

# A study on the comparison of technical indicators used in stock price prediction with the FAHP method

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## Abstract

Savers want to direct their savings to investment areas where they can get maximum efficiency. This is the most basic feature that a rational investor should have. Stock investors also want to manage their investments with this thought. In this respect, investors conduct detailed research on the sector and stock they plan to invest in. Predictions regarding the possible price formation of the stock in the future is one of these studies. In the finance literature, there are many indicators, ratios, analyzes, indicators and oscillators developed for the future price prediction of the stock. In this study, technical indicators used by licensed professional stock investors were obtained by taking expert opinion. These indicators were conveyed to the experts again to get their opinions with the help of the fuzzy comparison matrix and the experts were asked to compare the variables. The data obtained were analyzed with the Fuzzy Analytical Hierarchy Process (FAHP) method and the technical indicators and ratios used by the experts were listed according to a certain hierarchy. As a result of the analysis, it has been determined that the most important ratio in the stock price estimation process is the MV/BV ratio. While EBIT is the second most important ratio in stock price prediction, P/E is the third most important indicator.

**Keywords:** Stock, Technical Analysis, Indicators, FAHP

**JEL codes:** G12, G17, G32, C15

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## 1. INTRODUCTION

The financial system is built on five basic elements, which can be expressed as savers supplying funds, investors demanding funds, securities, intermediary institutions, and legal structure. The fact that all elements work in harmony and feed each other, undoubtedly, is one of the basic principles of the healthy functioning of the financial system in a country. In this way, savings will be brought to the economy, savers will be able to value their savings in more valuable investment areas, and business owners demanding funds will have the opportunity to finance their investments. Accordingly, it will be possible to pave the way for production and employment in the country (Afşar, 2007: 189).

Although all elements of the financial system are important, especially the savers, who supply funds, have the most important role in the system because an individual's savings are the savings s/he has acquired as a result of her labor. In this respect, savers always have the instinct to make the right choice among the alternatives while entrusting their savings to the financial system. This is a fundamental drive of rational human behavior predicted by the science of economics and finance (Gökten et al. 2008: 120).

The stock investors direct their savings to the optimum stock in the perspective of their own internal risk and return perception, such as risk-loving or prudent. Regardless of the risk or return profile, the stock investor, like every investor, makes a price prediction for the security s/he wants to invest in (Saraç and Kahyaoğlu, 2011: 137). There are many variable indicators, ratios, oscillators and indicators in the literature that are believed to give an idea to the investor about stock price prediction. These methods are based on the assumption that the past price activity of the technical analysis method will continue in the future. The fact that the methods are based on a hypothetical basis explains the inability to obtain the expected results regarding the indicators as a statistical situation. In this case, although expectations are built with scientific approaches, the fact that assumptions are the basis of these scientific approaches should not be ignored. In other words, it should not be forgot-

ten that exceptions can occur under any circumstance (Çetinyokuş and Gökçen, 2002:57).

In this study, it is aimed to compare the variables such as technical indicators, oscillators, indicators and ratios, which are frequently used in stock price estimation, with the Fuzzy Analytical Hierarchy Process (FAHP) method by taking the opinion of professional investment advisors licensed by the Capital Markets Board (CMB) and to determine the most important variable. The FAHP method is a blurred version of the Analytical Hierarchy Process (AHP) method, which is one of the multi-criteria decision-making methods. It is a method in which results can be obtained with scientific-based approaches in the process of choosing among alternative criteria. In the following parts of the study, firstly, the basic and technical analysis methods will be briefly explained, and then the literature review will be included. Then, the data set of the study will be introduced, and then the method used will be explained. Afterwards, the findings of the study will be conveyed, and the findings will be evaluated in the conclusion part. Comparing the methods with fuzzy multi-criteria decision-making methods by taking expert opinion reveals the original aspect of the study.

## 2. FUNDAMENTAL AND TECHNICAL ANALYSIS METHODS

There are many analysis methods that stock investors can use regarding stock price estimation. However, these analyzes can be considered in two main groups. These are fundamental analysis and technical analysis methods.

### 2.1. Fundamental analysis methods

Economic analysis is grouped as sector analysis and firm analysis. In the economic analysis, the global economic conjuncture should be evaluated, then, the existence of a suitable environment for investment is evaluated by taking into account the country's economy. At the same time, the countries that can be invested are also evaluated. In economic analysis, the investor interprets the main basic indicators such as gross national product, inflation, and per capita income. In sector analysis, on the other hand, investors examine the dynamics of the sector to which the

investment planning companies are affiliated. At this stage, investors evaluate the main issues such as the existence of a government incentive to the sector, the business volume of the sector, and the profitability of the sector. In the firm analysis stage, some internal variables related to the companies evaluated for making investment decisions are examined and investigated. Major indicators such as production capacity, market share in the sector, profitability over the years and dividend policy are examined. In these examinations, the liquidity ratios, leverage ratios, activity ratios, profitability ratios, growth rates and market performance ratios of the firm should be evaluated by the investors (Gacar, 2009: 70; Karabıyık and Anbar, 2010: 203).

## 2.2. Technical Analysis Methods

They are methods based on the assumption that the movements of stock prices in the past time period will be repeated in the future. The main methods that can be used in technical analysis can be grouped as charts, trend lines, support and resistance levels, price formations and technical indicators.

### 2.2.1. Charts

Charts are a method often used in technical analysis. In the chart method, past price movements are observed on a two-axis plane, and it is tried to predict the formats that the chart can take in the future. There are chart types such as line, bar, dot and candlestick. In line charts, closing prices in certain periods are reflected and interpreted on the chart. In bar charts, the highest and lowest prices that occur in certain periods are reflected on the chart as a line, and a small horizontal line representing the closing price is added to the left side of the line. In this way, while observing the intraday floor and ceiling prices, it is possible to interpret the closing price and the price performance of the day. Dot charts are a type of chart where significant price changes are tracked. Price increases are represented by X and decreases by 0. In periods when the closing prices rise one after the other, the X sign is placed on the end of the day price level, and if the rise continues, the same sign is placed on each price level similarly. If there is a decrease compared to the previous

day at the end of the day, then the symbol 0 is placed on the realized price level. In this type of chart, significant changes in price levels can be observed as a whole. In candlestick charts, more than one information is displayed on the chart, including the opening price, the closing price, the lowest price during the day, the highest prices realized during the day, and the increase or decrease information compared to the previous day. If the closing price is above the opening price, the candle-shaped graph is left empty, while the opposite is the case, the inside of the graph is painted black and thus the direction of the change for the previous period is transferred to the investor (Korkmaz and Ceylan 2012: 312; Akarsu et al. 2022: 54).

### 2.2.2. Trend Lines

It is a technique based on the assumption that stock prices move with a certain trend impulse. This trend can be up, down or horizontal. A downward trend indicates that the stock price is in a decrease, an upward trend indicates that the prices are in an upward trend, while a horizontal movement is interpreted as the prices do not change and gather energy before an upward or downward movement. The markets in which the prices are in an upward trend can be expressed as a bull market, and the markets in which they are in a downward trend can be expressed as a bear market (Çetinyokuş and Gökçen: 2002: 48).

### 2.2.3. Support and Resistance Levels

It is a method frequently used in estimating the buying and selling times of stocks and making inferences about the future course of prices. Support points are expressed as a change in direction as a result of a demand (buying) pressure that occurs when stock prices are in a downward trend, and resistance points are expressed as a change in direction as a result of a supply (sell) pressure that occurs when stock prices are in an upward trend. Price formations are expressed as the appearances of trend lines realized by stock prices over time. Price formations provide information about the behavior patterns of stocks. Although there are many types of formations, the main ones can be listed as shoulder-head-shoulder formation, triangle formation and consolidation for-

mations. Shoulder-head-shoulder formation can be observed frequently. After a certain amount of transaction volume increases, prices decrease due to low demand. Afterwards, an increase occurs far beyond the previous price increase, and then the price level decreases again due to low demand. The oscillation with this second drop has a wider wavelength compared to the first. Then, with the revival of demand, the first swing is repeated, and the shoulder-head-shoulder formation becomes observable on the chart. Triangle formations are the observable occurrence of a triangle form when looking at stock price trends. While price movements realize the up and down oscillation frequencies, each price transformation takes place in a shorter time compared to the previous one and the triangle form is realized. Consolidation formations refer to the formation that occurs when the prices show up and down movements with short fluctuations and follow a horizontal course on the average after a long period of rising or falling. In this formation, the stock is gathering strength for the continuation of the previous activity with a sideways movement (Foan, 2006: 78; Başıoğlu, 2009: 474).

#### 2.2.4. Technical Indicators

These are the indicators that investors use to support their buying and selling decisions while forming price changes related to stock prices. There are a lot of types. The main ones are moving averages (MA), Bolinger bands (BB), relative strength index (RSI), momentum, price change rate (ROC), moving average fit-mismatch indicator (MACD), price oscillator, equilibrium trading volume and price change rate. In this study, only the main indicators are briefly mentioned (Tek et al. 2022: 15).

Moving averages provide an average information about the course of the trend by removing the daily effect of price movements. The average expression means taking the arithmetic average of the closing prices on a given day, and the mobility expression means adding dynamism to the average by subtracting the oldest day's price against the addition of each new day's closing price. With the moving averages indicator, instant volume changes are prevented from creating a misleading effect on the investor (Dan-

iswara et al. 2022: 18).

Bolinger bands are drawn on the assumption that the upper and lower prices are considered as the limit on the chart created by the stock prices. In case the stock price chart goes outside the determined bandwidth area, it is recommended to dispose of the stock (Day et al. 2022: 2).

The relative strength index (RSI) is often used in the stock market and gives an idea to the investor about the buying and selling of the stock. The RSI indicator is an index created based on the principle of taking the arithmetic average of the closing prices, which increase and decrease in stock prices in a certain time period. This index is examined in a separate chart. 30 being the lower limit and 70 the upper limit; if the index falling below the lower limit rises again, according to the RSI indicator, the stock offers a buying opportunity, and if the index above the upper limit enters a decreasing trend by breaking, it is interpreted as the stock is overvalued according to the RSI indicator and should be disposed of (Pabuççu 2019: 248).

Momentum is obtained by multiplying the closing price of the stock by 100 to the closing price of a certain time ago. The obtained value is interpreted as how quickly the stock has changed from the determined day to this time. Between 80 and 120 are generally accepted lower and upper limits. If the obtained momentum value is above the critical value of 100, the stock is disposed of, and if the momentum value is below the critical value, the stock is considered as a buying opportunity (Çetinyokuş and Gökçen 2002: 50).

Rate of change (ROC) is an indicator that gives an idea of how the closing price of a stock changes compared to the closing price of a specified time, similar to the momentum indicator. The difference from the momentum is that it expresses the percentage change and the critical value indicator, which gives the idea of buying or selling, is accepted as zero instead of a hundred.

MACD is an indicator obtained by subtracting the long-term calculated average from the short-term calculated average from the short-term and long-term exponential moving averages formed by the closing values of the stock prices. It is cal-



culated to predict the possible direction of the price movement of the stock and to give an idea to the buying and selling decisions (Çetinyokuş and Gökçen 2002: 50).

The price oscillator is the difference between two moving averages of stock prices. If the short-term average is higher than the long-term average, it is considered a buy, if the short-term average is lower than the long-term average, it is considered a sell (Karabıyık ve Anbar, 2010: 208).

The equilibrium trading volume indicator gives an idea about the relationship between stock prices and trading volumes in the market. It is an indicator obtained by adding the trading volumes when the price of the stock increases and deducting the realized trading volumes from the total when it decreases. The indicator can give an idea about the course of the stock in the future (Korkmaz and Ceylan 2012: 312).

### 3. LITERATURE

The main examples from the national and international literature scanned regarding machine learning-based technical indicators, oscillators, financial ratio and analysis methods in stock valuation and stock price estimation methods are listed chronologically as follows.

Çetinyokuş and Gökçen (2002) analyzed financial indicators with the help of profit support systems in order to contribute to the portfolio diversification process of the stock investor. As a result of the analysis, they stated that decision support systems are an auxiliary method in decision processes with high levels of uncertainty and although the formations are indicators with long-term knowledge, exceptional situations such as not realizing expectations may be encountered. Chong and Ng (2008) examined the effectiveness of moving averages and relative strength index (RSI) indicators in the FT30 index in the UK sample. As a result of the research, they found that the MACD and RSI indicators offer more return opportunities compared to many alternative options, especially the buy and hold strategy. Mitra (2011) aimed to examine the effectiveness and usability of the moving average indicator in stock investment in the Indian sample. As a result of the research, they found

that technical indicators offer profitable buying opportunities, but transaction costs significantly reduce profit opportunities. Chong et al. (2014) aimed to examine the effectiveness of the RSI and MACD indicators in the stock price prediction process in a sample of five OECD countries. As a result of the research, MACD and RSI indicators indicated that abnormal returns can be obtained in Milan Comit General and S&P/TSX Composit index. In addition, the RSI indicator indicates that the Dow Jones industrial index is profitable. Ilaşlan (2014) investigated the analysis of estimating stock prices using the Markov chains method in a sample of listed banks. As a result of the research, stock price predictions for the next day were successfully realized in 9 of 10 banks listed on the stock exchange. At this point, it is concluded that Markov chains can be used as an alternative method in stock price estimation. Öztürk (2016) aimed to determine trading limits by using technical indicators in stock trading transactions. Öztürk developed a new indicator in the context of exponential moving averages in his study. As a result of the analysis, he stated that the indicator he developed performed better than the buy and hold strategy. Astuty (2017) examined the effects of basic factors and systematic risk on stock prices in the Indonesian stock market sample. As a result of the research, it was confirmed that price earnings ratio, earnings per share, net profit margin, market value/book value variables have a significant impact on stock prices. Park and Irvin (2017) aimed to measure the effectiveness of technical analysis methods used in stock valuation. As a result of the research, he stated that 56 of the 95 enterprises gave positive results regarding the profitability of technical indicators, 20 of them gave negative results and 19 of them gave mixed results. Akşehir and Kılıç (2019) investigated the applicability of machine learning methods in stock price estimation in the sample of banks operating in the BIST banking sector. As a result of the examination, they found that the random forest, decision trees and regression models gave successful results in stock price estimation. Oguz et al. (2019) aimed to examine the effectiveness of technical analysis indicators in predicting the future prices of stocks. In their research, they compared the performance of simple, weighted, exponential

moving averages, MACD, RSI and stochastic oscillator indicators. As a result of the analysis, they concluded that the exponential moving average method is the best indicator compared to other indicators. Pabuççu (2019) aimed to test the movements of BIST index data with the help of technical indicators. As a result of the analysis, it was concluded that the support vector machine algorithms were the most successful algorithms, then the artificial neural networks algorithm and then the Naive Bayes algorithm were successful. Özkan (2021) aimed to measure and compare the effectiveness of 52-week bottom-peak analysis and gross profitability indicators. As a result of the analysis, although the portfolio created based on the 52-week bottom-peak analysis indicator was found to be statistically insignificant, it was determined that the return of the portfolio created was positive. The portfolio created based on the gross profitability indicator was found to have statistically positive and positive returns. Alaca and Güran (2022) aimed to predict stock index with the help of technical indicators and emotion scores during the covid-19 pandemic process. As a result of the analysis, they concluded that emotion scores have an effect on the index at certain periods. Day et al. (2022) examined the profitability of investment strategy in bitcoin markets with the help of Bolinger band indicators. As a result of the analysis, they stated that those following the investment strategy by using the Bolinger bands indicators in the Bitcoin markets can reach 20% profitability, and when they base the moving averages indicator as 60 days instead of 20 days, their profitability can reach 50%. Daniswara et al. (2022) aimed to compare the performances of Bolinger bands, moving averages and RSI index indicators by examining them in the Indonesian stock market sample. As a result of the analysis, they concluded that the price predictions for stocks in the strategies developed using all three indicators do not differ from the actual prices of the stocks and they follow a similar trend. In addition, they stated that the RSI indicator has a relatively more optimally accurate performance among the three indicators. Naranchimeg and Bolor (2022) examined the effect of financial indicators on stock price in the Mongolian stock market sample. As a result of the research, some indicators such as return

on assets, return on equity, earnings per share were found to be directly correlated with stock prices. Seshu et al. (2022) aimed to perform the performance analysis of stocks with the help of Bolinger bands and indicators based on short-long-term memory models in the sample of the top 50 most traded companies in the Indian stock market. As a result of the analysis, it was observed that the portfolios created within the scope of short indicators were successful in one third of the time periods tested retrospectively. In this respect, investing in the strategies suggested by the indicators offered the possibility of return above the index.

In this study, the technical indicators that are frequently used in the stock price estimation process, expert opinions obtained from professional stock investment advisors licensed by the Capital Markets Board will be examined with FAHP, a fuzzy multi-criteria decision-making method, and the most important indicator in the stock price estimation process will be tried to be determined. Obtaining expert opinion from professional investors and using fuzzy multi criteria decision making method is the original aspect of the study.

#### **4. DATA SET and METHOD**

This study aims to determine the technical analysis methods used by professional stock investors with CMB license in Turkey while creating their stock portfolio, and then to determine which is the most important indicator by ordering these techniques in a certain hierarchy with the FAHP method.

The data set of the study was obtained in 2 rounds. In the first round, the technical indicators they used were obtained by taking expert opinion from six CMB licensed professional stock investors. In the second round, these indicators obtained from the experts were sent to the experts to get their opinions with the help of the fuzzy comparison matrix and the experts were asked to compare the variables.

In the first round, the basic indicators used by the investment experts in creating a stock portfolio were determined as in Table 1, thanks to the expert opinion.

**Earnings Before Interest and Tax:** It is abbreviated as EBIT in finance literature. It can also be expressed as the sum of depreciation expenses with operating profit. In other words, the EBIT value is obtained by adding the depreciation before interest and tax. EBIT is an indicator of operating performance in a business. Tax and interest policies may differ in different countries, in different regions of the same country, and in different sectors. Adding depreciation again, which does not actually have a cash outflow in the EBIT value, and the fact that interest and tax payments have not yet been made will minimize the comparison problems arising from sectoral and regional application differences. In summary, comparisons with EBIT can be made much more objectively. While other alternative variables are constant, it is considered that the enterprise with more EBIT value is more valuable than the alternative.

**Market Value /Book Value:** It is one of the most commonly used ratios in stock valuation. It expresses the market value of the enterprise against a certain unit of equity. In other words, it gives an idea about whether the company's stock is cheap or expensive when compared to its own capital. A high Mv/Bv ratio is interpreted as being expensive in relation to the stock price, while a low Mv/Bv ratio is interpreted as being cheap in relation to the stock price.

**Price Earnings Ratio:** Another ratio frequently used in stock valuation is the price-earnings ratio. It refers to the price that must be paid for one unit of earnings related to stocks. It refers to the price that must be paid for one unit of earnings related to stocks. A high ratio means that

the stock price is expensive. A low P/E ratio is interpreted as a cheap stock price. In another interpretation, a high P/E ratio can be expressed as investors foresee a potential for the relevant stock in the future and pricing this situation in the current period. Similarly, a low P/E ratio can be considered by stock investors as a prediction of a contraction in the future for the business and pricing it now. Better evaluations can be reached when the stock demand information about the P/E ratio is interpreted together.

**Dividend Yield:** Stock investors expect two main gains from a stock, the first of which is capital gains. Capital gains mostly meet the expectations of investors who make portfolio investments within the scope of short-term investment strategy. The second basic gain that stock investors expect from stock investments is dividend, in other words, share of profit. The concept of dividend yield is an indicator that includes the stability information regarding the dividend distributions of the companies that have been offered to the public over the years. It shows the amount of dividend that can be obtained for each TL invested in the stock. Dividend yield is frequently used by investors when comparing stocks with stable dividend distribution policy (Camgöz: 2022: 1422).

**Company's Debt Burden:** Debt is short-term and long-term foreign resources provided by enterprises to meet their financing needs in addition to their own capital. Foreign resources, together with the equity capital, constitute a resource richness in terms of the growth and diversification of the activities of the enterprise. At the same

**Table 1.** Technical Indicators and Ratios used in the analysis

| Ratio                                  | Abbreviation     |
|--|------------------|
| Earnings Before Interest and Tax       | EBIT             |
| Market Value /Book Value               | Mv/Bv            |
| Price Earnings Ratio                   | P/E              |
| Dividend Yield                         | Dividend Y.      |
| Company's Debt Burden                  | Company's D. B.  |
| Net Profit                             | Net Profit       |
| 52-Week Bottom-Top Analysis            | 52-Week High/Low |
| Moving Average Convergence/ Divergence | MACD             |
| Ichimoku Kinko Hyo Indicator           | Ichimoku         |

time, the tax-reducing effect of the interest paid as a cost of foreign funding is another positive aspect of borrowing. However, excessive borrowing is a dangerous process that may result in the company not being able to meet its obligations and then facing the risk of bankruptcy. In this respect, stock investors care about the debt burden of the businesses they plan to invest in.

**Net Profit:** The profits obtained by the enterprises as a result of their activities are an indicator of the efficiency of the enterprises in question. The fact that the net profit amount obtained by a business, which has intensive activities such as inventory turnover, asset turnover or receivables turnover, is low, is interpreted as ineffective activities. In this respect, stock investors meticulously follow the news about the disclosure of quarterly net profit information. If the profit obtained by the business as a result of its activities is distributed to the shareholders, it will have an increasing effect on the dividend yield of the company. If the profit obtained is not distributed to the partners but directed to auto-financing, in this case, it will have a reducing effect on the costs of the enterprise and increase the net profit for the next period. In any case, the company's ability to achieve greater net profit is a desirable expectation in both cases.

**52-Week Bottom-Top Analysis:** It is a method frequently used by investors in stock price prediction. It contains the bottom and top price information of the closing prices of the stock in the last year. The highest price in the process is interpreted as resistance and the lowest price as support. The stock investor interprets the current market price according to the support and resistance points of the past 52 weeks. Some investors interpret the situation that the stock price is close to the resistance point as an insurmountable point in the context of the 52-week bottom-top analysis and interpret the stock price to enter a downward trend after this point. In some cases, if the resistance point, which is the 52-week top price indicator, is exceeded, a performance above the market can be expected (Özkan, 2021: 708).

**MACD:** Two exponential moving averages are calculated as short-term and long-term and this

indicator is obtained by subtracting the long-term (usually 26 days) exponential moving averages from the exponential moving average series calculated as short-term (usually 12 days). A 9-day exponential moving average chart is added on top of the 12-day and 26-day exponential moving averages difference chart, which can also be expressed as a signal line. Stock investors interpret the 9-day exponential moving averages chart as a buy message when it goes above the signal line, and if the stock goes below the signal line as a sell message. Instead of intraday price information of stock prices, the closing price of the day is taken as data (Wang and Kim 2018: 2).

**Ichimoku Kinko Hyo Indicator:** The indicator helps to identify support, resistance and a trend on the chart so that stock prices can be predicted. In the indicator, there are moving averages series with 9 time period expressed as Tenkan Sen and moving averages series with 26 time period expressed as Kijun Sen. These two series are important for identifying resistance and support series. Senkou Span A and Senkou Span B points are obtained from Tenkan Sen and Kijun Sen values. Senkou Span A is the point obtained by shifting the arithmetic mean of the 9 and 26 time period averages by 26 time periods. Senkou Span B is the point obtained by adding 26 time periods to the value obtained by taking the arithmetic average of the highest and lowest prices in 52 time periods. The region referred to as the Ichimoku cloud is the part between Senkou Span A and B. If the stock price chart exceeds the border between points A and B, it is interpreted that the stock price will enter an upward trend. If the stock price follows a downward trend between points A and B, it is interpreted that the stock price will enter a downward trend (Keskin, 2019: 34).

In this study, the extended Fuzzy Analytical Hierarchy Process (FAHP) method developed by Chang (1996) was used as the application method.

The FAHP method is reached as a result of the criticism of the missing aspects of the Analytical Hierarchy Process method, uncertainty and indecision in the human thinking, pairwise comparison processes, and adding these criticized



aspects to the model by developing them.

Chang (1996)'s FAHP method follows the following workflow (Paksoy et al. 2013: 123):

$X = \{x_1, x_2, x_3, \dots, x_n\} \rightarrow$  set of objects and  $U = \{u_1, u_2, u_3, \dots, u_n\}$  set of purposes and  $U = \{u_1, u_2, u_3, \dots, u_n\}$  size analysis value;  
 $M_{gi}^1, M_{gi}^2, \dots, M_{gi}^m, i = 1, 2, \dots, n \rightarrow M_{gi}^j, m_j = 1, 2, \dots, m$   $M_{gi} = (l_i, m_i, u_i)$

**Step 1:** Fuzzy synthetic expansion value by purpose:

$$S_i = \sum_{j=1}^m M_{gi}^j \cdot \left[ \sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} \quad (1)$$

equation is obtained. Fuzzy addition operation of m extension analysis for the pairwise comparison matrix considered to reach the  $\sum_{j=1}^m M_{gi}^j$  value.

is applied as such:

$$\sum_{j=1}^m M_{gi}^j = (\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j).$$

In order to obtain  $\left[ \sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1}$  fuzzy sum operation of  $M_{gi}^j, j = 1, 2, \dots, m$  values:

Is written as such:

$$\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j = (\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j)$$

and its reverse is calculated as such.

$$\left[ \sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} = \left( \frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i} \right). \quad (2)$$

**Step 2:** Calculated synthesis values are compared and weight values are obtained by using these values.  $M_1 = (l_1, m_1, u_1)$  ve  $M_2 = (l_2, m_2, u_2)$  ve for comparison of triangular fuzzy numbers:

Likelihood degree of  $M_2 \geq M_1$  is calculated with the help of the equation:

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[ \min(\mu_{M_1(x)}, \mu_{M_2(y)}) \right] =$$

$$hgt(M_1 \cap M_2) = \mu_{M_1(d)} = \begin{cases} 1, M_2 \geq M_1 \\ 0, l_1 \geq u_2 \\ \frac{(l_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)}, d. d. \end{cases} \quad (3)$$

**Step 3:** The degree of probability of a convex fuzzy number greater than k fuzzy numbers  $M_i, (i = 1, 2, \dots, k)$ ,

is as such:

$$V(M \geq M_1, M_2, \dots, M_k) = \min V(M \geq M_i), i = 1, 2, \dots, k \quad (4)$$

In such a case, the following assumption can be made:

$$S_i, k = 1, 2, \dots, n; i \neq k \text{ for } d^i(A_i) = \min V(S_i \geq S_k), k = 1, 2, \dots, n; k \neq i.$$

It is expressed as such:  $W^t = (d^t(A_1), d^t(A_2), \dots, d^t(A_n))^T$ . It has  $A_i, (i = 1, 2, \dots, n)$  n elements. (5)

**Step 4:** Weight vector normalized with normalization of W value

It is expressed as follows:  $W = (d(A_1), d(A_2), \dots, d(A_n))^T$ . W, is not a fuzzy number and it is calculated as such:

$$d(A_i) = \frac{d^t(A_i)}{\sum_{i=1}^n d^t(A_i)}. \quad (6)$$

The fuzzy linguistic comparison scale information used in the FAHP method is as in Table 2.

**Table 2.** The fuzzy linguistic comparison

| Linguistic Variable    | Fuzzy Scale | Counter Scale   |
|------------------------|-------------|-----------------|
| Equal Importance       | (1,1,1)     | (1/1,1/1,1/1)   |
| Moderate Importance    | (1,3,5)     | (1/5, 1/3, 1/1) |
| Strong Importance      | (3,5,7)     | (1/7, 1/5, 1/3) |
| Very Strong Importance | (5,7,9)     | (1/9, 1/7, 1/5) |
| Absolute Importance    | (7,9,9)     | (1/9, 1/9, 1/7) |
| Intermediate Values    | (1,2,3)     | (1/3,1/2,1/1)   |
|                        | (3,4,5)     | (1/5, 1/4, 1/3) |
|                        | (5,6,7)     | (1/7, 1/6, 1/5) |
|                        | (7,8,9)     | (1/9, 1/8, 1/7) |

Source: Karabulut and Erbaşı, 2016: 21

## 5.FINDINGS

In this article, in which the extended Fuzzy Analytical Hierarchy Process (FAHP) method developed by Chang (1996) is used, it is aimed to determine the order of importance of the indicators and ratios used by stock investors in technical analysis. The matrix created with the help of fuzzy linguistic comparison scales in Table 2 is summarized in Appendix-1.

The way in which each  $S_i$  values are obtained according to Chang's FAHP algorithm as a result of applying the processes listed in step 1 in the matrix in Annex-1 is as in Appendix-2.

Using the obtained "*l, m and u*" values, the results of the comparison of the synthesis values and the determination of the weight values, with the help of the processes of which stages are explained in detail in step 2, are given in Appendix-3.

The likelihood degrees of the criteria, which were explained in detail in step 3 of the implementation processes, were calculated and obtained as in Appendix-4.

Based on the likelihood degrees of the critical values in Appendix-4, the normalized weight vector was obtained as in Table 3 by normalizing the  $W$  value, the stages of which were transferred in step 4.

**Table 3.** Normalized Weight Vector

|                             |      |
|-----------------------------|------|
| MV/BV                       | 0.28 |
| EBIT                        | 0.27 |
| P/E                         | 0.25 |
| 52-Week Bottom-Top Analysis | 0.15 |
| Dividend Yield              | 0.05 |
| Company's Debt Budget       | 0    |
| Net Profit                  | 0    |
| MACD                        | 0    |
| Ichimoku Knko Hyo Analysis  | 0    |

According to the normalized weight vector information in Table 3, the market value/book value indicator was determined as the most important indicator with a weight of 0.28 among the indicators and ratios used.

The indicator with secondary importance in stock price estimation was found as the earnings before interest and tax with a weight of 0.27.

The price-earnings ratio of stocks was the third most important indicator with a weight ratio of 0.25.

The 52-week Bottom-Top Analysis was identified as the fourth important level indicator with a weight ratio of 0.15.

It was also determined that the dividend yield

was an indicator with a fifth significance level with a weight ratio of 0.05 according to the calculated normalized weight vector data.

The company's debt burden, net profit, MACD and Ichimoku Knko Hyo Analysis indicators were not included in the order of importance according to the normalized weight vector data.

## 6. CONCLUSION

Stock investors in the financial system are important elements of the system that supply their financial savings to the system. Increasing the number of savers in a financial market is a development that can bring multiple benefits. The increase in savers, especially individual investors, not only provides them with a return in the process, but also meets the financing needs of those who demand funds and allows investments to be financed indirectly. These indirect effects may lead to a chain increase in the production of goods and services in the country in the long run and, accordingly, an increase in employment, welfare, and per capita national income. In this respect, minimizing the adverse selection costs of savers will indirectly maximize many benefits.

Stock investors, who can be expressed as a saver, also want to predict the market prices of stocks before investing in stocks. In these predictions, they want to know whether the price is high or low. They want to sell stocks that are overpriced according to market value and buy stocks that are underpriced according to market values. They make their predictions about the future price formations of stocks with the help of many types of technical indicators, ratios, oscillators and indicators. In this study, it was aimed to compare the technical indicators, ratios, oscillators and indicators used by stock investors in the stock price prediction processes with the FAHP method and to determine the most important indicator.

As a result of the analysis, it was found that the best technique according to the FAHP method is the market value/book value approach in the process of making stock buying and selling decisions. This ratio gives important information about whether the company's stock is priced cheaply or expensively in the market. It proposes

a buying strategy for stocks with a market value close to book value. EBIT was determined as a ratio of secondary importance in stock purchase decisions according to the FAHP method. The high EBIT value means that the operating performance of the enterprise is also high. With high EBIT, financial expenses and tax liabilities can be met, the possible high net profit that can be achieved and this makes the shareholders happy. The 52-week Bottom-Top Analysis and dividend yield are other important indicators for the development of an effective and efficient stock buying strategy.

When the results are evaluated in general, it is predicted that the inclusion of stocks with low MV/BV value, high EBIT value and low P/E value in the portfolio prior to stock investment will increase the value of the portfolio.

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### Appex 2. Obtaining Si Values

|                     |         |         |        |   |        |        |        | L      | m      | u      |
|---------------------|---------|---------|--------|---|--------|--------|--------|--------|--------|--------|
| S(EBIT)             | 15.0000 | 24.0000 | 33.000 | ⊗ | 0.1429 | 0.2105 | 0.2381 | 2.1429 | 5.0526 | 7.8571 |
| S(MV/BV)            | 15.0000 | 24.0000 | 33.000 | ⊗ | 0.1429 | 0.2206 | 0.2672 | 2.1429 | 5.2941 | 8.8168 |
| S(P/E)              | 16.3333 | 26.5000 | 37.000 | ⊗ | 0.1128 | 0.1780 | 0.2448 | 1.8421 | 4.7181 | 9.0559 |
| S(Dividend Y.)      | 6.6000  | 13.9167 | 22.333 | ⊗ | 0.0476 | 0.0759 | 0.1351 | 0.3143 | 1.0570 | 3.0180 |
| S(Company's D.B.)   | 5.8000  | 9.1667  | 13.667 | ⊗ | 0.0400 | 0.0571 | 0.0909 | 0.2320 | 0.5238 | 1.2424 |
| S(Net Profit)       | 5.0190  | 8.4500  | 12.867 | ⊗ | 0.0323 | 0.0444 | 0.0667 | 0.1619 | 0.3756 | 0.8578 |
| S(52-Week High/Low) | 4.4667  | 7.2500  | 12.333 | ⊗ | 0.0345 | 0.0517 | 0.0980 | 0.1540 | 0.3750 | 1.2092 |
| S(MACD)             | 3.0190  | 4.0333  | 7.533  | ⊗ | 0.0270 | 0.0385 | 0.0667 | 0.0816 | 0.1551 | 0.5022 |
| S(Ichimoku)         | 8.7333  | 12.5833 | 18.333 | ⊗ | 0.0413 | 0.0606 | 0.1070 | 0.3609 | 0.7626 | 1.9623 |

### Appex 3. Determining Weight Values by Comparing Synthesis Values

|                                    |      |                                 |      |                                     |      |
|------------------------------------|------|---------------------------------|------|-------------------------------------|------|
| S(EBIT)≥MV/BV                      | 0.96 | S(MV/BV)≥EBIT                   | 1.00 | S(Dividend Y.)≥EBIT                 | 0.18 |
| S(EBIT)≥P/E                        | 1.00 | S(MV/BV)≥P/E                    | 1.00 | S(Dividend Y.)≥MV/BV                | 0.17 |
| S(EBIT)≥Dividend Y.                | 1.00 | S(MV/BV)≥Dividend Y.            | 1.00 | S(Dividend Y.)≥P/E                  | 0.24 |
| S(EBIT)≥Company's D.B.             | 1.00 | S(PD/DD)≥Company's D.B.         | 1.00 | S(Dividend Y.)≥Company's D.B.       | 1.00 |
| S(EBIT)≥Net Profit                 | 1.00 | S(MV/BV)≥Net Profit             | 1.00 | S(Dividend Y.)≥Net Profit           | 1.00 |
| S(EBIT)≥52-Week High/Low)          | 1.00 | S(MV/BV)≥52-Week High/Low)      | 1.00 | S(Dividend Y.)≥52-Week High/Low)    | 1.00 |
| S(EBIT)≥MACD                       | 1.00 | S(MV/BV)≥MACD                   | 1.00 | S(Dividend Y.)≥MACD                 | 1.00 |
| S(EBIT)≥Ichimoku                   | 1.00 | S(MV/BV)≥Ichimoku               | 1.00 | S(Dividend Y.)≥Ichimoku             | 1.00 |
| S(P/E)≥EBIT                        | 0.95 | S(Net Profit)≥EBIT              | 0.00 | S(Şirketin B.Y.)≥EBIT               | 0.00 |
| S(P/E)≥MV/BV                       | 0.92 | S(Net Profit)≥MV/BV             | 0.00 | S(Company's D.B.)≥MV/BV             | 0.00 |
| S(P/E)≥Dividend Y.                 | 1.00 | S(Net Profit)≥P/E               | 0.00 | S(Company's D.B.)≥P/E               | 0.00 |
| S(P/E)≥Company's D.B.              | 1.00 | S(Net Profit)≥Dividend Y.       | 0.44 | S(Company's D.B.)≥Dividend Y.       | 0.64 |
| S(P/E)≥Net Profit                  | 1.00 | S(Net Profit)≥Company's D.B.    | 0.81 | S(Company's D.B.)≥Net Profit        | 1.00 |
| S(P/E)≥52-Week High/Low)           | 1.00 | S(Net Profit)≥52-Week High/Low) | 1.00 | S(Company's D.B.)≥52-Week High/Low) | 1.00 |
| S(P/E)≥MACD                        | 1.00 | S(Net Profit)≥MACD              | 1.00 | S(Company's D.B.)≥MACD              | 1.00 |
| S(P/E)≥Ichimoku                    | 1.00 | S(Net Profit)≥Ichimoku          | 0.56 | S(Company's D.B.)≥Ichimoku          | 0.79 |
| S(52-Week High/Low)≥EBIT           | 1.00 | S(MACD)≥EBIT                    | 0.00 | S(Ichimoku)≥EBIT                    | 0.00 |
| S(52-Week High/Low)≥MV/BV          | 1.00 | S(MACD)≥MV/BV                   | 0.00 | S(Ichimoku)≥MV/BV                   | 0.00 |
| S(52-Week High/Low)≥P/E            | 1.00 | S(MACD)≥P/E                     | 0.00 | S(Ichimoku)≥P/E                     | 0.03 |
| S(52-Week High/Low)≥Dividend Y.    | 0.57 | S(MACD)≥Dividend Y.             | 0.17 | S(Ichimoku)≥Dividend Y.             | 0.85 |
| S(52-Week High/Low)≥Company's D.B. | 0.87 | S(MACD)≥Company's D.B.          | 0.42 | S(Ichimoku)≥Company's D.B.          | 1.00 |
| S(52-Week High/Low)≥Net Profit     | 1.00 | S(MACD)≥Net Profit              | 0.61 | S(Ichimoku)≥Net Profit              | 1.00 |
| S(52-Week High/Low)≥MACD           | 1.00 | S(MACD)≥52-Week High/Low)       | 0.61 | S(Ichimoku)≥52-Week High/Low)       | 1.00 |
| S(52-Week High/Low)≥Ichimoku       | 0.69 | S(MACD)≥Ichimoku                | 0.19 | S(Ichimoku)≥MACD                    | 1.00 |

**Appex 4. Likelihood Degrees of Critical Values**

|  |      |                                |
|--|------|--------------------------------|
| $d^1(F_1) = \min[V(S_{EBIT} \geq S_j)] =$            | 0,96 | $\Rightarrow 0,96/3,62 = 0,27$ |
| $d^1(F_1) = \min[V(S_{MV/BV} \geq S_j)] =$           | 1,00 | $\Rightarrow 1,00/3,62 = 0,28$ |
| $d^1(F_1) = \min[V(S_{P/E} \geq S_j)] =$             | 0,92 | $\Rightarrow 0,92/3,62 = 0,25$ |
| $d^1(F_1) = \min[V(S_{Dividend Y.} \geq S_j)] =$     | 0,17 | $\Rightarrow 0,96/3,62 = 0,05$ |
| $d^1(F_1) = \min[V(S_{Company's D.B.} \geq S_j)] =$  | 0,00 | $\Rightarrow 0,00/3,62 = 0,00$ |
| $d^1(F_1) = \min[V(S_{Net Profit} \geq S_j)] =$      | 0,00 | $\Rightarrow 0,00/3,62 = 0,00$ |
| $d^1(F_1) = \min[V(S_{2-Week High/Low} \geq S_j)] =$ | 0,57 | $\Rightarrow 0,57/3,62 = 0,15$ |
| $d^1(F_1) = \min[V(S_{MACD} \geq S_j)] =$            | 0,00 | $\Rightarrow 0,00/3,62 = 0,00$ |
| $d^1(F_1) = \min[V(S_{Ichimoku} \geq S_j)] =$        | 0,00 | $\Rightarrow 0,00/3,62 = 0,00$ |
| Total  | 3,62 | Total 1,00                     |