neural network branch of MATLAB software application. Since the neural network toolboxes in MATLAB software application are intended to be used in ordinary and non-professional conditions and have a higher error compared to the manual configuration condition, this study uses the input codes obtained after performing a huge number of tests. In order to arrive at opinions relevant to the industry as well as the customers, this study uses the opinions of individuals who were unbiased and non-stakeholders while related to the car industry so that they can add both versions of an opinion to the questionnaire [3]. Table I represents the target data which include the sales volume of Kia and Hyundai cars in the USA from 2010 to 2015.

In order to extract the monthly effective data and the seasonal effect on buying behavior, we ranked the high-sale months using data classification in Excel software application and then the obtained rankings were normalized. This data, presented in Table II, is the input variables of the study for the artificial neural network to teach it and determine implicit relations between the network inputs and the network outputs. We use the term "implicit" because, in order to discover the relations among the data, the artificial neural network assesses the numbers in its black box. Hence, finding the exact relations and allocated weights by the network itself is highly complex, even impossible due to being highly time-consuming task.

TABLE I: SALES VOLUME DATA FOR KIA AND HYUNDAY CARS IN THE US

Month	2010	2011	2012	2013	2014
January	52626	65003	78211	80015	81016
February	58056	76339	96189	93816	90221
March	77524	106052	127233	117431	121782
April	74059	108828	109814	110871	119783
May	80476	107426	118790	120685	130994
June	83111	104253	115139	115543	118051
July	89525	105065	110095	115009	119320
August	86068	99693	111127	118126	124670
September	76627	87660	108130	93105	96638
October	73855	90092	92723	93309	94775
November	67324	86617	94542	101416	98608
December	75246	94155	98613	96636	110094

TABLE II: CLASSIFICATION AND RANKING OF HIGH-SALE TO LOW-SALE MONTHS

Ranking in Each Year					
Month	2010	2011	2012	2013	2014
January	12	12	12	12	12
February	11	11	9	9	11
March	5	3	1	3	3
April	8	1	6	6	4
May	4	2	2	1	1
June	3	5	3	4	6
July	1	4	5	5	5
August	2	6	4	2	2
September	6	9	7	11	9
October	9	8	11	10	10
November	10	10	10	7	8
December	7	7	8	8	7

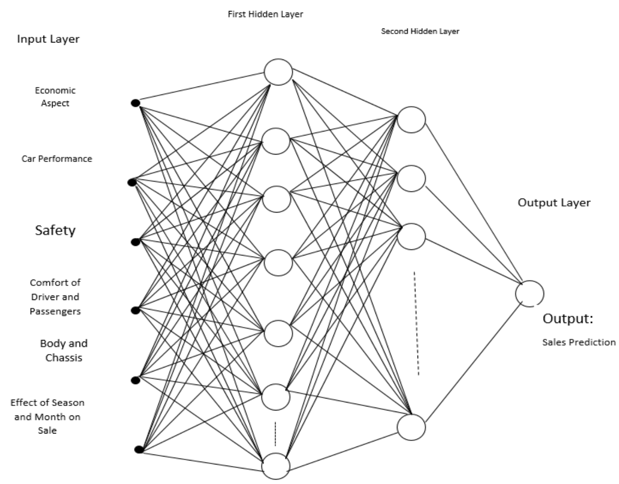

Figure 3: The Schematic Representation of the Neural Network Formed in the Study with Expected Inputs and Output

Due to the presence of an output at the end for predicting sales in each country (The US and Canada), a neuron is placed in the output layer of the neural network. The most important advantage of using this method is that even if the training accuracy for the network is not high, the network still keeps its generality [7]. Therefore, generally, the neural network involves six inputs and an output with two hidden layers. A schematic representation of the utilized neural network is presented in Fig.3.

The research data is categorized into three sections including training data, test data and evaluation data. The training data is simply used for adjusting the weights and biases of the neural network, while the test data is not involved in the training process of the network and it is just used for the generalization test of the network. The evaluation data is used for testing the generalization of the network in each stage of network training and then it is used for adjusting the network's weights and biases. MSE is used as a function of the neural network performance. In order to improve the performance of the network, the cross validation process is used for interrupting the training of the network. In this process, if the error of the network over the evaluation data after n times subsequent trainings is not improved, then the network training will be stopped in order to maintain the generalizability of the network. This study uses $n = 6$ as the criterion for stopping the network training. Another criterion used for maintaining the generalizability of the neural network is the gradient of the network in each repetition and, in this study, in order to reach the desired results, 1×10^{-5} is adopted [5].

V. Analyzing the Sensitivity of the Neural Network

In this section, the best algorithm for training the neural network and determining the number of neurons in the hidden layers is selected. Moreover, the sensitivity analysis is carried out on the fraction of data to be used as the test and evaluation data sets. Therefore, it has been tried to optimize the parameters of the neural network based on the network error.

VI. Selecting the Best Pattern for Network Training

The number of neurons in the first and second hidden layers are considered to be 10 and 1, respectively. By changing the network training algorithm, the training error over the test data is measured. The error obtained over the test data is used for selecting the network training algorithm based on a network with higher generalization capability [4]. Since the initial weights and biases of the network are selected randomly and these values affect the performance of the network, the neural network was carried out 30 times for each algorithm and the minimum error in these 30 runs was selected as a criterion for measuring the appropriate algorithm for training the network [6]. Accordingly, the results are presented in Fig.4.

Figure 4: MSE Minimum Value over the Test Data for Different Neural Network Training Algorithms

Based on the results presented in Fig.4, training algorithms of *Trainlm* and *Trainbr* have the lowest error-based on the mean error MSE. Since the *Trainbr* algorithm has the lowest error, it is used for training the network.

VII. Determining the Optimal Value for the Number of Neurons in the First and Second Hidden Layers

Determining the number of neurons in hidden layers is of particular significance in the structure of neural networks. The presence of huge number of neurons in hidden layers will lead to the higher complexity of the neural network and increasing number of its adjustable parameters (weights and biases). Whereas, the presence of a fewer number of neurons in hidden layers can lead to a situation where the neural network is not able to efficiently describe the relations present between the inputs and output of the network. In order to determine the optimal number of neurons in the first and second hidden layers, by keeping all the other parameters constant, the first and second hidden layers vary between 5 and 12 and between 1 and 10, respectively, and the value of the minimum error (MSE) for each state over the test data is calculated. This computational tolerance is presented in Table III, along with extracting the optimal solution.

VIII. The Results Obtained from Training the Neural Network

Based on the sensitivity analysis carried out in the previous section and the adjustment of different parameters for the neural network, the following values are selected for the neural network and in order to reach the best results over the neural network, the network is run multiple times in order to obtain the lowest value of MSE.

TABLE III. COMPUTATIONAL TOLERANCE

Network Training Algorithm	*Trainbr*
The Fraction of Training, Test, and Evaluation Data	15%, 15%, and 70%
Neurons in the First Layer	10
Neurons in the Second Layer	1

After training the optimized neural network, Fig.5 is obtained for the error of the network. It is worth mentioning that after 8 repetitions from the beginning of network training, variations in the values of network parameters significantly reduced, indicating the convergence of the network in low repetitions. It should also

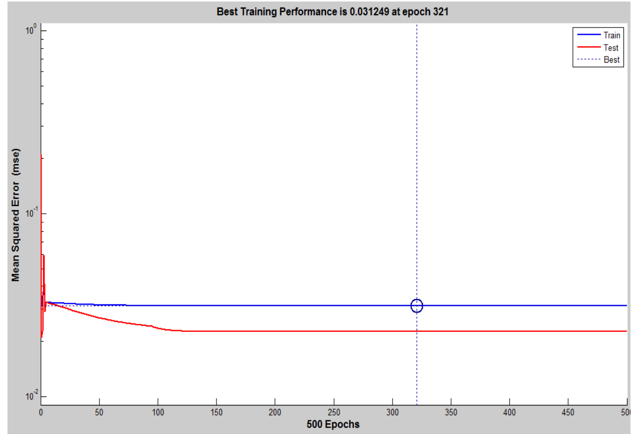

Figure 5: Error Curve for Optimized Neural Network over the Training and Test Data

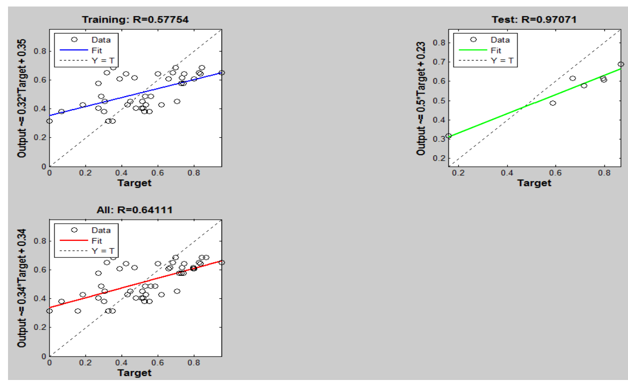

Figure 6: The Curve for Correlation among the Factors and Following the Regression Pattern

be said that the network training is carried out in Batch mode, which means that the selection of weights and biases of the network is done after applying all the training data. Another method is to update the weights and biases of the network after applying each individual input. In Fig.5, we trained and optimized the network using the Bayesian command. As mentioned before, the method with lowest error for optimizing the problem is to use the training algorithm. Perhaps, in most cases, the Levenberg-Marquardt (LM) algorithm provides a suitable solution. However, regarding the current study which differs from other studies, due to limited data at the input level and the lack of rich data for forming the network, the Bayesian algorithm provides a better optimization.

In the fields of management and economics, it is highly common to use the regression method for predicting a factor or some factors in the future. The regression method

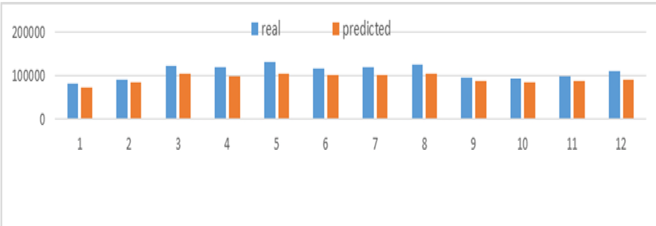

Figure 7: Comparing the Prediction of the Neural Networks with the Real Values of the Data

TABLE IV: COMPARING THE RESULTS FOR THE PERFORMANCEOF THE NEURAL NETWORK vs CONVENTIONAL PREDICTION METHODS

MSE		
Artificial Neural Network	Linear Regression	Exponential Regression
0.44 × 10 e8	1.64 × 10 e8	37 × 10 e8

uses data trends to predict the next step of the data. Generally, regression is classified as linear or non-linear or exponential. In this study, in order to evaluate the performance and efficiency of the neural network, the prediction data are compared to the real data as well as the data predicted by the regression method. The linear regression is closer to reality compared to the non-linear regression [10]. In order to facilitate the comparison, the data are simplified based on 10 to the power of 8 [1]. As can be inferred from Table IV, each model or method providing lower error compared to the real data, is more reliable and usable. In this study, the neural network is used as a pioneer network in minimizing the prediction error. Fig.7 shows how much the error of this claim is compared to the real data.

IX. CONCLUSIONS AND RECOMMENDATIONS

In this study, neural networks were used for predicting car sales. The important point and the differentiating aspect of this study compared to previous studies is using limited data which is considered one of the weaknesses of neural networks. However, at the end, with the proper architecture and training and using an optimal algorithm, this study was successful in optimizing this network even for limited data. The results obtained over training, test, and evaluation data indicate the capability of the neural network as one of the artificial intelligence methods for accurate prediction of car sales. Using the simulation carried out for the neural network and determining the method for changing car sales based on different parameters, it was concluded that the neural network is able to efficiently predict the normal trend of car sales based on the six factors of price, performance, safety, appearance, and comfort as well as the effects of months on the sale volume. Accordingly, it was concluded that based on the data utilized, the highest impact from car aspects on the sale are for safety and generally, the sales variations are influenced by the season and month. The trained neural network can be used in the future as a criterion for predicting car sales over limited data. Accordingly, before manufacturing the desired car, the trained neural network can be used to determine if this manufactured car attracts enough demand and sale capability or not or the investment will be influenced by demand risk loss. Based on the positive performance of neural network in this study, it is recommended to compare the artificial neural network and fitting curves for subjects with limited and poor data [9].

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