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Artificial Neural Networks: A Brief Literature Review

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Abstract

There are thousands of studies in the literature on the use of artificial neural network methods in estimation problems. As in all issues, modeling is one of the essential processes for the solution of estimation problems. In order to make a good prediction, it is necessary to pay attention to the necessary rules. The more attention is paid to the estimation stages, the more accurate the assessment will be, and the results can be generalized. In this study, publications in the literature on artificial neural networks were examined. This work aims to explore the studies on artificial neural networks and emphasize their importance. It is also of great importance to increase the number of studies in this field.

Keywords: Artificial Intelligence, Artificial Neural Networks, Intelligence, Neural Networks.

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1.INTRODUCTION

Artificial Intelligence (AI) and Artificial Neural Networks (ANN) are among the most trendy topics today. Many studies in the field of artificial intelligence are available in the literature.[1-8] Many publications on artificial neural networks have been studied in detail.

Intelligence is defined as the computational part of the ability to achieve goals in the world. AI is defined as the science and engineering of making intelligent computer programs and intelligent machines. [9]

Artificial intelligence is a field in which the most severe and intensive studies are carried out globally. Artificial intelligence has entered almost every area of our lives. Artificial intelligence is a set of software and hardware systems with many abilities, such as exhibiting human-like behaviors, numerical reasoning, movement, speech, and sound perception. In short, artificial intelligence enables computers to think like humans. Machine Learning and AI will impact doctors, hospitals, and many others working in healthcare. [8]

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. It is natural proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. [10]

The followings can be said as a result of the findings obtained from the study. [11]

1. The highest R2 value was reached for the period determined in the study, in which the previous day's index, USD, and overnight interest values were used as variables.
2. The R2 values showed that the ISE index value could also be modeled successfully with feedforward artificial neural networks.
3. It is considered that the effect of the days of the week on the index forecast is not significant. Foreign stock markets did not have a positive impact on the index forecast.

Neural networks performed slightly better than the simple moving average method in predicting the direction of the index. [11]

It shows that ANN techniques can be used as an estimation tool and give good results. The good results of the regression technique and Box-Jenkins models are closely related to the number of observations. Box and Jenkins state that Autoregressive Integrated Moving Average (ARIMA) models should be studied with more than 70 observations. On the other hand, ANN techniques allow working with fewer data. However, ANN techniques can sometimes produce negative results, showing black box characteristics. Therefore, when used as an estimation tool, the results obtained with traditional methods can be used to support ANN techniques. A network established by the nature of the problem will give good results. Therefore, suitable network structures should be searched according to the investigated problem. [12]

It has been tried to predict the future prices of second-hand cars with ANN in the study. [13] To see the prediction accuracy of the ANN, the results were compared using time series analysis methods. All models created in the study can be used successfully in estimating used car prices. On the other hand, although the differences between the observed error values between the methods used are not very high, ANN is more successful in all data

sets has shown that this method can be an alternative to classical statistical methods. As a result, it can be stated that the ANN, where the appropriate parameters are selected, can be successfully used to predict the current and future prices of second-hand cars. Although ANNs are perceived as black boxes, they can be recommended to be used in the automobile industry, as in many other fields, due to their uncomplicated design, ability to adapt to the problem quickly, and ability to produce successful results despite a small number of data. [13]

The ANN model estimates were compared with the measured evaporation amount and the most common empirical method results. In the ANN model, climatic parameters such as wind speed, air temperature, relative humidity, and insolation (solar radiation) gave the evaporation amount the lowest error and the best estimation results. It has been seen that Artificial Neural Networks are a model that can be applied in the estimation of water loss by evaporation and the studies and determination of changes in the water planning needed. The reason why ANN is more advantageous than traditional methods in estimating evaporation amounts is explained as the fact that the structure of ANN can include the nonlinear dynamics of the problem in the solution. It is thought that the ANN model created for the determination of evaporation in a region can be used to determine dam reservoir changes and operation strategies, studies on water resources, and their planning stages. [14]

According to the results obtained from the ANN and Support Vector Machines (SVM) methods, the differences between the actual values and the estimated values were compared statistically with the hypothesis test. There was no significant difference between the 95% confidence interval values. [15]

In the light of this information obtained, the following can be said: [15]

- It has been observed that the days of the week affect the index forecast.
- Foreign stock markets are considered to affect the index forecast positively.
- As in both methods, the models created with the data from the previous day, the models created with the data two days ago; It was observed that the models created with the data from two days ago produced higher prediction results than the models created with the data from three days ago.

The results showed that both ANN and SVM methods could be used in stock market index estimation. [15]

The study [16] is preliminary in estimating the occupancy rates of accommodation establishments in Turkey using artificial neural networks. The study reveals that occupancy rates in accommodation establishments can be predicted using artificial neural networks. Therefore, practitioners in the tourism sector and decision-making managers can use artificial neural networks to alternative traditional estimation methods in their future planning studies. Five explanatory variables were used to estimate the occupancy rate in the study. In future research, occupancy rate estimates can be made using more variables or variables other than these five variables used in the study. For example, exchange rates, disposable income per capita, comparative price indices between countries, average accommodation prices, Gross National Product (GNP) in tourist sending countries, promotional and marketing expenditures; It can play an essential role in determining the occupancy rates and the number of tourists coming to the country. In future studies; by using artificial neural networks, estimates can be made regarding the occupancy rates of accommodation establishments operating within the borders of a specific region or province (for example, Antalya and its surroundings), the expenditures of local and foreign guests in accommodation establishments, the number of overnight stays of tourists and the average length of stay. These estimation studies will guide the managers of tourism enterprises and local governments in their future decision-making and planning studies. [16]

In the study [17], in addition to the variables frequently used in the literature to estimate the net energy demand of Turkey with ANN, different variables that may affect the energy demand were investigated. To evaluate the success of the estimation study and measure its performance, regression and time series models were developed with the determined variables, and comparisons were made with the proposed ANN model. In addition, it has been seen that the input variables of building area and the number of vehicles used in this study, unlike the literature, effectively increase the estimation performance. As a result of the analyzes and comparisons made, it was determined that the proposed ANN model could make excellent and high-accuracy estimations. With this model, Turkey's net energy demand was estimated from 2011-2025. [17]

In the study [18], new automobile sales figures in Turkey were estimated using the Artificial Neural Networks method. In this study, monthly data between January-2007 and June-2011 were considered. In the study, the variables affecting automobile sales were determined as gross domestic product, real sector confidence index, consumer confidence index, investment expenditures, consumption expenditures, consumer price index, vehicle purchase, dollar, and time. They can be a helpful resource for automotive sector managers in their future decision-making and planning studies. [18]

In the study [19], the population, Gross Domestic Product (GDP), energy production and consumption, energy use for transportation, and greenhouse gas emission amounts of EU-28 countries and Turkey between 1990-2030 for five years were used. The amount of greenhouse gas emissions has been estimated by the ANN model, which gives successful results. The data set in the study covers a long-range and many countries. This increased the reliability of the results obtained. With the estimation, it has been determined that if Turkey continues its assumed development course, the number of emissions will be 1244.13 Mt CO2 equivalent in 2030. [19]

In the study [20], the natural gas consumption of Ankara was estimated by using artificial neural networks and ARIMA time series analysis methods. In the models used in this study, the variables are only past natural gas consumption observations. Among the factors affecting natural gas consumption, variables such as the price of natural gas, the costs of alternative energy sources (such as oil, coal, electricity), air temperature, and the number of subscribers can be counted. The lack of data on these different variables and the inability to include them in the models constitute one of the study's limitations. The low

number of data on natural gas statistics every month in our country has hindered the creation of models that will make monthly forecasts. In future studies, regression models can be created by obtaining data on different variables, and the estimation results can be compared.

The results obtained from the study [21]; reveals that the demand for tourism enterprises can be predicted correctly by using the ANN model so that the practitioners in the tourism sector and the managers in the decision-making position can use the ANN model as an alternative to traditional forecasting methods in their future planning studies. In the study, six variables that affect tourism demand at specific rates were determined, and these variables were used as inputs. As input to the model, data entries related to the previous 48-month period were made, and forecasts were produced for the next 6-month period. According to the correlation results between the tourism demand forecasts delivered by the ANN model and the tourism demand realized in this period, it can be said that the model's explanatory power is high. The Mean Absolute Percentage Error (MAPE) value, widely used in measuring forecast errors in the relevant literature, is below 10%, that is, at the "high accuracy" level. It can be stated that these results are very positive results, similar to the applications made with ANN in the related literature. Thanks to these data obtained from the study, the operators in the province will be able to make their plans one season in advance and develop strategies for their investments in advance. [21]

In the study [22], ANN was used to predict gold prices. When traditional estimation methods are compared with ANN, estimation with ANN goes through training, validation, and testing stages, it needs more data than other methods. On the other hand, more data provides better results for the economic variables to be estimated. [22]

Today, insurance companies are of great importance to the financial world. This importance is because insurance companies provide funds to the system, take part in risk management, and are an investment option for investors. This empirical study is based on the fact that the stocks of insurance companies are an investment alternative for investors. The study investigated whether it is possible to provide information to investors by predicting the stock prices of seven companies traded on the Istanbul Stock Exchange (ISE) and making up the ISE Sector Index. For this purpose, estimations were made between 15 days and two months with Artificial Neural Network Models from Machine Learning Techniques. The results show that all predictions up to two months are thriving, especially those up to 1 month are pretty successful. As a result; By using Artificial Neural Network Models, it has been demonstrated that investors can be guided by providing preliminary information about the stocks of insurance companies in the ISE. [23]

In the study [24], a model that predicts the amount of food produced in enterprises or the demand for personnel using artificial neural networks is proposed. The proposed model has been tested with actual data, and the results are given. Experiment results analyses and comparisons have revealed that the proposed ANN model can make predictions with high accuracy, so the model is quite good in terms of performance. At this point, it has been observed that the performance of the model decreases, and the error rate increases significantly when the number of neurons in the hidden layer is determined too low or too high when choosing the model. This situation can be shown as a sign that the model memorized or forgot what it learned. In this context, although the prediction models created with ANN give effective results, the experimental results found with traditional methods can be used to support ANN. [24]

When the estimation results of ANN and Regression Models are compared, it is seen that models developed with the artificial neural network are much better than regression models. However, in both models, it is seen that the forecast values produced in November, December, January, and February are weaker than the other months. This situation is thought to be due to the heavy rainfall in the winter months and the presence of snow cover on the soil. The prediction models created in the application were applied to each station separately, and it was observed that the model's predictive power was relatively high at different stations. In this case, it can be said that the model can be generalized to the whole of Turkey. To make predictions for future years with the models developed for predicting soil temperature in the next year, the structure of the models should be changed, and the artificial neural network model should be retrained according to the desired year. [25]

In the analysis part of the study [26], the imported variable, which has an important place in the Turkish economy, was tried to be estimated using the Artificial Neural Networks Method. In the literature, no study has been found in which imports are calculated using the Artificial Neural Networks Method and economic variables. An analysis of the domestic and foreign literature on the selection of the independent variables used to estimate imports has been made, and the studies on the factors determining the substance have been examined in detail. [26]

The study [26] aims to examine all aspects of imports in Turkey in the historical process and reveal the predictability of substances by using the Artificial Neural Networks Method. It is to guide the researchers who will use the Artificial Neural Networks Method in estimating the import, which input variables can be used, the architecture of the network, the number of hidden layers, the number of neurons in its layers, and the activation functions they will use. In addition, it has been concluded that it can be used to estimate the variables of the future years. Since its explanatory power is high, the estimation results are consistent and accurate. The estimation of imports in Turkey is fundamental, especially for macroeconomic purposes. It was considered the primary role of the foreign trade deficit in creating Turkey's current account deficit, the importance of determining policies and strategies regarding imports increases. In this context, the most critical finding of the research is that the Artificial Neural Networks Method can be used to determine the import demand. [26]

The course of some macroeconomic variables is or will be closely related to the goals of sustainable development and growth in an economy. Today, when the world's countries feel the phenomenon of globalization on a micro and macro basis, it is not possible for governments to determine their economic policies independently of each other. Especially since economic and political uncertainties threaten all

macro policies intensively in underdeveloped and developing countries, including Turkey, such countries have to find a way to get rid of it with the minor damage and formulate appropriate policies. The most realistic and practical method of developing these policies is to predict macro and microeconomic variables. It is necessary to create detailed analyzes and forecast models for macroeconomic indicators such as unemployment rate, inflation rate, and the ISE index, which is not independent of macro targets and responds quickly to political and economic developments in the country. Soft computing techniques such as ANN, fuzzy logic, and genetic algorithm have the opportunity to solve very complex models, unlike traditional time series. In this respect, many models, including these methods, have been used in forecasting studies. [27]

In the study [28], software was developed by using Matlab program to create artificial neural network models. All Multi Layer Perceptron (MLP) models made within the scope of the study have a 3-layer architecture consisting of the input layer, output layer, and one hidden layer. Thanks to the implemented software, 100 different artificial neural network models were obtained by changing the number of input neurons and the number of neurons used in the hidden layer from 1 to 10. Before the data is entered into the networks created with MLP, it is adapted to the network structure; Necessary input and output vectors have been created. By presenting the training data to the network, the network's learning process was performed. Among these hundred models, the artificial neural network model was selected, which gives the Mean Squared Error (MSE) and MAPE value for the test data. [28]

Natural events do not always allow comfortable modeling to classical methods. Other methods can be used more appropriately in cases of uncertainty and uncertainty. Therefore, in this study, 1603 pieces of data from 1990-1999 were analyzed using feedforward back-propagation artificial neural networks and radial-based artificial neural networks method, which can be expressed as soft computing in the literature. The ANN model training was done using the ANN model, and the daily evaporation amount was estimated for 1033 data from Sapanca Lake between 2000-2004. At the same time, estimations were made using the Penman-Monteith (PM) model of the same years, and the results obtained with this method were compared with the results obtained with ANN. [29]

In the study [30], logistic regression analysis, one of the statistical methods used for predicting credit risk, and artificial neural networks are used to compare the credit risk estimation power of the methods. When the classification successes of the methods are examined according to the analysis results, it is seen that the correct classification rate of the artificial neural network model is 70.3%, and the correct classification rate of the logistic regression model is 65.1%. It has been determined that the artificial neural network method is superior to the logistic regression analysis in predicting credit risk. As a result, the artificial neural networks method can be used as an alternative method to logistic regression analysis to predict whether new customers who request loans will repay their loans regularly in the future when the variables affecting the order of loan repayments are known. Thus, by estimating whether customers who request loans will pay their loans regularly in the future, loans may not be extended to customers who are expected not to pay their loans regularly. Customers' loans in this class can be monitored more closely than other loans. In this way, the credit risk undertaken by the bank can be reduced. [30]

The study [31] discusses the estimation of flows in a stream from precipitation observations in that stream's basin. Akarçay basin, a closed basin in the Central Anatolian Region, was chosen for the application. Four different types of models were designed depending on the location of the precipitation observation stations in the bay and the observation range. The models were created by going through the training and testing phases by the ANN methodology. Artificial neural network architectures were established with the feed-forward backpropagation method, and the obtained prediction results were compared with the regression analysis results. As a result of the studies, the following effects were observed. [31]

Firstly, it was tried to predict the future flow value by using previous river flows. The results obtained using an artificial neural network with a feed-forward backpropagation algorithm were compared with the development of regression analysis. It was seen that flow prediction with artificial neural networks gave better results. [31]

- Flow estimates were made using Thiessen precipitation averages. The results obtained using an artificial neural network with a feed-forward backpropagation algorithm were compared with the regression analysis results. It was seen that the feed-forward back propagation method gave better results in flow estimation. In addition, as can be seen from the precipitation model that gave the best results, it was seen that the precipitation up to 5 months ago issued a higher correlation in estimating the flow at time t. [31]
- Flow estimates were made using average precipitation and previous flow values. When the results obtained are compared with the regression analysis results, it was seen that the artificial neural networks were more successful in estimating the current values. [31]
- The future flow is estimated using artificial neural networks and the precipitation values of the stations located upstream and the previous flow values. When the results obtained are compared with the regression analysis results, it was seen that the artificial neural networks were more successful in estimating the current values. [31]

The tests made with Artificial Neural Networks and statistical methods are estimations for dining halls where table d'hôte meals are served in the study. [32] This study reveals that artificial neural networks and other methods can be used successfully in cafeteria demand forecasting like another demand forecasting. As a continuation of this study, a study can be conducted to estimate food data other than table d'hote cafeteria data. In addition, data from university units located on different campuses can also be evaluated. The cafes and student cafeterias inside the university, the data of the schools outside the Kınıklı campus, and the criteria affecting the demands of these data can be determined, and systems can be designed to reduce the total amount of waste food within the university. Thanks to the created user interface, daily forecasts can be made for the future. The daily estimates can be compared with the expert opinion, and it can be ensured that the specialist opinion is positively affected. With expert opinions, the program

outputs can be created as separate network architecture, and a layered structure or fuzzy systems in which two outcomes are evaluated can be designed. [32]

In recent years, the artificial neural network method has been used extensively for this purpose. When the studies using the artificial neural network method are examined, it is observed that this method generally shows a higher prediction performance than the others. In the study, [33], the prediction performances of artificial neural network, linear and nonlinear multiple regression models were compared using five independent variables, and the number of German tourists coming to Antalya was estimated monthly for the years 2005 and 2006 with the artificial neural network model, which gives better performance values than the others. The study reveals that using artificial neural networks; tourism demand can be predicted monthly. Therefore, practitioners in the tourism sector and managers in decision-making can use artificial neural networks as an alternative to traditional forecasting methods in their future planning studies. For future studies; By using artificial neural networks and different variables, tourism demand for Turkey or a particular region, occupancy rates in accommodation establishments operating within the borders of a specific region or province, expenditures of domestic and foreign guests in accommodation establishments, number of overnight stays of tourists and estimation of the average length of stay can be suggested. It is thought that these estimation studies will guide the managers of tourism enterprises and local governments in their future decision-making and planning studies. [33]

In the study [34], it demonstrates the usability of the neural network model as an essential tool in business failures. Today, business failures are becoming a subject of curiosity by business managers, investors, and potential investors. In particular, business owners and investors attach importance to failure estimation in evaluating the effectiveness of the activities carried out within the scope of the business and taking corrective measures. At this point, it can be said that models for failure predictions can also be used as a control tool. The results obtained from the study also support the conclusion that the artificial neural network model can be an effective control tool in this sense. [34]

The results of the artificial neural networks and time series methods used in the study [35] are presented in tables in the previous section. Considering the results, artificial neural networks from prediction models predicted energy consumption data with higher performance. The performance of time series is directly related to the number of data, and therefore a worse result was obtained. [35]

The 90% success rate achieved in this network structure reveals a successful network structure when the previous studies are examined. Since the human factor also plays an essential role in predicting a sports event, it is pretty standard for the network to make huge mistakes sometimes. Still, among the rounded values close to 0, the home team is more dominant, and the away team is more prevalent in the ones close to 1 with the test set results and the test set results. It is evident when the results of the matches are compared. [36]

In the study [37], dibis dam level estimation was tried to be determined by establishing ANN models. For this reason, 2 ANN models were found on two different input variables. 4, 6, 8, and 10 neurons were used in each ANN model. In the first model, the flow into the chamber, the flow out, and precipitation are used as input parameters. It was observed that the results were insufficient in all sub-models created. In the second model, the flow entering the chamber, the flow leaving the room, and the initial water level were used, and the average R-value was found to be 0.88735. According to the obtained values, the most striking part is that the output values diverge from the actual values when the initial water level is subtracted from the models. Therefore, knowing the initial water level is extremely important for estimation. Another remarkable result is that when the precipitation amount is excluded from the models, it is seen that the forecast results are affected very little and can be considered as a forecast model in models where the precipitation parameter is not used. However, the fact that it reduces the margin of error, albeit a little, shows that precipitation data should be used. Finally, for this study, it can be stated that the changes in the number of neurons do not affect the models very much and give results close to each other. [37]

Estimation of hydrometeorological data is essential for studies in water resources. Precipitation forecasting is critical for water resources engineering. However, precipitation is a complex variable to predict. In the study [38], artificial neural networks, which are a successful method in modeling difficult-to-predict variables, were applied for daily precipitation forecasting, and successful results were obtained. To increase the technique's success and bring a different approach to precipitation forecasting, wavelet transform was used with artificial neural networks, and very successful results were obtained. [38]

In recent years, estimating the future values of economic variables with ANNs has become widespread [39]. It produces more successful results than traditional estimation methods, especially in evaluating the importance of financial assets such as stocks. In the study [39], 5-day price and price direction forecasts were made for 27 stocks of the BIST30 index. In the estimations made for 27 stores, the average absolute error was 21 cents, and the average fundamental percentage error was 1.80%. The success rate of estimating the price direction of stocks as “will increase” or “decrease” was determined as 58% on average. It seems possible to obtain more successful results by adding company- and industry-specific variables to the input list for the estimated stocks. By adding the said variables to the input list and making changes in the parameters of the ANNs to be established, more successful results are aimed in the future studies to be carried out by us. Comparing the results using traditional estimation techniques with the same data set and variables will also be the subject of our future studies. [39]

In the study [40], various ANN models have been developed for the flow prediction of the Göksu River. While developing the flow estimation models, the flow values of station 1714 1, 2, 3, 4, and 5 days ago and the current values of stations 1719 and 1720 that day were used as inputs. Among these models, it was observed that the model developed with the flow values of station 1714 1, 2, 3, 4, and 5 days ago gave better results than the other models with the salience coefficient and meant absolute error value. As a result, it has been seen that the ANN method can be used in the estimation of the flow from the

stream on the Göksu River and in cases where measurement cannot be made or to complete the missing data. [40]

Due to the nature of mathematical explanations obtained from a limited number of experimental observations. This makes ANNs stand out. Because ANN can produce results without the need for complex differential equations. Since the noisy data in the input and output data are distributed over the network by the ANNs, there is not much loss in their accuracy. The reason ANNs can be applied to many different problems is the nonlinearity of the transfer function. The ANN approach does not require a previously defined functional structure because it can adapt directly to the form of the problem. [41]

In the study [42], three different ANN models, namely MLP, Radial Basis Function Networks (RBFN) and Recurring Elman Networks, and the autoregressive model obtained by the Box-Jenkins method were used in the estimation of economic growth rates, and which model was more successful was investigated. The ANN models used in the study have advantages over the autoregressive model obtained by the Box-Jenkins method, such as learning and nonlinear modeling relationships with ties without the need for any prior knowledge and assumptions. However, there are also disadvantages such as the lack of a specific rule in determining the network's structure to be established with ANN and the selection of parameters, the large number of changeable parameters, and the inability to explain the behavior of the network. [42]

The results obtained from the study [43]; show that ANNs are tools with high generalization ability and, therefore, predictive ability. In addition, the designed ANN software model and the profitability estimation performed by the model are objective because it is transparent and does not rely on intuitive observation or expert judgment. It is highly consistent and robust against user changes. Because it is not affected by user differences and makes successful predictions, this software model; is thought that it will provide convenience in estimating bank profitability. In conclusion, in the light of the findings obtained in this study; The developed innovative software model, which measures bank profitability with ANN, which is an essential flexible calculation technique, will also make the prediction made with current data by entering new data that will emerge in the future into the model and can be used as a successful tool in forecasting studies. The designed software model brings with it the opportunity to have a more user-friendly structure and the ability to adapt to changing conditions to better respond to the research requests and expectations of the users. The study of the periodicity of bank data between years is another subject of study. In this context, it is aimed to perform panel data analysis by adding 2013 and 2014 data in the following research. [43]

In the study [44], the maximum ground acceleration estimation was made with the artificial neural network, and the results were compared with the regression for the method's accuracy. The correlation coefficient between the estimated accelerations using the artificial neural network and the measured accelerations was 92% in the training phase and 64% in the testing phase. The test result shows that the generalization capacity of the network is good. However, it is possible to increase this capacity further with the arrangements in the network. Compared to the regression, the neural network predicted the accelerations with a higher correlation coefficient. This indicates that artificial neural networks should be investigated as an alternative method for more real acceleration estimations. [44]

Load forecasting analysis is used to make economic electricity generation and distribution planning. In this study, the load estimation for the Nigde region was carried out with two different methods. These are the neural network backpropagation algorithm and the moving average method from nonlinear trend analysis. According to the Theil test and standard deviation results, the appropriate estimation method was chosen. In general, it is seen from the results obtained that the most suitable way for the Nigde region is the use of artificial neural networks. The estimations obtained by both methods for 2001 were compared with the actual values, and it was found that the estimation results were very close to the actual values. In addition, it has been seen that the 4-input single-output network structure used is a very suitable structure for load estimation. [45]

In the study [46], models were created using the Artificial Neural Networks method to complete the historical precipitation data that could not be measured during precipitation or a newly established station. These models were compared with the weighted average and mean harmonic methods, frequently used in the literature to predict precipitation amounts. As a result of the calculations, it was found that the 4-neuron ANN model was superior to the other two standard calculation methods in terms of giving the smallest error values and forming the appropriate scatter diagram. It has been seen that the average harmonic method also predicts the daily precipitation forecasts in the considered basin better than the weighted average method. It has been observed that the harmonic mean method can also be used in hydrometeorological similar and close stations. It can be stated that ANN models will be superior to other methods in calculating missing precipitation data. [46]

The ANN model gives positive results in solving problems that depend on many variables that do not have a linear relationship between them. Traditional statistical analyzes generally argue that the indicators show a normal distribution. Regression analysis also assumes a linear relationship between dependent and independent variables. This is a critical error that affects the prediction accuracy. Past research shows that this relationship is not linear. In this case, the use of ANN analysis gives more accurate results in cases where the assumptions of the regression analysis, which are frequently used, are not realized. On the other hand, Time series analysis is a method that aims to model the stochastic process, which gives the structure of the observed series about an event observed at certain time intervals and makes predictions for the future with the help of observation values from past periods. It is impossible to reach a definite conclusion about whether the relationship in the used time series is linear or nonlinear. Therefore, time series alone cannot give a very accurate result. For future studies, predictions can be suggested using ANN models with different architectures. In addition, prediction performance can be examined by using hybrid methods where ANN and time series are used together. Although artificial neural networks can model linear and nonlinear relationships, they cannot provide the same efficiency for every data set. Hybrid models can model linear and nonlinear components separately. Studies show

that combining more than one method to model different functional relationships in the data instead of calculating separately gives better results. [47]

With the study [48], it was concluded that the ANN structure, which can acquire the ability to learn without the need for a mathematical model and the establishment of a rule-based structure, can be recommended as an effective decision support system to predict whether companies will successfully survive the economic crisis if appropriately designed. A holistic evaluation of the companies' financial indicators was carried out, and it was observed that the successful/unsuccessful situations specified in the actual outputs of the system could be predicted 100% accurately with the test results performed after the training of the system. In addition, it can be said that the warning system is successful and sufficient in developing a model proposal, based on the fact that the primary financial variables used in realizing this forecast make the forecasting ability of the system high. Considering the manufacturing companies, focusing on the success of the company rather than the predictive power of the indicators, and using the ANN model while making financial forecasts are the privileged aspects of the study. In terms of application, this study is essential for proposing an early warning system that companies can benefit from. This study provides an example that the use of ANN can yield very successful results to predict the firm's success in crises depending on the given financial indicators. However, to obtain more generalized results, it is considered to expand the trial set in terms of time, the number of samples, and variables in future studies. In the following research, to test the model's overall performance, the sample set can be expanded to include the crisis in the current period. The success situations of the firms can be estimated and compared with their real problems. The proposed feed-forward, multi-layered ANN model, can be described as a black box that does not provide information about the one-to-one effects of the inputs used and their relations with each other but models the complex relationships of the inputs collectively. For this reason, revealing the prominent factors in the firm's success during the crisis and analyzing their relations with each other could not be included in the scope of the study. In this direction, in the later stages of the study, it can be ensured that the financial indicators given as inputs are subjected to cluster analysis with feedback and self-regulatory ANN structures to distinguish the prominent factors in firm success. [48]

The study [49] examines the factors that determine the rental value of houses in Turkey. In determining rents, the actual rent paid for the rented houses and the imputed rent for the places where the landlords or others live without paying rent are taken as a basis. Hedonic regression model and ANN were used to estimate the rental value. The semi-logarithmic form was chosen as the functional form. In addition, the Least Squares Method was used in model estimations. The model results showed that the effect of all variables, except the age of the house, on the house rent was in line with the expectations. According to the results obtained, the most important variables affecting the housing rent were found to be the type of the house, the type of building, the number of rooms, the size of the house, and other structural variables such as the water system, pool, natural gas, and cable broadcast. It has been determined that artificial neural networks are an effective and better alternative method than the hedonic method in estimating the rental values of the houses. [49]

In the study [50], the daily flows of the Coruh River-Bayburt flow observation station located in the Çoruh basin were modeled based on the intrinsically dependent structure. When the presented performance results are examined, it has been proven that the ANN model, which is thought to represent the daily flows of the Coruh River, is superior to the classical autoregressive model. When the error sizes and determination coefficients in the training and testing periods are also considered, it is seen that the ANN results are pretty successful. In addition, it seems possible to use ANN approaches to successfully model the flow characteristics of river basins since the data to be presented to the artificial neural networks do not have to be symmetrically distributed and provide a technically fast modeling opportunity. In addition, it is thought that the prepared model can be easily used in different scenario-based studies in line with climate change predictions. [50]

With the regression method, the factors that had a minor effect on the outcome variable were determined as the days of the week and the weather in the study. [51] The success of ANN can be understood from the test values. ANN stands out as the more successful method in the study. If the data diversity in the used data set is high, there will be an opportunity to examine the relationship between the parameters. If it can diversify the input parameters more and increase the dataset, the system's success will increase even more. The conditions under which the maximum demand will occur can also be found using the decision tree algorithm. [51]

In the study [52], the relationship between the monthly average flow data of the flow observation station numbered 2157 in the Middle Euphrates Basin and the monthly total precipitation data of the precipitation observation station number 17204, one of the artificial neural network methods, Feed Forward Back Propagation Neural Network method, Generalized Regression Artificial Neural Network and Radial Based Artificial Neural Network and the results were compared with Multiple Linear Regression (MLR) method. Within the scope of the study, 70% of the data to these stations were used in the training process, and the remaining 30% was used only in the testing phase. Precipitation and flow values were taken as input data according to five different situations, and flow values were estimated according to these situations. It was seen that the three artificial neural network methods used were more successful than the MLR method. [52]

In the study [53], the heating requirements per unit area for the greenhouses of Mersin province center and its districts were analyzed using artificial neural networks, a sub-branch of artificial intelligence applications. In the study, according to the Levenberg-Marquardt (LM) training algorithm, the heating need of the greenhouses was estimated by using the months, latitude, longitude, altitude, and average temperature data needed in the greenhouses of Mersin in different networks structures. In the artificial neural network model, Mersin districts (Anamur, Bozyazı, Aydıncık, Silifke, Erdemli and Mezitli) were used as training data. The training data were estimated using different network structures in the LM training algorithm. Artificial neural networks are algorithms that make decisions, draw conclusions, draw conclusions from the data in hand in case of insufficient data, reach the best result with

less data, learn and remember in the computer environment. Due to these advantages of artificial neural networks, they are used in many fields, especially in engineering. [53]

In the study [54], the future monthly average sunshine intensity of Burdur province was estimated using the artificial neural networks (ANN) method. The monthly average sunshine intensity values required for the calculations were taken from the Turkish Meteorology Institute. As a result of the study, a formula was derived from calculating the monthly average sunshine intensity values in the future. The future monthly average sunshine intensity values of Burdur province are given in a table by making estimations. It is seen that the results are in good agreement with the data we have. Therefore, it has been evaluated that the artificial neural network method may be a suitable method for this and similar studies. [54]To predict the calculated Standardized Precipitation Index (SPI) values of Şanlıurfa station using precipitation and previous index values, 16 models were created using artificial neural networks (ANN). All models designed to estimate SPI-1 values were quite insufficient to predict SPI-1. In the 3, 6, and 12-month SPI estimations, it was seen that the estimation performance of the models in which only precipitation was used as input was low. Still, the drought index estimation was more successful, especially in the models that added the previous drought index values. In particular, it is essential to predict the drought and take the necessary precautions to minimize the possible adverse effects of the drought. Therefore, increasing the use of modern calculation methods in estimating drought and increasing the studies on their applicability in different regions will be beneficial in terms of informing practitioners. [55]

In the study [56], the closing prices of stocks for the years 2006-2016 were tried to be estimated using different methods. These methods are multiple linear regression, artificial neural networks, and fuzzy logic. Compared to the regression analysis, which is one of the classical methods in stock price estimation, estimations made using fuzzy logic and artificial neural networks were more realistic. It can be concluded that better decisions can be made about various portfolios using these two methods rather than an obscure model. We can offer investors the opportunity to make the right decision through new models created by using these methods with different sectors or variables. [56]

Many physical and statistical models have been developed to date for snowmelt prediction. These developed solutions may not yield very successful results because they are highly complex and include many parameters in the model. Artificial neural networks, which have been used successfully to solve many physical and mathematical problems in recent years, have also achieved a successful result in the prediction of snowmelt as a result of this study. This is because the artificial neural network method gives better results in solving such complex problems. The 71% success achieved from comparing the melting values obtained with the ANN model with the measured flow values will be even higher if the comparison is made between the measured melting values and the calculated values. [57]

As with all complex problems, choosing the most suitable portfolio is not easy. In recent studies, optimum portfolio creation methods have been tried by making measurements on risk and return. In the study [58], it has been tried to determine whether ANN can be used to create the optimum portfolio by estimating the stock price correctly. Because accurately predicting the stock price is one of the most critical issues for investors. With an approximate estimation system to the actual result, the investor can turn to the right stocks so that his investment can turn into profit. To assist investors, this study showed that ANN could approximate stock price. In stock price estimation, ANN can be used as an alternative to classical methods, and based on these results, the stock to be invested can be decided. Future studies can investigate whether there is a difference in ANN estimation between sectors and whether it will be possible to approach the correct value in crisis environments. [58]

The study [59] presents vibration analysis of rectangular plates using artificial neural networks. After the training phase, artificial neural networks have some advantages over classical programming techniques in terms of speed and required capacity. However, numerical analysis techniques still maintain their popularity due to their vast application potential and researchers' preference. A new study is being conducted on this subject, which has a history of ten years in our country, and the usability and superiority of the method show itself from time to time. In addition, training the network with the experimental results suggests that the results will be pretty healthy if used together with the experimental studies. It is not always possible to say that the technique will be superior to classical programming. However, problems that can be solved in a very long time with classical programming can be solved faster and more quickly after the training is completed. [59]

ANN was used in the study. [60] Cloud forecasts and past production values were used as inputs to the forecasting system. Results were obtained for different network structures and different information. The obtained results were evaluated, and it was seen that the cloud prediction system was more successful. This shows that Solar Power Pant production forecasting systems using meteorological forecast data can be more successful than systems using only historical production values. In future studies, it is recommended to consider temperature, pressure, and precipitation forecast values in addition to the cloudiness forecast data used in this study. In addition, it is thought that different ANN structures and training algorithms can increase prediction performance. [60]

2. Conclusions

As in every developing and changing field, artificial neural networks have shown many changes and developments. ANN technique is used for prediction purposes. Artificial neural networks, which have been used successfully in the solution of many physical and mathematical problems in recent years, have also achieved successful results in many prediction-related studies. Although the prediction models created with ANN from the studies give effective results, it is seen that the experimental results found with traditional methods can be used to support ANN. In addition, artificial neural networks models were created using various software, and solutions to the problems were made. It has been concluded that the artificial neural network method can be a suitable method for many and similar study areas.

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