Osmaniye Korkut Ata Üniversitesi
İktisadi ve İdari Bilimler Fakültesi Dergisi
Cilt: 7, Sayı: 1, Haziran 2023, ss. 89-102

Osmaniye Korkut Ata University
Journal of Economics and Administrative Sciences
Vol: 7, Issue: 1, June 2023, pp. 89-102

MEASUREMENT OF FIRM PERFORMANCE USING ACCOUNTING BASED RATIOS WITH ARTIFICIAL NEURAL NETWORKS AND DECISION TREE METHODS: A STUDY IN BORSA ISTANBUL

Geliş Tarihi: 18.05.2022

Kabul Tarihi: 23.06.2023

Makale Türü: Araştırma Makalesi

Doç. Dr. Mustafa KILLI[1]

Öğr. Gör. Dr. Yusuf IŞIK[2]

Abstract

Sustainability, which is one of the most basic purpose of companies, can be achieved with high company performance. Many financial and non-financial performance measurement tools can be used to measure firm performance. Performance evaluation is an important management accounting tool as a process that allows future decisions to be based on solid foundations. Ratio analysis is one of the financial measurement tools used to measure firm performance. These ratios, which are sometimes a leading indicator, may indicate that companies should take various measures. This study aimed to determine the relationship between accounting-based ratios and firm performance using artificial neural networks and decision tree methods, which are data mining techniques. For this purpose, analyzes were carried out on the ratios obtained by using the 2021 financial statements of the companies in the Borsa Istanbul (BIST) holdings and investment companies sector. As a result, when both data mining methods were compared, it was seen that the analysis prediction values made with artificial neural networks were more consistent than the decision tree model.

Keywords: Management Accounting, Financial Performance Measurement, Artificial Neural Networks, Decision Tree.

JEL Codes: M40, G17, C45, C53.

YAPAY SİNİR AĞLARI VE KARAR AĞACI YÖNTEMLERİ İLE MUHASEBEYE DAYALI ORANLAR KULLANILARAK FİRMA PERFORMANSININ ÖLÇÜLMESİ: BORSA İSTANBUL'DA BİR UYGULAMA

Özet

Firmaların en temel amaçlarından biri olan sürdürülebilirlik, yüksek şirket performansı ile sağlanabilir. Firma performansını ölçmek için birçok finansal ve finansal olmayan performans ölçüm aracı kullanılabilir. Performans ölçümü, geleceğe yönelik kararların sağlam temellere dayanmasını sağlayan bir süreç olarak önemli bir yönetim muhasebesi aracıdır. Oran analizi, firma performansını ölçmek için kullanılan finansal ölçüm araçlarından biridir. Kimi zaman öncü gösterge niteliğinde olan bu oranlar, şirketlerin çeşitli önlemler alması gerektiğinin göstergesi olabilir. Bu çalışmada, veri madenciliği tekniklerinden yapay sinir ağları ve karar ağacı yöntemleri kullanılarak muhasebe tabanlı oranlar ile firma performansı arasındaki ilişkinin belirlenmesi amaçlanmıştır. Bu amaçla Borsa İstanbul (BİST) holding ve yatırım şirketleri sektöründe yer alan şirketlerin 2021 yılı mali tabloları kullanılarak elde edilen oranlar üzerinde analizler yapılmıştır. Sonuç olarak her iki veri madenciliği yöntemi karşılaştırıldığında yapay sinir ağları ile yapılan analiz tahmin değerlerinin karar ağacı modeline göre daha tutarlı olduğu görülmüştür.

Anahtar Kelimeler: Yönetim Muhasebesi, Finansal Performans Ölçümü, Yapay Sinir Ağları, Karar Ağacı.

JEL Kodları: M40, G17, C45, C53.

[1] Osmaniye Korkut Ata Üniversitesi, mkilli@osmaniye.edu.tr, ORCID: 0000-0002-9283-9852
[2] Hatay Mustafa Kemal Üniversitesi, isik.yusuf@hotmail.com, ORCID: 0000-0001-5842-4365 (Sorumlu Yazar)

1. INTRODUCTION

Decision making is the most important element in the performing of all management functions. Managerial accounting is all the accounting studies carried out by targeting business managers, starting from collecting the necessary numerical information for the business managers to make sound decisions, to the preparation of reports appropriate to their needs (Büyükmirza, 2010, p. 29). In the decision-making process, which is one of the most important parameters of management accounting, the information produced by the accounting information system should be analyzed correctly (Mirzaey, Jamshidi, & Hojatpour, 2017, p. 3523).

Although the most basic purpose of businesses is seen as profit maximization, this purpose has evolved into value maximization (Ece, 2018, p. 301). For this purpose, a large number of financing, operating and investment activities are carried out. All the activities carried out affect the business performance positively or negatively in proportion to their success. Therefore, financial performance is in the position of an indicator of all the activities carried out by the enterprises as a whole. n other words, financial performance can be defined as how effectively a business uses its resources and its financial position (Karaoğlan and Şahin, 2017, p. 63). For this reason, accurate measurement of financial performance is important both in revealing the current situation and in the decision making by the enterprises about the future.

Performance evaluation is an important management accounting tool as a process that allows to monitor the extent to which the predetermined targets have been achieved, to identify the weak points in a timely manner and to base the decisions to be taken for the future on solid foundations (Durgut, 2017, p. 247). In this context, Weygandt, Kimmel and Kieso (2010) considered financial performance measurement necessary for going concern, while Büyükarıkan and Büyükarıkan (2014) stated that accurate measurement of financial performance is a red line in the predictions to be made about the future of businesses. Martin, Gayathri, Saranya, Gayathri, and Venkatesan (2011) stated in their study that measuring financial performance is important in predicting possible bankruptcy and avoiding high bankruptcy costs. With a successful foresight, high bankruptcy costs will be eliminated in terms of business, and business owners, managers, third parties in commercial relations with the business, investors, creditors and financial markets in general will be protected from the environment of concern that bankruptcy will bring.

Ratio analysis is one of the simplest and most widely used methods to measure firm performance. However, in recent years, in line with the developments in information and communication technologies, it is seen that data mining applications are used to measure company performance both in the academic and in the business world (Seyrek and Ata, 2010, p. 71). Artificial neural networks (ANN) and decision trees are among the most commonly used data mining methods. ANN, a data processing technique inspired by the way the human brain works (Wu & Feng, 2018, p. 1645), is a mathematical model that imitates the biological nervous system (Singh & Chauhan, 2010, p. 37). The most important feature of ANN is that it can perform to learning with the data in a data group and learn the connections between the data (Bardi, 2020, p. 191). In addition to learning, ANN also has the ability to analyze information and establish relationships between information (Uğur & Kınacı, 2006, p. 345; Yürük and Ekşi, 2019, p. 399). A decision tree is a structure used to divide a data set containing many records into smaller clusters by applying a set of decision rules (Albayrak and Yılmaz, 2009, p. 33). Decision trees are becoming increasingly popular for data mining because they are easy to understand and interpret, require little data preparation, process numerical and categorical data, and perform very well with a large data set in a short time (Delen, Kuzey & Uyar, 2013, p.

3976). Today, information based on artificial intelligence with abilities such as learning, estimation, classification and association can be considered as a tool to support management accounting.

In the context of financial performance, for going concern, it is necessary that the factors such as the efficiency of financing, operating and investment activities in general and specifically the ability to pay debts, the ability to obtain cash, the ability to collect receivables, the efficiency of sales, and keeping the sales costs at an optimum level should be at a high level is required. These specifically determined elements can be determined with the help of the ratios to be calculated by using the financial statements of the enterprise. In this study, it is aimed to compare the estimation levels of both methods by analyzing the financial performances by the ANN and decision tree methods by using the accounting-based ratios obtained from the financial statements of the companies listed in the Borsa Istanbul (BIST) Holdings and Investment Companies sector.

2. LITERATURE REVIEW

Data mining methods are used in many fields such as finance, accounting, auditing, banking, education, health and geography In this context, ANN and decision tree models, which constitute the analysis dimension of the study, were used by Tung, Huang, Chen & Shih (2005), in order to determine job attitudes; İbrahim and Rusli (2007), in order to predict the academic performance of students; Hidayati, Kanamori, Feng, and Ohwada (2016), in order to determine the corporate values of companies according to their company performance; Mishra and Dash (2014), in order to detect credit card fraud; Omar, Johari & Shmit (2017) used it for fraudulent financial reporting estimation and Hateffard, Dolati, Heidari, and Zolfaghari (2019) for mapping soil properties. In this section, some several studies on the use of ANN and decision tree methods together and independently in various financial analysis are given.

Bellovary, Giacomino, and Akers (2007) reported that for the first time in the 1930s, using the decision tree method, financial success/failure was determined by calculating 24 ratios over 29 firm data. Fitzpatrick (1932) carried out a pioneering study for the detection of financial success/failure with the ANN technique using 19 companies and 13 financial ratios. He determined that there were considerable deviations between the financial ratios of the firms that were identified as unsuccessful. Following these studies, which will be considered pioneers in the field, many studies have been carried out using different examples.

Olson & Mossman (2003), in their study compares neural network forecasts of one-year-ahead Canadian stock returns with the forecasts obtained using ordinary least squares (OLS) and logistic regression (logit) techniques. The results indicate that back propagation neural networks, which consider non-linear relationships between input and output variables, outperform the best regression alternatives for both point estimation and in classifying firms expected to have either high or low returns.

Lam (2004) investigated the integrating ability of fundamental and technical analysis methods into analysis for financial performance prediction by using ANN back propagation learning algorithm. In this context, financial statement instruments and macroeconomic variables related to the data of 364 S&P companies for the years 1985-1995 were used together. With the study, positive conclusions were reached on the ability of ANN to select companies with high returns.

Kirkos, Spathis and Manolopoulos (2007) used ANN, decision tree method and Bayesian networks to detect fraudulent financial statements. Data of 76 manufacturing

companies were used within the scope of their studies. As a result of the study, in parallel with similar studies, it was determined that data mining techniques gave successful results in detecting fraud.

Tsai and Chiou (2009) used ANN and decision tree methods to predict the level of earnings management in order to reduce the risk of financial crisis arising from earnings management and to prevent investors from experiencing a large loss in the stock market. As a result of the study, highly accurate estimations were achieved with both ANN and decision tree method.

Albayrak and Yılmaz (2009) analyzed the financial indicators of 173 companies in the industry and service sectors within the ISE 100 index between 2004 and 2006 using the decision tree method. As a result of the study, the mutual positions of the enterprises were revealed by using the decision tree technique and the most important variables affecting their place in the sector were determined.

Chen, Chi, and Wang (2015) analyzed earnings management of the biotechnology industry using ANN and decision tree model. In this context, variables related to earnings management were scanned with principal component analysis and bayesian network, then ANN and decision tree analysis were applied to determine whether the company earnings were seriously manipulated. As a result of the study, it was determined that the combination of the bayes network scanning method with the decision tree method had the best performance with a rate of 98.51%.

Ünkaya and Sayın (2019) analyzed with decision tree by using some financial ratios to determine the going concern risk. In this context, companies outside the publicly traded finance sector in Turkey for the period 1999-2016 were examined. As a result of the study, they determined the going concern risk with the decision tree analysis with a rate of 91%.

Yürük and Ekşi (2019) developed an algorithm for predicting financial failure using artificial neural networks and support vector machines. Within the scope of the analysis, 26 financial ratios were determined and as a result of various filters, 140 industrial enterprises from 181 companies were included in the analysis. As a result of the analysis, a success of over 70% was determined in both methods, and it was determined that the artificial neural networks performed better.

Arslantürk Çöllü, Akgün, and Eyduran (2020) determined the successful-unsuccessful companies by analyzing with decision tree algorithms the ratios determined by using the 2016-2018 data of 20 companies listed in BIST the textile, clothing and leather sectors. As a result of the research, it has been determined that the return on equity ratio, the current ratio, the ratio of fixed assets to equity, the ratio of trade receivables to total assets, inventory turnover and interest coverage ratio have an effect on financial success.

Pekin (2020) aimed to develop practical analysis techniques that will enable the use of text data in addition to numerical data in the analysis of financial performance of enterprises. For this purpose, the relationship between financial performance and text data in annual reports was analyzed through text mining, one of the data mining methods. In the analysis, annual reports and financial performance indicators of the BIST manufacturing sector between 2010 and 2017 were used. As a result of the research, it was found that there is a significant relationship between the financial performance and the text data in the annual reports.

Aksoy (2021) analyzed using machine learning methods artificial neural networks, regression tree and K-Nearest neighbor algorithm to make price estimation for manufacturing industry companies in BIST 30 index and Corporate Governance Index. The best result

(98.05%) was achieved by using artificial neural networks. He stated that the models used can be included in the models preferred by the investors.

Appiahene, Missah, and Najim (2020) used decision tree and neural network algorithms comparatively to predict operational efficiency for banks. In this context, bank efficiency and performance were evaluated in 444 bank branches. As a result of the study, they determined that the decision tree model gave the best prediction rate.

3. METHODOLOGY

3.1. Data Collection Tools

Holdings and investment companies generally contain more than one company share. These companies can be in the same industry or from different industries. Therefore, the performance of each company affects both their individual performances, their sectoral performances, and the performance of the holding and investment companies in which they are affiliates. For this reason, the performance level of holding and investment companies appears as a function of the performance level of more than one sector as an indicator. For this reason, the performance values of holding and investment companies are very important for an investor.

The data used in the research were obtained from the 2021 year consolidated financial statements of companies operating in the BIST Holdings and Investment Companies sector. There are 48 companies in the sector within the scope of the analysis. The financial data of the companies were accessed from the Public Disclosure Platform (PDP) website. The financial statements of 2 companies are not included in the KAP system, and the data of 6 companies are not sufficient to calculate the ratios used, so the analysis was made with the data of 40 companies. 21 ratios determined by using the financial statement elements are given in Table 1.

As seen in Table 1, while the first 20 ratios were determined as the independent variable, the "Return on Assets" ratio was determined as the dependent variable, and both analyzes were carried out within this scope.

Table 1. Ratios used in the analysis

Ratios	Formula	Variable Type
Current Ratio	Current Assets / Current Liabilities	The Independent Variables
Acid -Test Ratio	(Cash and Cash Equivalents + Securities + Trade Receiables) / Current Liabilities	
Cash Ratio	Cash and Cash Equivalents / Current Liabilities	
Ratio of Net Working Capital to Net Sales	(Current Assets - Current Liabilities) / Net Sales	
Financial Leverage Ratio	(Current Liabilities + Long Term Liabilities) / Total Assets	
Ratio of Equity to Total Assets	Equity / Total Assets	
Financing Ratio	Equity / Total Liabilities	
Assets Turnover Ratio	Sales/ Total Assets	
Equity Turnover Rate	Sales / Owner's Equity	
Working Capital Turnover Rate	Sales/ Current Assets	
Cost of Sales / Net Sales	Cost of Sales / Net Sales	
Short Term Debt Ratio	Current Liabilities / Total assets	
Ratio of Current Assets to Total Assets	Current Assets / Total Assets	
Ratio of Fixed Assets to Equity	Fixed Assets / Equity	
Return on Equity	Net Income / Owners' Equity	
Gross Profit Margin	Gross Profit / Sales	
Net Profit Margin	Net Profit / Sales	
Inventory to Total Assets Ratio	Inventory / Total Assets	
Ratio of Trade Receivables to Assets	Trade Receivables / Total Assets	
Ratio of Trade Payables to Liability	Trade Payables / Liabilities	
Return on Assets	Net Profit / Total Assets	The Dependent Variable

3.2. Analysis of Data

In this study, the financial performance levels of 40 companies operating in the BIST Holdings and Investment Companies sector were analyzed by using 21 ratios obtained from the 2021 financial statements with ANN and decision tree techniques, which are data mining methods, and the finding detection levels of both methods were compared.

In the analysis made with ANN, the consistency of the data used in the model directly affects the success of the results obtained. For this reason, the data must go through a certain process before creating an input to the analysis. This process, which is expressed as normalization, is a method used when it comes to scales of different sizes disrupting the data integrity in the total data (Tunç & Ülger, 2016, p. 105). The information presented as input to the analysis made with the ANN is converted to 0 and 1 values in the input layer. In this conversion process, there is only one match for each input value. Thus, the process known as "normalization" is realized. For this purpose, normalization was carried out separately for all elements contains different scales using the below formula.

$$x' = \frac{x - x_{min}}{x_{max} - x_{min}}$$

After this process, the analysis was carried out using the Matlab R2016a program. As seen in Figure 1, 70% for network learning of the data obtained during the analysis process, %15 for validation and %15 for testing learning was used randomly.

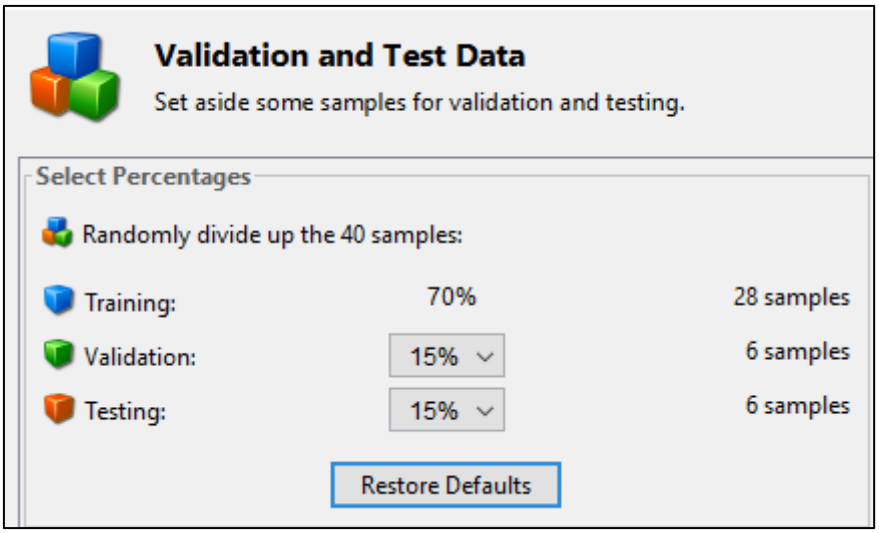

Figure 1. Training, validation and testing selection and percentages

There are no generally accepted processes while creating the model in the analyzes made with ANN Neural Networks (Ataseven, 2013, p. 103). Based on the data set analyzed by ANN, many tests are performed by changing the number of neurons in which the analysis of the input and output layers and the connection between these layers. An optimal result is tried to be obtained by changing the number of neurons whose optimal level is not known exactly. For this reason, the effect of neuron number on ANN training was investigated by changing in the range of 1-50 the number of neurons in the analysis.

Other features used for training ANN:

- Feed forward back propagation network architecture
- As a training function Levenberg Marquardt (TRAINLM),
- As adaptation learning function Gradient Descent With Momentum (LEARNGDM),
- Mean Squared Error (MSE) is used as a performance function.

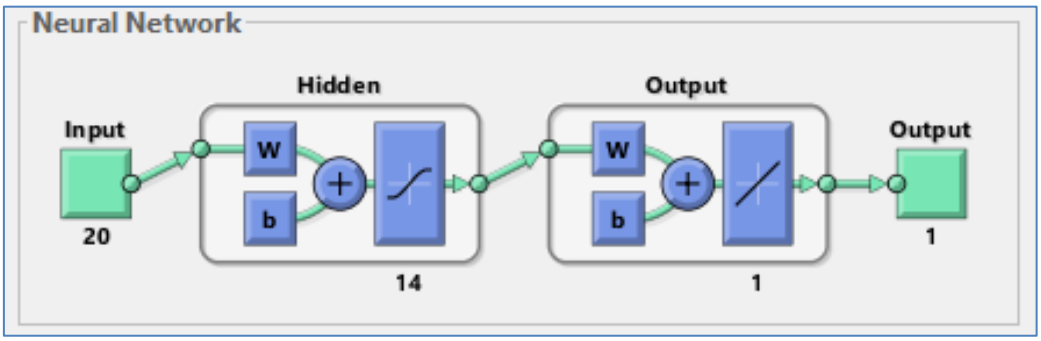

Figure 2. Block diagram of the ANN created with the interface nnstart function

During the analysis process, the initial learning of the network performed with 1000 iterations, and the number of neurons that gave the best results was determined by changing the number of neurons from 1 to 50. In this process, the analysis was carried out in 14 hidden layers, as the values that gave best results during iterative network learning were encountered in the number of 14 neurons.

For the analysis made with the decision tree, the values were used in their original form without normalization. The independent variables shown in Table 1 are used as they are, and

the dependent variable “Return on Assets” is classified as “Loss”, “Below Average Profit”, “Average Profit” and “Above Average Profit” based on the average profitability levels of all companies. and this classification was tested by decision tree analysis. As seen in Figure 3, "Complex Tree", "Medium Tree" and "Simple Tree" decision tree algorithms within the "Classification Learner" algorithms in the Matlab program were used in the analysis.

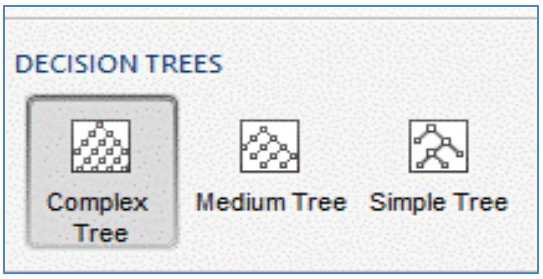

Figure 3. Decision tree algorithms

Finally, the effectiveness of the methods is discussed by comparing the results obtained with ANN and decision tree methods.

4. FINDINGS AND DISCUSSION

In the analysis made with ANN, the most optimal result was obtained in the number of 14 neurons. Information on ANN training is shown in Figure 4.

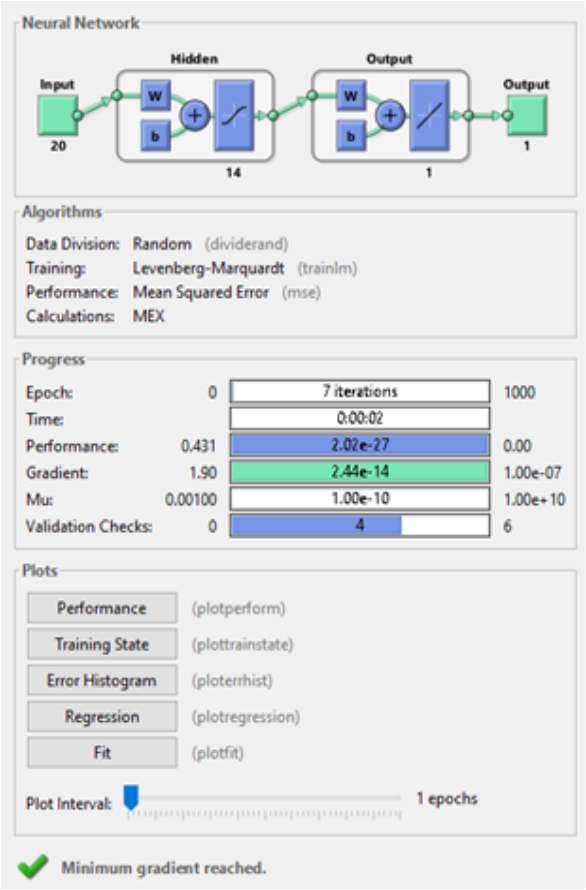

Figure 4. Neural network training

According to Figure 4, in the analysis made with 20 input data sets, 14 hidden layers and 1 output layer, the learning-validation-test distribution was randomly selected by the

Matlab program for each learning, and the most optimal learning level was achieved. The result of the network learning realized at the highest level by iteration of the learning process according to the number of 14 neurons is shown in Figure 5.

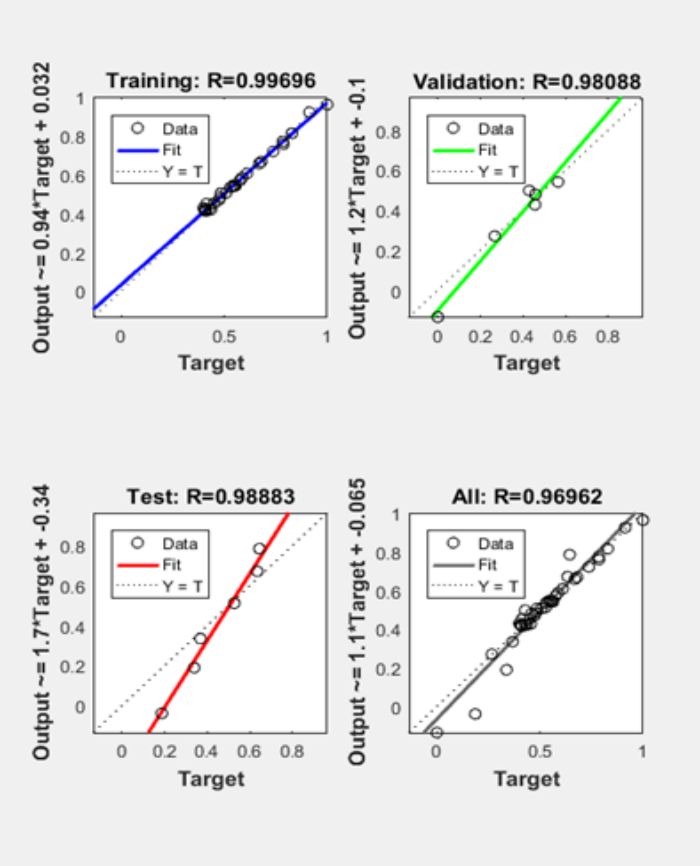

Figure 5. Neural network regression graph

As seen in Figure 5, RTraining = 0,99696, RValidation = 0,98088, RTest=0,98883 and RAll = 0,96962 were determined. If these values are close to 1, it is accepted that there is a harmony between the data obtained by ANN and the real data (Can and Şahin, 2021, p. 115). According to this result, it is seen that the relationship between the dependent variables and the independent variable of the group determined for the test in the learning-validation and test groups chosen randomly by the Matlab program is extremely high (0.9883).

As a result of the analysis made with the decision tree method, the learning levels of the decision tree algorithms are given in Figure 6.

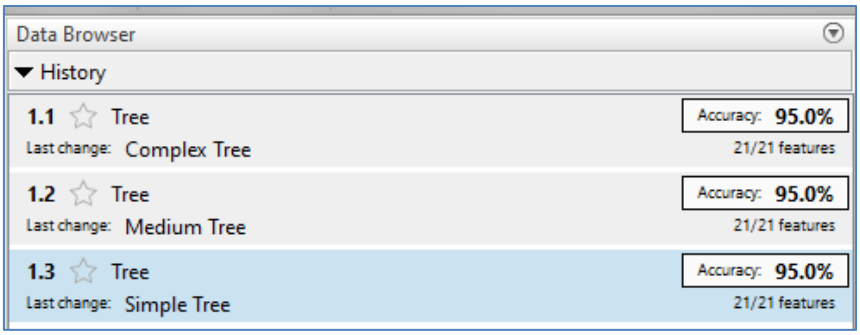

Figure 6. Decision tree algorithms learning rates

Working with the algorithm that highest training accuracy rate in decision tree analysis will determine the accuracy of the analysis result. As can be seen in Figure 6, the learning accuracy level of each decision tree algorithm is equal. For this reason, the success of all algorithms is equal, and the Confusion Matrix diagram of the "Simple Tree" algorithm is given in Figure 7.

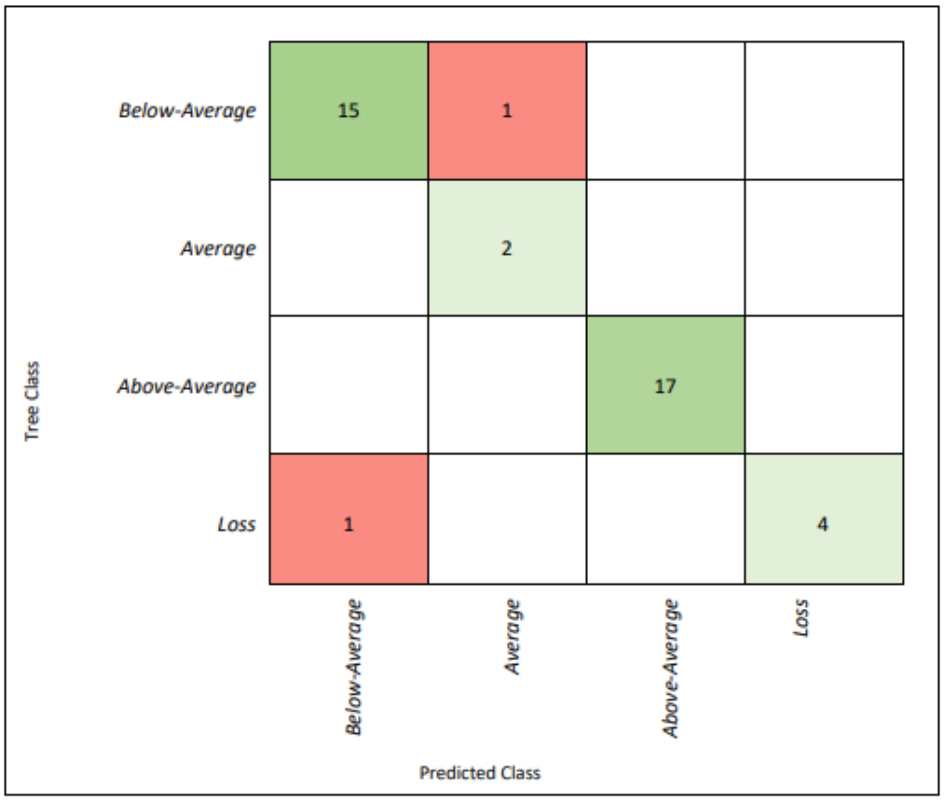

Figure 7. Confusion matrix diagram of the simple tree algorithm

According to Figure 7;

- 15 of the companies with below-average profitability were estimated true and 1 of them was false estimated,
- Companies with an average level of profitability have been true estimated,
- Companies with above-average profitability levels have been true estimated,
- 4 of the businesses with loss were estimated true and 1 was false estimated.
- The correct/incorrect percentages of the prediction values are given in Figure 8.

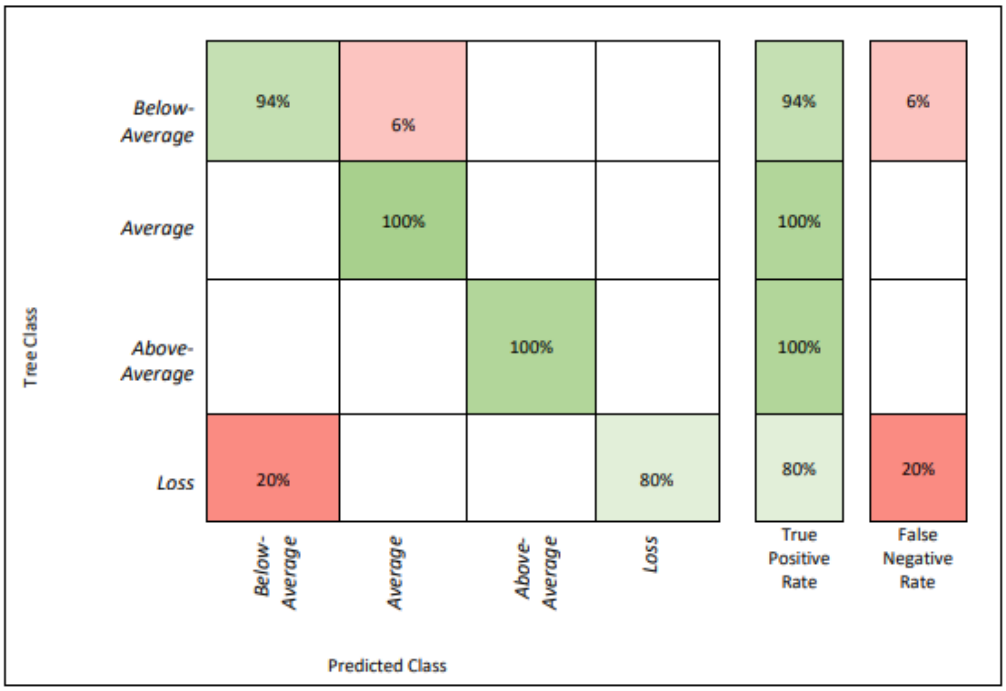

Figure 8. Confusion matrix (percentages of true/false prediction)

According to Figure 8;

- 94% of businesses with below-average profitability,
- 100% of businesses with an average level of profitability,
- 100% of businesses with above-average profitability and
- 80% of businesses with loss were estimated correctly.

When we look at the decision tree analysis as a whole, only 2 of 40 companies made false predictions and the true prediction rate (38/40) was 95%.

Considering the success of ANN and decision tree methods, the success rate of 95% in decision tree method, the degree of relationship between dependent and independent variables in ANN was determined as 99% in the network learning the and 98% in testing the network.

5. CONCLUSION

In order to ensure sustainability, businesses evaluate various alternatives and make decisions that give different results. Decisions taken affect firm performance in various ways. Accurate evaluation of performance will not only test the effectiveness of the decisions taken, but also determine the direction of new decisions to be taken. In this study, data mining methods were used to evaluate firm performance.

In the study, 21 ratios were determined by using the 2021 financial statements of 40 companies listed in the BIST Holdings and Investment Companies sector. The determined rates were analyzed by ANN and decision tree methods, which are data mining methods.

In the ANN analysis model, 21 ratios belonging to 40 companies were subjected to normalization and analyzed in the Matlab program with neuron numbers between 1-50. The relationship between the dependent variables determined for the analysis and the independent variable was examined, and the most optimal result (RTraining=0,99696, RValidation=0,98088, RTest=0,98883) was obtained in the number of 14 neurons. In the decision tree model, the data of the dependent variable is classified as “Loss”, “Below Average

Profit", "Average Profit" and "Above Average Profit", taking into account the average profitability level". This classification was evaluated as the result of estimation in the decision tree model, and decision tree analysis was carried out, and as a result of the analysis, 95% correct predictions were reached. When both data mining methods were compared, it was seen that the analysis estimation values made with ANN were more consistent than the decision tree model.

As a result, firm performance measurement with ANN and decision trees methods, which have abilities such as learning, estimation, classification and association can be considered as a tool to support management accounting in decision-making processes. By taking this study as a reference, making a similar analysis between the sectors that make up the partnership structure of the holdings and investment companies within the scope of the research will reveal the level of consistency in the sector preferences of the enterprises going to holding holdings.

REFERENCES

Albayrak, A. S. and Yılmaz, Ş. K. (2009). Data Mining: Decision Tree Algorithms And An Application On ISE Data. *Suleyman Demirel University The Journal of Faculty of Economics and Administrative Sciences*, *14*(1), 31-52.

Ataseven, B. (2013). Forecasting By Using Artificial Neural Networks. Öneri *Journal of Marmara University Institute of Social Sciences, 10*(39),101-115.

Appiahene, P., Missah, Y. M., and Najim, U. (2020). Predicting bank operational efficiency using machine learning algorithm: comparative study of decision tree, random forest, and neural networks. *Advances in fuzzy systems*, https://doi.prg/10.1155/2020/8581202.

Aksoy, B. (2021). Pay senedi fiyat yönünün makine öğrenmesi yöntemleri ile tahmini: Borsa İstanbul örneği. *Business and Economics Research Journal, 12*(1), 89-110.

Arslantürk Çöllü, D., Akgün, L. and Eyduran, E. (2020). Financial Failure Prediction with Decision Tree Algorithms: Textile, Wearing Apparel and Leather Sector Application. *International Journal of Economics and Innovation, 6*(2), 225-246.

Bardi, Ş. (2020). The Efficiency Analysis of Companies on BIST Food Beverage Index By Using Data Envelopment And Data Mining. *Suleyman Demirel University Visionary Journal, 11*, 185-199.

Bellovary, J. Giacomino, D. and Akers, M. (2007). A review of bankruptcy prediction studies: 1930–present. *Journal of Finance Education, 33*, 1–42.

Büyükarıkan, U. and Büyükarıkan, B. (2014). Analysis of Firms Operating in The It Sector Financial Distress Prediction Model's, *Akademic Review, 46*(7), 160-172.

Büyükmirza, K. (2010). *Maliyet ve Yönetim Muhasebesi*. Gazi Kitapevi (15.Ed), Ankara.

Can, N. S. and Şahin, A. Ş. (2021). Daily dew point temperature estimation with artificial neural networks method. *Gümüşhane University Journal of Science and Technology, 11*(4), 1154-1163.

Chen, F. H., Chi, D. J., and Wang, Y. C. (2015). Detecting biotechnology industry's earnings management using Bayesian network, principal component analysis, back propagation neural network, and decision tree. *Economic Modelling, 46*, 1-10.

Delen, D., Kuzey, C. and Uyar, A. (2013). Measuring firm performance using financial ratios: A decision tree approach. *Expert Systems with Applications, 40*, 3970–3983.

Durgut, M. (2017). Use and Reporting of Non-Financial Data in Performance Evaluation within the Scope of Management Accounting. *Research Journal of Politics, Economics And Management, 5*(2), 245-255.

Ece, O. (2018). The Determination of Relationship Between Value-Based Management And Corporate Sustainability For Value Maximization: An Application in BIST. *Manas Journal of Social Studies, 7*(1), 299-330.

Fitzpatrick, F. (1932) A Comparison of Ratios of Successful Industrial Enterprises with Those of Failed Firm. *Certified Public Accountant, 6*, 727-731.

Hateffard, F., Dolati, P., Heidari, A., and Zolfaghari, A. A. (2019). Assessing the performance of decision tree and neural network models in mapping soil properties. *Journal of Mountain Science, 16*(8), 1833-1847.

Hidayati, R., Kanamori, K., Feng, L., and Ohwada, H. (2016). Combining feature selection with decision tree criteria and neural network for corporate value classification. *In Pacific Rim Knowledge Acquisition Workshop* (pp. 31-42). Springer, Cham.

Ibrahim, Z., and Rusli, D. (2007, September). *Predicting students' academic performance: comparing artificial neural network, decision tree and linear regression*. In 21st Annual SAS Malaysia Forum, 5th September.

Karaoğlan, S. and Şahin, S. (2017). The Evaluation of Financial Performances of BIST XKMYA Companies by Multi-Criteria Decision-Making Methods and Comparison of Methods. *Ege Akademic Review, 18* (1), 63-80.

Kirkos, E., Spathis, C., and Manolopoulos, Y. (2007). Data mining techniques for the detection of fraudulent financial statements. *Expert Systems with Applications, 32*(4), 995-1003.

Lam, M. (2004). Neural network techniques for financial performance prediction: integrating fundamental and technical analysis. *Decision support systems, 37*(4), 567-581.

Martin, A., Gayathri, V., Saranya, G., Gayathri, P. and Venkatesan, P. (2011). A hybrid model for bankruptcy prediction using genetic algorithm, fuzzy c-means and mars. *International Journal on Soft Computing, 2*(1), 12-24

Mishra, M. K., and Dash, R. (2014). *A comparative study of chebyshev functional link artificial neural network, multi-layer perceptron and decision tree for credit card fraud detection*. International Conference on Information Technology, 228-233. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7033327

Mirzaey, M., Jamshidi, M. and Hojatpour, Y. (2017). Applications of artificial neural networks in information system of management accounting. *International Journal of Mechatronics, Electrical and Computer Technology (IJMEC), 7*(25), 3523-3530.

Olson, D. and Mossman, C. (2003). Neural network forecasts of Canadian stock returns using accounting ratios. *International Journal of Forecasting, 19*, 453-465.

Omar, N., Johari, Z. A., and Smith, M. (2017). Predicting fraudulent financial reporting using artificial neural network. *Journal of Financial Crime, 24*(2), 362-387.

Pekin, S. (2020). *Finansal performans tahmininde metin madenciliğinin kullanimi: bist imalat sanayi işletmelerinde bir araştırma*. (Doktora tezi). Eskişehir Üniversitesi, Sosyal Bilimler Enstitüsü

Seyrek, İ. H. and Ata, H.A. (2010). Efficiency Measurement in Deposit Banks Using Data Envelopment Analysis and Data Mining. *Journal of BRSA Banking and Financial Markets, 4*(2), 67-84.

Singh, Y. and Chauhan, A.S. (2010). Neural networks ın data mining. *Journal of Theoretical and Applied Information Technology, 5*(1), 37-42

Tsai, C. F., and Chiou, Y. J. (2009). Earnings management prediction: A pilot study of combining neural networks and decision trees. *Expert systems with applications, 36*(3), 7183-7191.

Tunç, A. and Ülger, İ. (2016). *Implementation Of Normalization Process Using Binning and Five Number Summary Methods to Financial Value for Feature Selection in Data Mining Applications*, 18. Akademic Informatics Conference, Proceedings Book, p. 47-58.

Tung, K. Y., Huang, C., Chen, S. L., and Shih, C. T. (2005). Mining the generation xers' job attitudes by artificial neural network and decision tree—empirical evidence in taiwan. *Expert Systems with Applications, 29*(4), 783-794.

Uğur, A. and Kınacı, A. C. (2006). *Yapay Zeka Teknikleri Ve Yapay Sinir Ağları Kullanılarak Web Sayfalarının Sınıflandırılması.* XI. "Türkiye'de İnternet" Konferansı Bildirileri (inet-tr'06), Ankara. http://inet-tr.org.tr/inetconf11/kitap/_inet06.pdf

Ünkaya, G., and Sayin, G. (2019). Going Concern Prediction Via Decision Tree Models Among Non-Finance Public Companies. *Mali Çözüm Dergisi, 29*(156).

Weygandt, J.J., Kimmel, P.D. and Kieso, D.E. (2010). *Managerial accounting*. Massachusetts: John Wiley & Sons.

Wu, Y. and Feng, J. (2018). Development and Application of Artificial Neural Network. *Wireless Pers Commun. 102*, 1645–1656. https://doi.org/10.1007/s11277-017-5224-x.

Yürük, M. F. and Ekşi, İ. H. (2019). Financial Failure Prediction of Companies Using Artificial Intelligence Methods: An Application in BIST Manufacturing Sector. *Mukaddime, 10*(1), 393-422.