Sainteknol Vol 20, No 1 (2022): Juli 2022

https://journal.unnes.ac.id/nju/index.php/sainteknol

Decision Support System for Stock Trading: Systematic Literature Review using PRISMA

Soetam Rizky Wicaksono, Rudy Setiawan, and Purnomo Purnomo

Universitas Ma Chung, Malang, East Jawa,
Indonesia

Abstract

So many traders rely on algorithm-based utilities with indicators taken from historical data and running trade data on the exchange. However, applied research on decision support systems (DSS) for short-term stock trading interests is generally carried out by methods that are difficult to implement. Therefore, for researchers to understand more deeply trends in this scope, it is necessary to conduct a literature review so that the following research is no longer in vain and gets a novelty. Based on the initial analysis, the following research questions were obtained: (1) what trends the main concerns of researchers in the scope of DSS for stock trading are, and (2) what are the research's gaps in the context. A Systematic Literature Review (SLR) was carried out to answer this question, and the PRISMA method was used. The initial selection resulted in a total of 136 articles since 2017. The final result of this stage makes a total of 36. The answer to the first question is Machine Learning and Neural Networks. As for the answer to the second, there are many algorithms and methods that have not been applied within the scope.

Keywords: Decision Support System, Stock Trading, Systematic Literature Review, PRISMA

INTRODUCTION

Research on stock trading is very interesting to do, especially during the pandemic and also post-pandemic. During the pandemic that caused the majority of people in the world to do work from home, trading stocks became an interesting alternative to running [1]. In the end, the rapid increase of traders occurred on various stock exchanges in the world at that time. This includes Indonesia, which during the pandemic, experienced a four-fold increase in the number of investors on the stock exchange and has broken the number of more than 7.5 million investors on the stock exchange [2]. This has caused many novice traders to look for shortcuts in understanding stock trading in general, either by searching for news or by using bots or utilities that use decision support systems in it.

The implementation of a decision support system in stock selection generally aims to assist novice traders in carrying out the process of buying and selling shares. This is because more than 80% of investors behave as traders due to a lack of education in it [3]. So many of them rely on certain algorithm-based

utilities with indicators taken from historical data and running trade data on the exchange. The algorithm used generally uses parameters derived from technical analysis or from historical data, which are then applied to supporting variables.

Although short-term trading behavior has quite challenging risks [4], many beginners actually jump into it, as quite tempting rewards await as a return from this process. So that there are more enthusiasts of this behavior which ultimately leads researchers to also conduct applied research that ultimately supports the implementation of short-term stock trading. The applied research ultimately tries to prevent beginners from becoming gamblers in the process of trading stocks [5], [6] because, without good technical analysis, short-term stock trading can plunge beginners into gamblers who are ready to lose at any time.

However, applied research on decision support systems for short-term stock trading interests is generally carried out by methods that are difficult to implement in general because each country has unique exchange conditions in it [7]. So it is believed that applied research that discusses decision support systems within the scope of short-term stock trading becomes sporadic and spontaneous for each country's conditions, as has been done in European countries [7], Iran [8], Taiwan [9], Turkey [10] and Indonesia [11]. Therefore, in order for researchers to understand more deeply trends in this scope, it is necessary to conduct a literature review so that the next research is no longer in vain and gets a novelty as a result. In addition, it can be studied in the end the gaps of research within that scope so that the next research can apply even better and proper algorithms.

Based on the initial analysis, the following research questions were obtained: (1) what trends are the main concerns of researchers in the scope of decision support systems for stock trading, and (2) what are the gaps in research in the context. To answer this question, a Systematic Literature Review (SLR) was carried out, which tried to collect data from various research sources, especially journal articles that have been proven to undergo a peer review process well so that their validity and eligibility can be accounted for. In implementing the SLR, the PRISMA method is used, which has been proven to be a solution in research using SLR [12]. PRISMA, which was originally used in the health sector [12], can also be used in the field of software engineering [13]. So it can be said to have the right fit for this research.

METHODS

PRISMA, which stands for The Preferred Reporting Items for Systematic reviews and Meta-Analyses, is a method for conducting systematic literature reviews by prioritizing clearly formulated research questions [14]. So that credible results and high confidence are obtained from the answers produced based on the review. PRISMA conducts at least 27 identifiable checklists in order to filter from the articles that will be selected and further analyzed.

In this study, filtering was carried out from three index databases, which are Scopus, Google Scholar, and Semantic Scholar, for the selection of journals with the keyword "*decision support system stock trading*." Furthermore, selective filtering is carried out by prioritizing articles that already have at least ten citations so that the impact factor can be accounted for. Then further filtering is carried out by ignoring search results in the form of *book chapters* and types of articles from fellow *literature reviews* in order to get articles that actually contain applied research according to the research questions at the beginning.

Next, check each article that has been filtered to whether it is accessible for full-text format and has a valid link to be reviewed and analyzed. Furthermore, grouping is carried out based on the algorithm or method used so that heterogeneity and homogeneity can be obtained from the selected articles. The results of each check of this article form the basis of the analysis in the next discussion. Briefly, the results of fulfilling the PRISMA checklist can be seen in table 1, which is an adapted version of PRISMA framework.

Table 1. Method checklist for PRISMA

Method for PRISMA	
Eligibility criteria	From 2017 to 2022 with citations of more than 10 and from journal article
Information sources	S = Scopus GS = Google Scholar SS = Semantic Scholar
Search strategy	From a single keyword: "decision support system stock trading."
Selection process	After filtering using eligible criteria, then filtering out by title. Then it omits any literature review articles and also omits any theoretical review.
Data collection process	Using Publish and Perish v 8, and repeat at least three times to ensure search results. Then export the result to Excel for further filtering process, and split them for each information source.
Data items	There is no specific filter for data items except for a real case study and direct implementation of any DSS algorithm. All selected items were downloaded in full-text PDF format for further review and inserted into Mendeley for an easier process.
Synthesis methods	- Grouping the result from each database and observing each article from its abstract - If abstract shows literature review or theoretical comparison, then omit it - Grouping is carried out based on the greatest similarities - The results of the subsequent grouping are further analyzed and then unified between databases - The results of the grouping reviewed were based on an abstract and full-text paper in order to get a level of heterogeneity and homogeneity to answer research questions and describe any methods used to tabulate or visually display the results of individual studies and syntheses.

Source: Data Processed, 2022

RESULT AND DISCUSSION

Initial Selection

The initial selection was made using *the Publish and Perish* application version 8 with keywords as described in the previous section. The results of the first search for the Scopus (S) database resulted in a total of 136 articles since 2017, for the Google Scholar (GS) and Semantic Scholar (SS) databases each limited to 500 articles since the same year limit. The results are then filtered, assuming citations greater than 10 to ensure the impact factor of each article is properly guaranteed. After that, the process of searching for the same articles from the three databases was carried out to ensure the uniqueness of the subsequent analysis study.

Next, preliminary filtering is carried out based on titles and abstracts to determine whether the content of the article does not fall into the category of literature review or comparison theory, as well as determine whether the article really contains the application of algorithms into stock trading. The next filtering was done by eliminating articles related to Twitter sentiment analysis in stock trading. This is done because Twitter sentiment is dominated by text and news analysis compared to the use of technical analysis parameters, which are the main reference for research questions in this study. The results of this second filtering obtained more than 80% of the number of articles reduced from the initial number.

Furthermore, filtering was carried out for redundant data from the three different index databases, and it turned out that only five articles were found to be redundant. Then the final stage of filtering is carried out, namely the suitability between the journal content and the context of the research questions. So it was found that there were 4 articles that did not display the application of case studies, the other 20 articles contained comparisons of the algorithms applied, and 10 articles that came from journals that were

doubtful of their existence (too short format, archives that did not come from the original site or journals that had many articles in one issue). The final result of this stage makes a total of 36 articles which are then merged into one list, which becomes the basic list in the next stage. An overview of this initial selection can be seen in figure 1 as PRISMA flow, which is the framework of the systematic literature review using PRISMA.

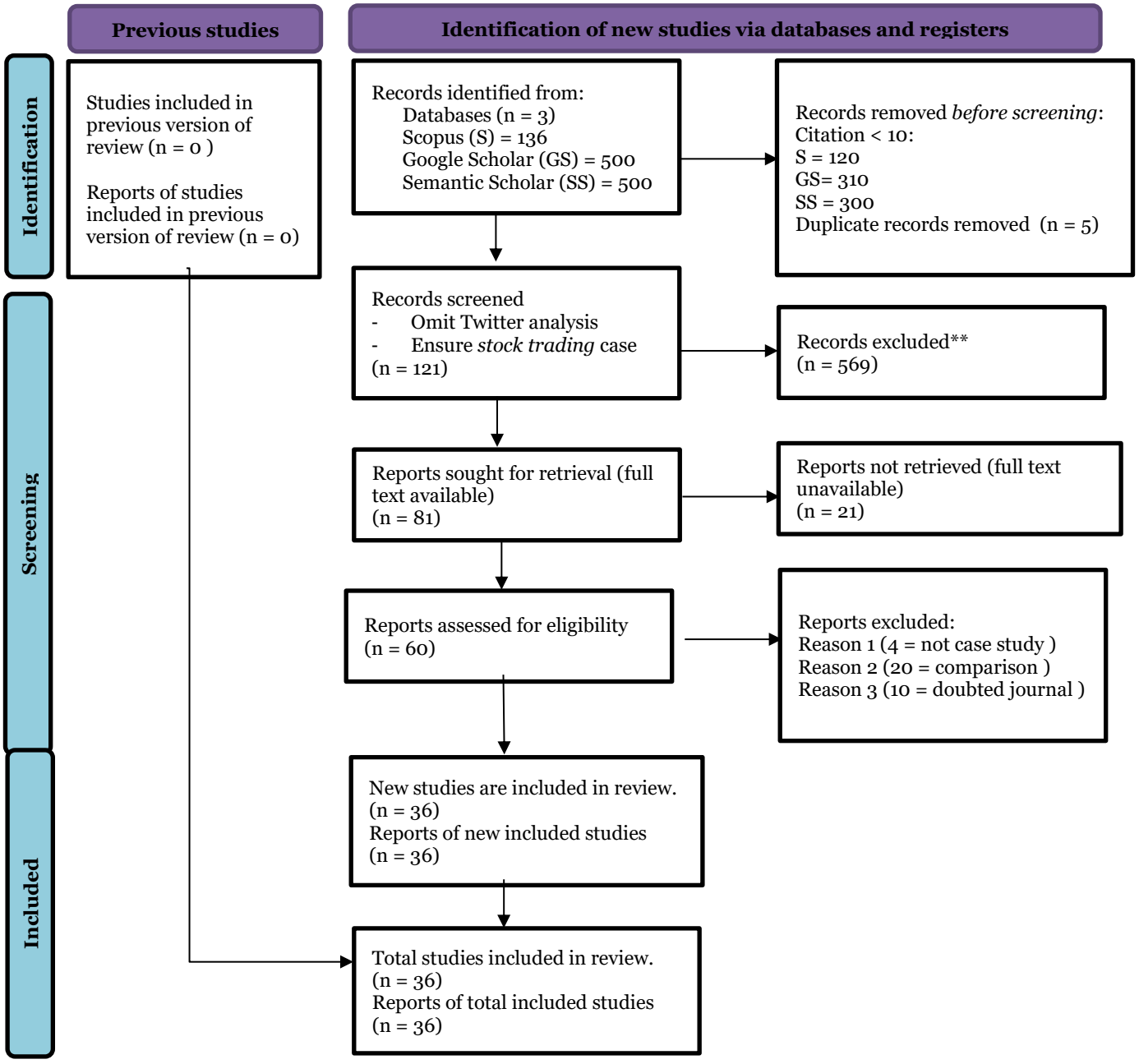

Figure 1. PRISMA flow framework

Analytical Process

Based on the initial filtering results, further grouping of selected articles based on existing content categories is carried out. Most categories were obtained in themes grouped into *Neural Network and Deep Learning*, specifically 19 articles, as shown in table 2. The majority of this group discusses *Deep Learning* combined with LSTM (Long Short-Term Memory Neural Network) to get predictions of stocks traded. Nevertheless, not all articles carry out the *backtesting* process of the results of the calculations of the applied algorithm. There are only a few that display the backtest results in full in order to prove whether the algorithm is indeed applicable. Some of the articles that showed the backtest results included Wang [15], who unfortunately did not explicitly mention the market exchanges that were tested, then from Kusuma's article [16], which conducted testing on the Taiwanese exchange, as well as an article from Long [17] who conducted testing on the Chinese exchange.

This is very unfortunate because backtests in the decision support system for stock trading are needed so that readers of articles from researchers can understand for further research whether it needs to be developed again or they have to find alternatives to other algorithms. So, in the end, the articles in this group seem to be just applying algorithms to stock trading cases by entering parameters from technical analysis and performing calculations and displaying charts to convince readers that the algorithm was successfully applied. In fact, research for stock trading should be anticipated by ordinary readers, both brokers and retail traders, who want a scientific way of trading stocks. But in the end, the published article does not provide a pragmatic conclusion and can be easily applied either in software applications or simply incorporated into the public utilities' available securities.

Even the parameters of the candlestick chart, which is the reference of the majority of traders [18], are rarely applied in this group. There are only a few articles that include candlestick charts in his research in this group, namely from Kim [19], which involves a long short-term memory-convolutional neural network (LSTM-CNN) model, as well as an article from Naranjo [20] that uses a fuzzy model, and an article from Kusuma who has even applied the results of his research to an interactive website for free [16]. This is also an important note for researchers because it is common knowledge that traders both on the stock exchange, forex, and crypto always use candlestick charts as the main reference in decision making.

Meanwhile, the majority of other articles focus more on the application of Neural Networks than the results of the application of the algorithm itself to the profitability of stock trading [19], [21]–[23]. So it seems that the research carried out is only the fulfillment of obligations for the application of algorithms, even though in stock trading, traders need empirical results that can be obtained from the backtest process so that they can be analyzed further during the trading process. The majority of articles also deal with the pretext that market conditions are always dynamic so that it is difficult to predict, although, in the article, they also do not explicitly mention which market is meant.

Table 2. Category Summary

Grouping Result	Count of Title
Machine learning	17
Neural Network & Deep Learning	19
Grand Total	**36**

Source: Data Processed, 2022

The next group is articles that discuss the application of *Machine Learning* as a basis for the application of algorithms in their research. Some of them apply SVM (Support Vector Machine) to be applied in the stock trading forecasting process. Some of the articles that fall into this category include Yingjun [24], which combines SVM and K-nearest, and two articles from Weyori that combine genetic algorithms [25], [26], as well as an article from Sedighi that combines three algorithms at once, namely Artificial Bee Colony (ABC), Adaptive Neuro-Fuzzy Inference System (ANFIS), and Support Vector Machine (SVM)[27]. Other articles besides discussing SVM also implement clustering algorithms such as K-Nearest [24], entropy [28] discussed by Karaca, as well as the application of tree-based classifiers by Khaidem [29].

As was the case in the previous group, there are not many articles that display backtest results from his research. In fact, more are only guided by datasets as training data but not used as material for backtesting. Similarly, the application of candlestick charts is very minimal in the application of its algorithm, both as a parameter and as a modeling reference. This suggests that not many researchers actually jumped in first to become real traders on the stock exchange, so they did not understand what the real needs of traders would expect from scientific research on stock trading.

Table 3. Pivot Table from Filtered List

Grouping Result
Machine learning
A comprehensive evaluation of ensemble learning for stock-market prediction
A feature weighted support vector machine and K-nearest neighbor algorithm for stock market indices prediction
A fuzzy decision system for money investment in stock markets based on fuzzy candlesticks pattern recognition
A Novel Hybrid Model for Stock Price Forecasting Based on Metaheuristics and Support Vector Machine
Characterizing Complexity and Self-Similarity Based on Fractal and Entropy Analyses for Stock Market Forecast Modelling
Efficient Stock-Market Prediction Using Ensemble Support Vector Machine
Forecasting daily stock market return using dimensionality reduction
Forecasting stock market crisis events using deep and statistical machine learning techniques
Fundamental analysis and technical analysis integrated system for stock filtration
Predicting short-term stock prices using ensemble methods and online data sources
Predicting Stock Market Trends Using Machine Learning and Deep Learning Algorithms Via Continuous and Binary Data; A Comparative Analysis
Predicting the direction of stock market prices using tree-based classifiers
Stock market one-day ahead movement prediction using disparate data sources
Stock market prediction using machine learning classifiers and social media, news
Stock price forecast based on combined model of ARI-MA-LS-SVM
Stock price movement prediction from financial news with deep learning and knowledge graph embedding
Stock price prediction using data analytics
Neural Network & Deep Learning
A novel graph convolutional feature based convolutional neural network for stock trend prediction
An innovative neural network approach for stock market prediction
An integrated framework of deep learning and knowledge graph for prediction of stock price trend: An application in Chinese stock exchange market
Application of Deep Reinforcement Learning on Automated Stock Trading
CNNpred: CNN-based stock market prediction using a diverse set of variables
Decision support from financial disclosures with deep neural networks and transfer learning
Deep learning networks for stock market analysis and prediction: Methodology, data representations, and case studies
Deep learning-based feature engineering for stock price movement prediction
Deep neural network and time series approach for finance systems: Predicting the movement of the Indian stock market
Financial time-series data analysis using deep convolutional neural networks
Forecasting daily stock trend using multi-filter feature selection and deep learning
Forecasting stock prices with a feature fusion LSTM-CNN model using different representations of the same data
Incorporating Markov decision process on genetic algorithms to formulate trading strategies for stock markets
ModAugNet: A new forecasting framework for stock market index value with an overfitting prevention LSTM module and a prediction LSTM module
Optimizing LSTM for time series prediction in Indian stock market
Quantitative Trading on Stock Market Based on Deep Reinforcement Learning
Stock trading decisions using ensemble-based forecasting models: a study of the Indian stock market
Using Deep Learning Neural Networks and Candlestick Chart Representation to Predict Stock Market
Using mixture design and neural networks to build stock selection decision support systems

Answering Research Questions

The initial results of this Systematic Literature Reviews stipulate that with the help of the PRISMA method, filtering of groups of articles can be obtained strictly. So that a list of articles that are really eligible for further review can be obtained. The results of the three database indexes, which are Scopus, Google Scholar, and Semantic Scholar have been carefully studied and sorted both in terms of redundancy, the number of citations, and the update of the article year. So it can be believed that the list of articles is really assumed to be the most appropriate to the research question.

Based on the review of existing articles, research questions that have been described in the introduction can be answered. The answer to the first question regarding the research trend of decision support systems in stock trading is in the two categories mentioned in table 3, which are: Machine Learning and Neural Networks. This makes the two categories all articles have a fairly large number of citations, such as articles from Kraus [30], which reached 137 citations, or two articles from Weng [31], [32] which, if the

two combined received 178 citations in July 2022. This indicates that research trends are indeed in these two categories.

As for the answer to the second question, namely the research gap that occurs, namely with the two major trends that have been described earlier, there are still many algorithms and methods that have not been applied in relation to decision support systems within the scope of stock trading. For example, in the MCDM (Multi-Criteria Decision Making) category, although there are already articles that discuss using methods from that category, they are not included in the SLR list due to the lack of citations. Similarly, the application of candlestick charts is very minimal, so there are still many things to be explored further. In addition, the lack of backtest testing is also a gap between the research results and the conditions in the real market. Even the parameters that are commonly used by traders on the exchange from the technical analysis are also still minimally appearing as the main variables.

CONCLUSION

The results of the article review using SLR assisted by the PRISMA method succeeded in filtering according to the keywords needed and were able to answer research questions effectively. This means that PRISMA can be used as a reference for research implementation using Systematic Literature Review. However, a wider database index coverage is still needed for subsequent research so that the analysis can be more accurate and have more options. Meanwhile, from the research questions at the beginning, both have been answered, namely, the trend of decision support system research in the scope of stock trading has been answered. The trend, with the filtering and selection that has been carried out, is more inclined to the application of Neural Networks as well as the application of Machine Learning for predictions in the scope of stock trading. But in its application, there is still very little backtest testing, so there is a gap between the research results and real conditions. As for the second research question, the gap in the research that has been filtered is the lack of research involving methods other than those in the trend, such as MCDM, or the involvement of parameters that are very commonly used by traders, such as candlestick charts. This is still an opportunity for researchers to be used as articles in future studies. So that the gap between the research results and the actual market conditions can be covered, in addition, if the gap is successfully closed, then the results of the study are expected to not only be output on paper but can be utilized empirically in the world of stock trading.

References

[1] D. Cahill, C. C. Ho, and J. (Wenling) Yang, “Mobility during the COVID-19 Pandemic and Retail Investor Attention,” *SSRN Electron. J.*, 2021, DOI: 10.2139/ssrn.3779295.
[2] S. Sidik, “Meledak! Investor Pasar Modal RI Nyaris 7,5 Juta,” *CNBC Indonesia*, 2021. https://www.cnbcindonesia.com/market/20211231071338-17-303447/meledak-investor-pasar-modal-ri-nyaris-75-juta.
[3] OJK, “INVESTASI SAHAM JUGA HARUS PUNYA STRATEGI DONG! YUK, BAGI INVESTOR PEMULA SIMAK ARTIKEL BERIKUT INI!,” *OJK*, 2021. https://sikapiuangmu.ojk.go.id/FrontEnd/CMS/Article/10433.
[4] J. Blocher, P. Haslag, and C. Zhang, “Short trading and short investing,” *J. Empir. Financ.*, vol. 59, no. October, pp. 154–171, 2020, doi: 10.1016/j.jempfin.2020.09.007.
[5] P. Schultz, “What Makes Short Selling Risky: Other Short Sellers,” *SSRN Electron. J.*, pp. 1–48, 2020, DOI: 10.2139/ssrn.3715524.
[6] A. Kumar, “Who gambles in the stock market?,” *J. Finance*, vol. 64, no. 4, pp. 1889–1933, 2009, doi: 10.1111/j.1540-6261.2009.01483.x.
[7] S. J. Camilleri and F. Galea, “The determinants of securities trading activity: evidence from four European equity markets,” *J. Cap. Mark. Stud.*, vol. 3, no. 1, pp. 47–67, 2019, DOI: 10.1108/jcms-02-

2019-0007.
[8] H. Ghodrati and S. R. Ghazi Fini, “Stock market liquidity and firm dividend policy: Evidence from Tehran Stock Exchange,” *Manag. Sci. Lett.*, vol. 4, no. 8, pp. 1849–1858, 2014, DOI: 10.5267/j.msl.2014.6.045.
[9] Y. C. C. Cheng and C. C. S. Huang, “A study of ANFIS-based multi-factor time series models for forecasting stock index,” *Appl. Intell.*, no. 111, 2016, DOI: 10.1007/s10489-016-0760-8.
[10] Y. Kara, M. Acar Boyacioglu, and Ö. K. Baykan, “Predicting direction of stock price index movement using artificial neural networks and support vector machines: The sample of the Istanbul Stock Exchange,” *Expert Syst. Appl.*, vol. 38, no. 5, pp. 5311–5319, 2011, DOI: 10.1016/j.eswa.2010.10.027.
[11] A. B. Paksi, “PENERAPAN F-TOPSIS DALAM ANALISIS FUNDAMENTAL BERDASARKAN RASIO KEUANGAN UNTUK MENUNJANG,” in *Seminar Nasional Teknologi Informasi dan Multimedia*, 2016, pp. 6–7.
[12] L. Shamseer *et al.*, "Preferred reporting items for systematic review and meta-analysis protocols (Prisma-p) 2015: Elaboration and explanation," *BMJ (Online)*, vol. 349. BMJ Publishing Group, Jan. 02, 2015, DOI: 10.1136/BMJ.g7647.
[13] S. Keele, “Guidelines for performing systematic literature reviews in software engineering,” in *Technical report, Ver. 2.3 EBSE Technical Report. EBSE*, 2007.
[14] M. J. Page *et al.*, “The PRISMA 2020 statement: An updated guideline for reporting systematic reviews,” *The BMJ*, vol. 372. BMJ Publishing Group, Mar. 29, 2021, DOI: 10.1136/BMJ.n71.
[15] J. Wu, C. Wang, L. Xiong, and H. Sun, “Quantitative Trading on Stock Market Based on Deep Reinforcement Learning,” *Proc. Int. Jt. Conf. Neural Networks*, vol. 2019-July, no. July, pp. 1–8, 2019, DOI: 10.1109/IJCNN.2019.8851831.
[16] R. M. I. Kusuma, T.-T. Ho, W.-C. Kao, Y.-Y. Ou, and K.-L. Hua, “Using Deep Learning Neural Networks and Candlestick Chart Representation to Predict Stock Market,” 2019. [Online]. Available: http://arxiv.org/abs/1903.12258.
[17] J. Long, Z. Chen, W. He, T. Wu, and J. Ren, “An integrated framework of deep learning and knowledge graph for prediction of stock price trend: An application in Chinese stock exchange market,” *Appl. Soft Comput. J.*, vol. 91, p. 106205, 2020, DOI: 10.1016/j.asoc.2020.106205.
[18] T. N. Bulkowski, “Encyclopedia of candlestick charts,” *Wiley trading Ser.*, p. 940, 2008, [Online]. Available: http://hym-2017.corpuscodea.es/pdf/Thomas N. Bulkowski - Encyclopedia of Candlestick Charts (2008).pdf%0Ahttps://www.amazon.com/Encyclopedia-Candlestick-Trading-Bulkowski-published/DP/B00EKYJEJK/ref=sr_1_3?s=books&ie=UTF8&qid=1499257147&sr=1-3&keywords=En.
[19] T. Kim and H. Y. Kim, “Forecasting stock prices with a feature fusion LSTM-CNN model using different representations of the same data,” *PLoS One*, vol. 14, no. 2, pp. 1–23, 2019, DOI: 10.1371/journal.pone.0212320.
[20] R. Naranjo and M. Santos, “A fuzzy decision system for money investment in stock markets based on fuzzy candlesticks pattern recognition,” *Expert Syst. Appl.*, vol. 133, pp. 34–48, 2019, DOI: 10.1016/j.eswa.2019.05.012.
[21] X. Pang, Y. Zhou, P. Wang, W. Lin, and V. Chang, “An innovative neural network approach for stock market prediction,” *J. Supercomput.*, vol. 76, no. 3, pp. 2098–2118, 2020, DOI: 10.1007/s11227-017-2228-y.
[22] W. Chen, M. Jiang, W. G. Zhang, and Z. Chen, “A novel graph convolutional feature based convolutional neural network for stock trend prediction,” *Inf. Sci. (NY).*, vol. 556, pp. 67–94, 2021, DOI: 10.1016/j.ins.2020.12.068.
[23] E. Hoseinzade and S. Haratizadeh, “CNNpred: CNN-based stock market prediction using a diverse set of variables,” *Expert Syst. Appl.*, vol. 129, pp. 273–285, 2019, DOI: 10.1016/j.eswa.2019.03.029.
[24] Y. Chen and Y. Hao, “A feature weighted support vector machine and K-nearest neighbor algorithm for stock market indices prediction,” *Expert Syst. Appl.*, vol. 80, pp. 340–355, 2017, DOI: 10.1016/j.eswa.2017.02.044.
[25] I. K. Nti, A. F. Adekoya, and B. A. Weyori, “A comprehensive evaluation of ensemble learning for stock-market prediction,” *J. Big Data*, vol. 7, no. 1, 2020, DOI: 10.1186/s40537-020-00299-5.
[26] I. K. Nti, A. F. Adekoya, and B. A. Weyori, “Efficient Stock-Market Prediction Using Ensemble Support Vector Machine,” *Open Comput. Sci.*, vol. 10, no. 1, pp. 153–163, 2020, doi: 10.1515/comp-2020-0199.
[27] M. Sedighi, H. Jahangirnia, M. Gharakhani, and S. F. Fard, “A novel hybrid model for stock price forecasting based on metaheuristics and support vector machine,” *Data*, vol. 4, no. 2, pp. 1–28, 2019, DOI: 10.3390/data4020075.
[28] Y. Karaca, Y. D. Zhang, and K. Muhammad, “Characterizing Complexity and Self-Similarity Based on

Fractal and Entropy Analyses for Stock Market Forecast Modelling," *Expert Syst. Appl.*, vol. 144, p. 113098, 2020, DOI: 10.1016/j.eswa.2019.113098.
[29] S. Basak, S. Kar, S. Saha, L. Khaidem, and S. R. Dey, "Predicting the direction of stock market prices using tree-based classifiers," *North Am. J. Econ. Finance.*, vol. 47, no. June, pp. 552–567, 2019, DOI: 10.1016/j.najef.2018.06.013.
[30] M. Kraus and S. Feuerriegel, "Decision support from financial disclosures with deep neural networks and transfer learning," *Decis. Support Syst.*, vol. 104, pp. 38–48, 2017, DOI: 10.1016/j.dss.2017.10.001.
[31] B. Weng, M. A. Ahmed, and F. M. Megahed, "Stock market one-day ahead movement prediction using disparate data sources," *Expert Syst. Appl.*, vol. 79, pp. 153–163, 2017, DOI: 10.1016/j.eswa.2017.02.041.
[32] B. Weng, L. Lu, X. Wang, F. M. Megahed, and W. Martinez, "Predicting short-term stock prices using ensemble methods and online data sources," *Expert Syst. Appl.*, vol. 112, pp. 258–273, 2018, DOI: 10.1016/j.eswa.2018.06.016.