

Stock Price Movement Prediction using Combinative Machine Learning: A Conceptual Model

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Abstract

Stock has dynamic characteristic and difficult to predict because its movement is affected by many factors. Various ways have been developed to predict stock price movements, including technical analysis and fundamental analysis. Besides these traditional techniques, there is also sentiment analysis. Many studies have tried to predict stock price movement through the machine learning approach using these various analysis techniques. However, the obtained results are vary depending on the object and variables used. This is because many factors influence stock price movements. These studies are presumed have not represented all existing factors. One of which is that no research considers the use of fundamental analysis in terms of currency exchange rates and stock prices index movements in other countries. Also, no studies consider the use of news in conducting sentiment analysis to predict stock price movements in Indonesia. This paper will describe a conceptual model that aims to predict stock price movements in Indonesia based on sentiment analysis, technical analysis, and fundamental analysis using machine learning approach.

Keywords

Fundamental analysis, machine learning, sentiment analysis, stock prediction, technical analysis

1. Introduction

The stock has dynamic characteristic and difficult to predict because its movement is affected by many factors. Even so, various ways have been developed to predict stock price movements (Masoud 2017). Two traditional techniques commonly used by investors. The first is a technical analysis that uses historical price such as opening price, closing price, transaction volume, average stock price, etc. The second is the fundamental analysis that uses qualitative and quantitative measurement based on the company's profile and financial condition, market condition, political, business, and economic conditions (Hur et al. 2006). Apart from these two traditional techniques, there is also the third technique called sentiment analysis (Derakhshan and Beigy 2019, Sert et al. 2020). The sentiment is defined as a person's perspective or opinion --in this case, an investor-- on information (Hu et al. 2012). Several studies have tried to examine the relationship between sentiment and stock prices. Tetlock (2007) found that negative news published by Wall Street Journal could lead to a drop in the share price. Then, Tetlock et al. (2008) also found that stock price movements in the United States are affected by the news sentiment published by news media such as Dow Jones News Service and Wall Street Journal. However, in a study conducted by Rizkiana et al. (2018), it was found that investor sentiment does not affect stock prices; instead, stock prices do affect investor sentiment. This is because the data source used in this study comes from investor's forum that contains discussion based on information as a form of response, not as a response trigger that will generate sentiment such as news. Rizkiana et al. (2019) also conducted research to examine the effect of sentiment on stock price movements by using news as one of the data sources. However, this study also obtained an insignificant result. This is because the amount of news used in this study is very small and only considers news related to the object under study, so it cannot represent all information or news related to the stock market circulating in Indonesia. Therefore, Rizkiana et al. (2019) stated that the selection of data sources that will be used to test the effect of sentiment must be chosen carefully because not all data on the internet can be used to represent investor sentiment.

However, along with the development of computational capabilities, Baker and Wurgler (2007) stated that nowadays the question is no longer whether investor sentiment affects stock price, but rather how to measure investor sentiment

and quantify its effect through stock price prediction. With the development of computational capabilities, several researches have tried to measure the impact of sentiment on stock price movements through prediction using artificial intelligence approach, one of which is machine learning. Using machine learning approach, stock price movements can be predicted through an algorithm that can identify relationship and pattern existed in the variables to form predictions (Maqsood et al. 2020). Vijn et al. (2020) also mentioned that stock price prediction using machine learning could improve prediction accuracy up to 60%-86% compared to prediction using traditional statistics. Li et al. (2020) has tried to predict stock price movement in China using machine learning based on sentiment analysis and obtained prediction accuracy between 40%-80%. Picasso et al. (2019) tried to predict stock price movement using machine learning by combining investor sentiment analysis obtained from the news with technical analysis such as historical price and obtained prediction accuracy between 50%-68%. The result obtained by Picasso et al. (2019) is in line with a theory proposed by Wu et al. (2012) that stated combining several analysis techniques can improve stock price prediction capabilities. However, the result obtained in previous studies were vary depending on the object and variables studied. These inconsistent results are due to the different investor behaviour and capital market condition in every country (Corredor et al. 2015). Many factors can affect stock price movements and factors used in those researches are considered not sufficient to represent all existing factors. Hence, it is necessary to combine analysis techniques such as sentiment analysis with both technical analysis and fundamental analysis as a predictor to predict stock price movements. However, there is still no research that tries to consider the use of fundamental analysis, such as currency exchange rates and foreign stock prices index movements to predict stock price movements, especially in Indonesia.

According to Wong (2017), the currency exchange rate is one of the most important factors affecting stock movements. According to Delgado et al. (2018) the strengthening of a country's currency exchange rate will affect the strengthening of the stock price index in that country. Dong and Yoon (2019) also stated that there is a correlation between the currency exchange rate and stock price movement in emerging markets such as Indonesia. Furthermore, Mensi et al. (2014) and Lee and Chou (2020) in their research mentioned that the movement of stock price index in one country, especially in the United States, can affect stock price movements in other countries, including Indonesia. Several studies related to stocks in Indonesia, such as Rizkiana et al. (2017), tried to predict stock price movements using survival analysis techniques based on sentiment analysis. Meanwhile, other studies such as Afrianto et al. (2013) and Yasin et al. (2014) have tried to predict stock price movements through a machine learning approach based on technical analysis such as historical prices. These studies only consider one aspect of the analysis, even though many factors can affect stock price movements. The use of one aspect alone is considered not able to represent all existing factors. Based on the description above, it can be seen that there is still no research that tries to predict the price movements of stocks in Indonesia using a machine learning approach by considering the three aspects of analysis previously described, namely sentiment analysis, technical analysis and fundamental analysis. So, the problem statement in this research is how to predict stock price movements in Indonesia based on sentiment analysis, technical analysis, and fundamental analysis through a machine learning approach.

The first objective of this study is to predict stock price movements in Indonesia based on sentiment analysis, technical analysis and fundamental analysis using machine learning approach. The second is to measure the impact of sentiment analysis, technical analysis, and fundamental analysis on the stock price movement's prediction result. There are several contributions in this research, namely, distinct from previous research that used comments and opinions from social media to measure sentiment analysis. This study uses news related to economy, business and politics circulating in Indonesia as a data source. In addition, the amount of news data used in this study is also more extensive than the research conducted by Rizkiana et al. (2019) and viewed from wider scopes, which are both microeconomic and macroeconomic scopes, so that it is expected to be able to represent the overall investor sentiment towards news circulating in Indonesia. The next contribution is that this research tries to consider using fundamental analysis which consists of Dollar-Rupiah exchange rate and foreign stock prices index movement as a predictor in the prediction model. Finally, as far as we know, this is the first study to predict stock price movements in Indonesia using a machine learning approach based on sentiment analysis, technical analysis and fundamental analysis. This paper itself will describe a conceptual model showing several factors that are expected to influence stock price movements in Indonesia. This model is built based on former empirical research and literature review.

2. Literature Review

Through the theory known as Efficient Market Hypothesis (EMH), Fama (1991) stated that the price of a stock reflects all circulated information, so it was impossible for an investor to gather and process all the information available to predict stock prices movements. However, due to the development of information technology, this theory is no longer relevant because using the internet and social media, investors can quickly obtain information and make decisions based on that information in a short time (Daniel et al. 2002, Guo et al. 2017). Thus, researches have been developed to prove that investor sentiment affects stock price movements. Teti et al. (2019) tried to identify the relationship between investor sentiment obtained via Twitter and stock price movements of technology companies in the United States. From this research, it is found that investor sentiment has the ability to predict stock price movements. However, according to Teti et al. (2019) this predictive ability only applies to large companies that are often highlighted or become discussion topics. This finding is in line with Guo et al. (2017) research who also found that the predictive ability of sentiment towards stock price movements only applies to stocks that receive close attention from investors. Li (2020) found that stock prices will increase when investor sentiment is positive and will decrease when investor sentiment is negative. However, if the sentiment is too positive (overoptimistic), the stock price will go down and vice versa. This phenomenon is called reversal effect.

Then Nisar and Yeung (2018) found a relationship between public sentiment on stock price movements in a short period of time. Nisar and Yeung (2018) also found causation between investor sentiment and the closing price of stocks. Furthermore Rizkiana et al. (2018) tried to examine the effect of investor sentiment on stock price movements in Indonesia. Based on this research, it was found that what happened was the opposite: stock price movements are affected by investor sentiment. This is because the data source used in this study come from a forum that is more likely to discuss events that have occurred as a form of response and not act as response trigger that form sentiment like news. Rizkiana et al. (2019) conducted another research to examine the effect of investor sentiment on stock price movements in Indonesia by using a sentiment index that combines sentiment from forum, search volume for a stock on Google, and news sentiment. Although the research conducted by Rizkiana et al. (2019) uses news sentiment, the amount of news involved was tiny and only used the news related to the object under study (microeconomic scope), so it cannot represent the overall investor sentiment towards the circulated news in Indonesia. Rizkiana et al. (2019) also added that selecting data sources that will be used to measure sentiment must be done carefully because not every data available on the internet can be used to represent investor sentiment.

In this study, in order to represent the overall investor sentiment regarding news related to stocks in Indonesia, researchers will use news data that occupied both microeconomic and macroeconomic scopes with larger amount of data to measure investor sentiment as one of the variables to predict price movements. The news selected is only news related to economy, business, and politics obtained from online news media such as CNBC Indonesia and Kontan. The use of a large amount of news data that occupied microeconomic and macroeconomic scopes in this study is expected to represent the overall investor sentiment regarding news circulating in Indonesia. According to Demirer and Kutan (2006), based on the method used, stock price movement prediction can be classified into two types, namely traditional statistical methods and computational intelligence method. Methods based on computational intelligence can identify nonlinear data patterns to provide better prediction results than traditional statistical methods. Several researchers have tried to predict stock price movements using computational intelligence methods such as machine learning. Nelson et al. (2017) and Henrique et al. (2018) tried to predict stock prices based on technical analysis and found that machine learning can provide better prediction results than random predictions. Furthermore, Sert et al. (2020) and Li et al. (2014) tried to predict stock prices using sentiment analysis, and the results showed that the accuracy rate obtained in this study are $\pm 40\%$ and $\pm 60\%$ respectively. Research conducted by Siering (2012) not only used sentiment, but also investor attention as measured by search volume on Google and obtain an accuracy rate of 56-58%. Maqsood et al. (2020) tried to combine sentiment analysis with technical analysis measured by historical prices. The results showed that combining sentiment analysis with technical analysis in a prediction model can provide much better results than using only one of them. The result obtained by Maqsood et al. (2020) is also supported by other studies such as Derakhshan and Beigy (2019), Nguyen et al. (2015), Picasso et al. (2019), Li et al. (2020), Nam and Seong (2019), and Li et al. (2020) which are able to obtain an accuracy rate of $\pm 60\%$ by combining sentiment analysis with technical analysis, where according to Schumaker and Chen (2009), Tsibouris and Zeidenberg (1995), and Si et al. (2013) if the accuracy rate is $>56\%$ then the prediction results can be said to be satisfactory.

Even so, the results obtained on these studies were inconclusive and tend to vary depending on the object and the variables used. This is due to conditions and investors behaviour differences in each capital market (Corredor et al. 2015). In addition, there are many factors that can affect stock price movements, and it is presumed that these studies have not been able to represent all the existing factors. This can be seen from the research previously described, which only considers the use of sentiment analysis and/or technical analysis. None of these studies had considered the use of fundamental analysis in predicting stock price movements. Therefore, to fill the gaps in previous research, this study will consider the use of fundamental analysis combined with news sentiment analysis and technical analysis to predict stock price movements in Indonesia using a machine learning approach. The fundamental analysis itself in this study is measured based on the movement of Dollar-Rupiah exchange rate and stock price index movements in other countries which according to Wong (2017), Delgado et al. (2018), and Lee and Chou (2020) can affect stock price movements. To answer whether the effect of currency exchange rates on stock price movements also applies in Indonesia, Dong and Yoon (2019) suggest a relationship between currency exchange rates and stock price movements in emerging markets such as Indonesia. In addition, Mensi et al. (2014) and Lee and Chou (2020) in their research also stated that stock price index movements in other countries, especially in the United States, can affect stock price movements in other countries, including Indonesia.

Besides fundamental analysis, this research will also use sentiment analysis and technical analysis as independent variables in the prediction model as in previous studies. Sentiment analysis has been shown to increase prediction accuracy, as in the research of Nguyen et al. (2015) which shows that the use of sentiment analysis in prediction can increase the accuracy rate by 2.07% compared to using technical analysis only. However, there is still no research that shows that sentiment analysis, especially news sentiment, can be used to predict stock price movements in Indonesia. Even so, Anusakumar et al. (2017) showed that there is a strong correlation between investor sentiment and stock price movements in emerging markets. Other studies that conducted by Maqsood et al. (2020), Steyn et al. (2020) and Bayram (2017) also showed that sentiment analysis has the ability to predict stock price movements in emerging markets. Salisu and Vo (2020) who used the Indonesian capital market as one of its research subjects also prove that sentiment analysis, especially sentiment related to health news during the COVID-19 pandemic, can be used to predict stock price movements. Supporting this research, Debata et al. (2018) also concluded that sentiment analysis could be used as a predictor of stock price movements in emerging markets, including Indonesia. The emerging-market itself can be defined as a rapidly growing capital market but has not met the criteria as a developed capital market. This classification is based on certain characteristics and criteria owned by a capital market, so that the characteristics between one market to another market with the same category will not be much different (Mody 2004). According to Garten (1997), Cavusgil et al. (2002), OECD (2009), and Casadella (2018), Indonesia's capital market can be classified as an emerging market because the capital market in Indonesia is growing rapidly and still has the potential to grow further in the future. The findings in these studies can be used as an indirect reference which shows that sentiment analysis has the ability to predict stock price movements, including stocks in Indonesia.

Then, this study will also use technical analysis as a predictor in the prediction model. Technical analysis is a traditional analysis technique that investors often use to predict stock price movements because of its ability to identify trends formed from past data. Technical analysis can be measured based on historical prices and technical indicators such as averages, so it is very suitable to predict stock price movements in the short term (Pring 2002). There have been many studies that use technical analysis to predict stock price movements such as Nelson et al. (2017), Dai et al. (2021), Cervelló-Royo et al. (2015), and Neely et al. (2014). In addition to research, many books discuss the application of technical analysis techniques to predict stock price movements such as Pring (2002), Schwager (1999), and Murphy (1999). In their research, Henrique et al. (2018) also suggested that prediction models using technical analysis can be used both in emerging markets and developed markets. So, it can be concluded that technical analysis measured based on historical prices and technical indicators can be used as predictors to predict stock price movements. Therefore, the use of sentiment analysis, technical analysis, and fundamental analysis as predictors in this study is expected to increase the level of accuracy in predicting stock price movements in Indonesia.

3. Conceptual Model Development

3.1. Method

The data would be processed using Support Vector Machine (SVM) method. SVM is a method in machine learning that classify the data based on a particular algorithmic pattern to detect what patterns can cause stock prices to rise or

fall (Derakhshan and Beigy 2019). In this study, the SVM method was chosen because according to Joachims (1998) and Nguyen and Shirai (2013) the SVM method can be used for high-dimensional data and shows good results in classifying data and building predictive models. This is because the SVM method is not affected by data outliers and it is not prone to overfitting. Specifically, the SVM method used in this study is the Kernel SVM. The difference between these two types of methods is that in the regular SVM/linear SVM method, the data is assumed to have a linear distribution pattern and is used to process data that is linearly distributed. In contrast, in the Kernel SVM method the data is assumed to be not linearly distributed. Hence, it is more appropriate to process data with non-linear distribution patterns such as stock price data (Eremenko and Poventes 2018). In this study, because the data used are sentiment and stock prices that are not linearly distributed, the Kernel SVM method will be used in order to obtain better results with a higher level of accuracy. As for the SVM algorithm mathematically can be described as equations (1) and (2),

$$x_2 = x_1 + \lambda w' \quad (1)$$

$$wx_1 + b + \lambda ww' = 1 \quad (2)$$

with limit in the form of equation (3).

$$\lambda = \frac{2}{ww'} = \frac{2}{\|w'\|^2} \quad (3)$$

For every training data x_1 in a pair of class-feature forms:

$$S = \{(y_i, x_i) | y_i \in (1, -1), x_i \in R^n, \forall i = 1, \dots, l\} \quad (4)$$

will be done,

$$\min_{w', b} \frac{1}{2} \|w'\|^2 \quad (5)$$

with limit,

$$y_i(w' + b) \geq 1, \forall x_i \quad (6)$$

In general, factors that can influence stock price movements can be viewed from three aspects: sentiment analysis, technical analysis, and fundamental analysis (Derakhshan and Beigy 2019, Sert et al. 2020). Based on these three aspects, the influence can be further broken down according to the sub-categories of variables that represent each of these aspects. The following will describe the development of a conceptual model according to the variables in each of its aspects based on previous research.

1. Sentiment Analysis

Sentiment analysis can be categorized again based on the data source and the scope of information used. Based on the data source, sentiment analysis is divided into two types: news sentiment and social media/forum sentiment (Derakhshan and Beigy 2019). Meanwhile, based on the scope of information sentiment analysis can be distinguished into microeconomic scope, which only uses information related to the company or object under study, and the macroeconomic scope, which uses aggregate information related to global conditions. Research conducted by Derakhshan and Beigy (2019), Nguyen et al. (2015), and Li et al. (2020) use social media sentiment data in microeconomic scope, while Maqsood et al. (2020) used social media sentiment data in macroeconomic scope to conduct sentiment analysis. Siering (2012) and Picasso et al. (2019) use the sentiment that comes from news under the microeconomic scope in their research. Other studies such as Sert et al. (2020) uses data from both news and social media under the macroeconomic scope. However, in order to build conceptual model, this research will refer to Li et al. (2014), Nam and Seong (2019), and Li et al. (2020) who use news with microeconomic and macroeconomic scope in conducting sentiment analysis. This is done so that this research can focus on the ability of news sentiment circulating in Indonesia in predicting stock price movements.

2. Technical Analysis

Technical analysis is generally divided into two types, namely historical prices and technical indicators. Historical price consists of the opening price, closing price, high and low prices, and the trading volume of a stock in the past. While technical indicators are calculations made using historical prices such as averages, MFI (Money Flow Index), or RSI (Relative Strength Index). Research related to stock price prediction generally always uses technical analysis as one of its predictors because of its proven ability and can be applied in various capital market conditions. However, related to the use of technical analysis, this study refers to Nelson et al. (2017), Picasso et al. (2019), Li et al. (2020), and Afrianto et al. (2013) because these studies use both historical prices and technical indicators as a variable to measure technical analysis.

3. Fundamental Analysis

The use of fundamental analysis to predict stock price movements can be exercised qualitatively or quantitatively. In this study, fundamental analysis will be measured quantitatively by using the Dollar-Rupiah exchange rate variable and foreign stock price index movements. The use of this variable is based on the research conducted by Wong (2017), Delgado et al. (2018), and Dong and Yoon (2019) which state that currency exchange rates are one of the factors that can affect stock price movements, as well as the research conducted by Lee and Chou (2020)

and Mensi et al. (2014) which state that the stock price index movements in other countries, especially in the United States, can affect the movement of stock prices in other countries. However, these studies are limited to testing their effect without making predictions. Based on these findings, this study will try to involve the use of currency exchange rate variables and foreign stock price index movements to measure fundamental analysis and determine its impact on the prediction result.

The conceptual model in this study can be illustrated in Figure 1.

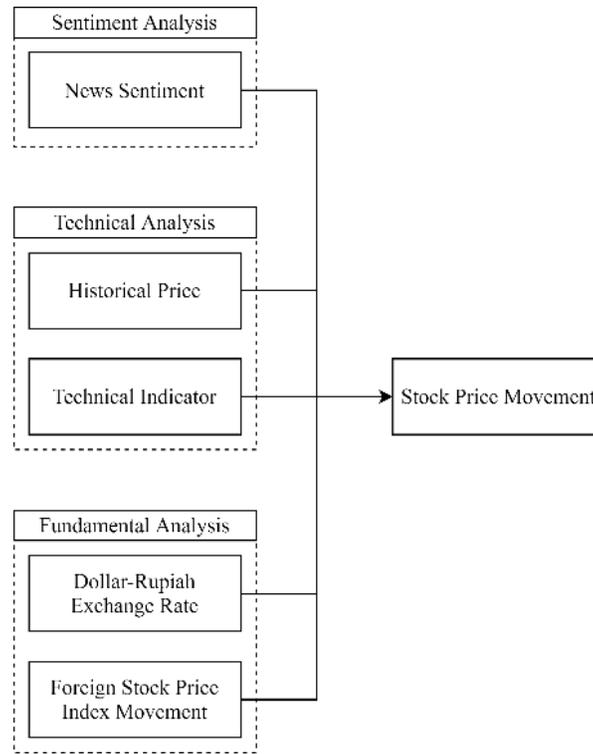


Figure 1. Research Conceptual Model

For comparison, Figure 2 illustrated acquired accuracy from each previous research described in the development of conceptual model.

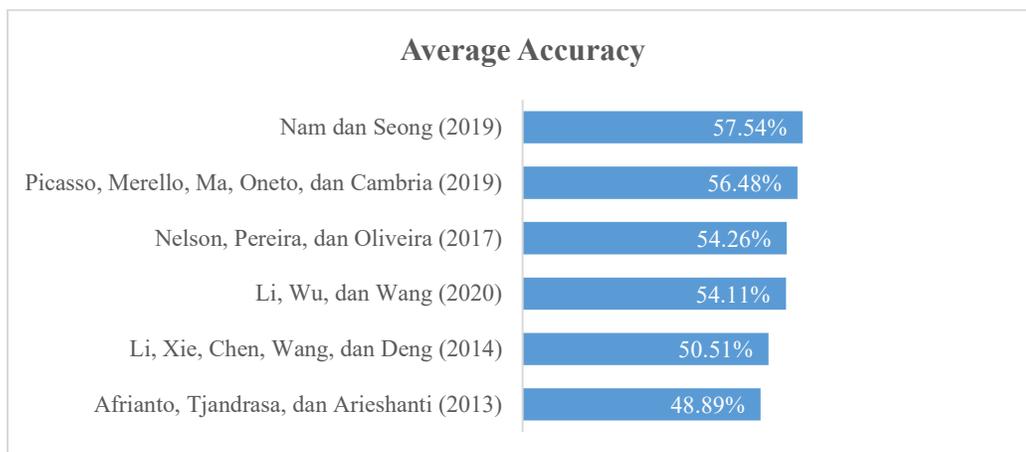


Figure 2. Accuracy Comparison from Previous Research

3.2. Data Collection

The data collected in this study consisted of news related to economy, business, and politics, historical stock prices, currency exchange rates, foreign stock price index movement, and stock price movements data of companies with the largest market capitalization in each industrial sector listed on the Indonesia Stock Exchange which is PT. Astra Agro Lestari Tbk with stock ticker AALI from the Agriculture sector, PT Chandra Asri Petrochemical Tbk with stock ticker TPIA from the Basic Industry and Chemicals sector, PT. Unilever Indonesia Tbk with stock ticker UNVR from the Consumer Goods Industry sector, PT. Bank Central Asia Tbk with stock ticker BBCA from the Finance sector, PT. Telekomunikasi Indonesia (Persero) Tbk with stock ticker TLKM from the Infrastructure, Utilities, and Transportation sector, PT. Adaro Energy Tbk with stock ticker ADRO from the Mining sector, PT. Astra International Tbk with stock ticker ASII from the Miscellaneous Industry sector, PT. Pakuwon Jati Tbk with stock ticker PWON from the Property, Real Estate, and Building Construction sector, PT. United Tractors Tbk with stock ticker UNTR from the Trade, Service, and Investment sector. The variables used then divided into two categories, namely dependent variables and independent variables. Furthermore, data processing is carried out to predict stock price movements in Indonesia based on sentiment analysis, technical analysis, and fundamental analysis with machine learning approach using Python programming language.

- **Dependent Variable**

The dependent variable is a variable that becomes the main concern in research (Situmorang 2010). This study's dependent variable is nine companies' stock price movements with the largest market capitalization in each sector listed on the Indonesia Stock Exchange. This price movement is defined as 1 if the stock price goes up, and 0 if the stock price goes down. The company's stock movement data is collected from the Yahoo Finance website.

- **Independent Variable**

Independent variable is a variable that can effect changes in the dependent variable (Situmorang 2010). The first independent variable used in this study is related to sentiment analysis, which is news data taken from the online news media's Twitter account such as CNBC Indonesia and Kontan. This news will later be processed to get the sentiment on the news, whether the news contains positive information that can raise stock prices or negative news that can lower stock prices. The second data is the historical price of stocks which consists of the opening price, closing price and transaction volume related to technical analysis. The third and fourth variables cover aspects of fundamental analysis consisting the Dollar-Rupiah exchange rate and stock price index movements in other countries comprised of DJI Index (Dow Jones Industrial Average, USA), IXIC (NASDAQ, USA), GSPC (S&P 500 Index, USA), FTSE (FTSE 100 Index, UK), N225 (Nikkei 225 Index, Japan), HSI (Hang Seng Index, Hong Kong), and SSEC (Shanghai Composite Index, Shanghai). The foreign stock price index movement is defined as 1 if the index price goes up, and 0 if the index price goes down. Data regarding historical prices, currency exchange rates, and foreign stock price index movements are obtained from Yahoo Finance website.

4. Conclusion

Various factors could affect the price movement in the stock market. Previous studies have developed a model to predict stock price movement by using a combination of technical and fundamental analysis. Recently, some model included sentiment analysis in the prediction model. The accuracy rate of the prediction varies from each model. A research gap has not considered the use of fundamental analysis in terms of currency exchange rates and stock prices index movements in other countries. Therefore, this paper aims to contribute to the stock prediction knowledge area by combining sentiment analysis, technical analysis, and fundamental analysis using a machine learning approach to predict Indonesia's stock price movements. The conceptual model proposed the combination of sentiment analysis from the news sentiment, historical price and technical indicator to perform technical analysis, and fundamental analysis from Dollar-Rupiah exchange rate and foreign stock price index movement to predict the stock price movement. The model that has been validated through literature review will be used as a framework to test the model quantitatively using machine learning approach. For further research, this paper proposed the data collection which consists of news related to economy, business, and politics, historical stock prices, currency exchange rates, foreign stock price index movement, and stock price movements data of nine companies with the largest market capitalization in each industrial sector listed on the Indonesia Stock Exchange.

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