

Machine Learning and Deep Learning as Predictive Forecasters of Capital Markets: A Systematic Literature Review.

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Abstract

As the sun dips across the horizon, the stock exchange closes the bell, marking the closure of the day for traders and analyst to think and speculate the next day stock trends. The financial time series are old fashioned though a base line for all prediction methods. However there is a need to understand the prediction accuracy and capital market volatility augmented by fluctuations. The researchers carried out a systematic literature review to unleash the instruments that play the role of predictors in capital market today. It was found after assessment of the high impact research papers that Machine learning and Deep learning are major technological areas that is aiding the capital market predictions and behavioral analysis. with multiple techniques within to support prediction algorithms and clustering techniques for data analysis to support, this study summarizes the most five common set out the complete list of algorithm and techniques used.

Keywords: Capital market predictions, Data Science, Deep Learning, , Machine learning, prediction algorithms.

1. Introduction

The entire globe follows the capital markets in various forms , may be from a small investor to a capitalist. The stock market has always shown a trend of volatility and fluctuations causes many investors and even technical experts clueless about the capital market behaviour. The tradition approach of technical analysis has benefited the predictions but not always at a long term point of view. It was thus evident to bring in better optimised tools and techniques

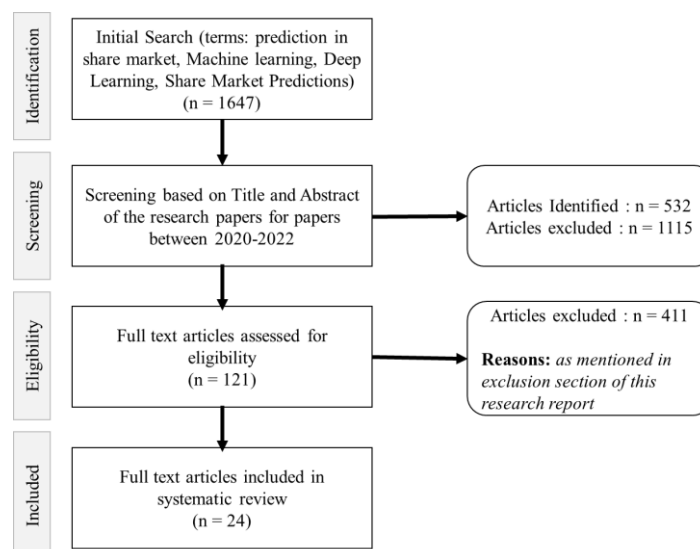
to stabilise and appropriately predict the behaviour. Machine learning and Deep Learning though not a very new concept in the digital world today, has been a boon in the prediction of capital market. The study was conducted to explore these predictors and understand to fetch answers to the research questions framed.

2. Methodology

The methodology adopted for this research paper is Systematic Literature Review (SLR), with an intent to assist in, fetching the information from peer reviewed sources (Thomas, 2013/2016, p. 59). The objective of using this methodology was also to ensure that the information gathered from the sources are reliable, valid and repeatable (Xiao & Watson, 2017). Researchers used a methodology which is proven for all “systematic reviews”, called as “PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (Sarkis-Onofre et al., 2021). As per the recommendations made in this methodology, following steps were conducted as part of research process.

(a) Information sources and Search

The researchers’ first conducted the search electronically across the databases such as : Google scholar, IEEE, Springer and ScienceDirect. The later three databases were chosen since the SLR is focused on the research area pertaining to technology. All the databases were searched between January 1, 2015 until June 30, 2022. The search terms were concentrated to share market and prediction, machine learning , augmented by the filtration criteria of citation (greater than 99 citations). The researchers’ used the PRSMA flow chart to approach the search process with inclusions and exclusions parameters as depicted in the figure below.



n represents the sample size at each phase of PRISMA flow chart

Figure1 : PRISMA flow chart used for search process within SLR in scope.

(b) Inclusions and Exclusions

The source databases returned output of several research papers, articles and case studies. It was paramount important to bring a lean approach through filtration. The inclusion and exclusions was thus drawn to favour the equity of the research objective as described in table below.

<i>Inclusion criteria</i>	<i>Exclusion criteria</i>
1. Title and Abstract covering the context .	1. No other languages were considered than English.
2. Machine learning and Deep Learning were major contributors in publications with prime importance to prediction in share markets	2. Patents, blogs , thesis were excluded.
3. Research questions are addressed through the abstract in selected articles	3. Conceptual articles only were not considered.
	4. Articles not fully empirical in nature.

To eliminate the “*risk of bias*”, the researchers followed dual assessment, sensitivity analyses ,cross validity and reliability of outcome as suggested by (Viswanathan et al., 2012).

(c) Framing the research questions

The three research questions that were framed by initial assessment by the researchers are as follows :

RQ-1: " Necessity of predictions in capital market with modern technology ?"

RQ-2: “What instruments are playing vital role in being predictors ?”

RQ-3: “What are the techniques, tools and methods of prediction used?”

3.Findings

The Systematic literature review , helped the researchers to bring a convergence in answering the research questions framed for the study as follows:

(a) RQ-1: " Necessity of predictions in capital market with modern technology ?"

The world has witnessed a great advent information technology and digital transformation. The global capital markets is now widely accessible for strategic investors and global citizens (Yoo et al., n.d.). The “*financial time series*” are difficult to make predictions today due to the dynamism's and non-linear financial asset’s prices and thus machine learning is found to

be one of the most researched and used technology today (Henrique et al., 2019). On similar note, the researchers summarized the need of predictions in the table below to bring ‘common themes’ together from all articles reviewed in SLR.

Themes Answering RQ-1	<i>Prediction Accuracy plays vital role in fluctuating capital market</i>	<i>Capital Market volatility requires prediction and it is required to bring a balance.</i>
<i>Articles which supported the themes to answer RQ-1</i>	1. ((Hsu et al., 2016)) 2. ((Kumar & Thenmozhi, 2006)) 3. ((Parmar et al., 2018))	1. ((Schewert, 1989)) 2. ((Guresen et al., 2011b))
Rationale	Articles selected from High Impact journals with citation > 100 and with empirical value	

(b) RQ-2: " What instruments are playing vital role in being predictors?"

Through reviewing the research articles, the researcher’s observed that the two instruments are playing major role in being predictors of capital market. The analysis is summarized in the table below.

Table 1 :Machine learning and deep learning themes to support the objective

Themes Answering RQ-2	“Machine learning (ML)” is the most powerful tool for prediction as it uses predictive algorithms.	“Deep Learning (DL)” leverages financial time series method to extract relevant information (Nabipour et al., 2020).
<i>Articles which supported the themes to answer RQ-2</i>	((A.Sharma,2017)) ((Zhong & Enke, 2019)) ((Shen & Shafiq, 2020)) ((Budiharto, 2021))	((Nabipour et al., 2020)) ((Chong et al., 2017)) ((Vargas et al., 2017)) ((Moghar & Hamiche, 2020)) ((Pang et al., 2018))
Rationale	Articles selected from High Impact journals with citation > 100 and with “thematic value”.	

(c) RQ-3: “What are the most common techniques and methods of prediction used?”

It is found that there is a common set of techniques and methods referenced by all researchers through their research articles. There are prediction techniques augmented by clustering

techniques too, however the researchers found that few are most common mentioned which are most useful. The table below depicts these five most useful techniques/methods with number of articles providing ample applicability and rationalizing the answer to RQ-3.

Table 2 :Fivecommon techniques/methods used

	<i>Features & Article References</i>
<i>“Artificial Neural Networks (ANN) ” (prediction technique)</i>	“Bayesian regularized artificial neural network” is proposed , to accurately forecast financial market behaviour as suggested by (Ticknor, 2013), (Atkins et al., 2018), (Selvamuthu et al., 2019)
<i>“ Convolutional Neural Networks (CNN) “ (prediction technique)</i>	“Deep learning mechanism to predict the directional movement “(Vargas et al., 2017), “LSTM (Long short term memory) and CNN helps in forecasting the patterns in capital market trends frequently (Zhou et al., 2018).”
<i>“Naïve Biased Technique” (prediction technique)</i>	“ Naïve biased technique with nuero linguistic programming helps to boost predictions of capital market accurately” (Nabipour, Nayyeri, Jabani, Mosavi, et al., 2020)
<i>“Fuzzy Based prediction technique” (Clustering technique)</i>	“ Fuzzy logic was build clusters and technical indexes as input variable for predictions within capital market” (Esfahanipour & Aghamiri, 2010)
<i>“K-means “ (clustering technique)</i>	“(Nanda et al., 2010) proved through his research paper that data mining with K-means can play a vital role in capital market predictions”.

4. Limitations and Scope of future work

1. The Systematic Literature Review (SLR) was conducted using PRISMA methodology , however Meta Analysis would have brought in more statistical analysis against the findings. Researchers can use these findings and explore further using meta analysis.
2. The researchers have considered only handful of databases and research articles which are cited more than 100 . Due to limitation of study time allotted, the researchers have not considered other databases and citations less than 100.

5. Conclusion

The systematic literature review has drawn up the fundamentals of capital market predictions using various techniques used in Machine learning and Deep learning. The review has

summarized the techniques, though only five common ones which are widely cited by many researchers across the globe. It is found that both deep learning and machine learning has two important common themes as mentioned under RQ-2. The research revealed that there are many research articles who have concluded the usefulness of machine learning and deep learning as predictors of capital markets and are used widely across the society today.

References

1. Atkins, A., Niranjana, M., & Gerding, E. (2018). "Financial news predicts stock market volatility better than close price". *The Journal of Finance and Data Science*, 4(2), 120–137. <https://doi.org/10.1016/j.jfds.2018.02.002>
2. Budiharto, W. (2021). "Data science approach to stock prices forecasting in Indonesia during Covid-19 using Long Short-Term Memory (LSTM)". *Journal of Big Data*, 8(1). <https://doi.org/10.1186/s40537-021-00430-0>
3. Chong, E., Han, C., & Park, F. C. (2017). "Deep learning networks for stock market analysis and prediction: Methodology, data representations, and case studies". *Expert Systems with Applications*, 83, 187–205. <https://doi.org/10.1016/j.eswa.2017.04.030>
4. Esfahanipour, A., & Aghamiri, W. (2010). "Adapted Neuro-Fuzzy Inference System on indirect approach TSK fuzzy rule base for stock market analysis". *Expert Systems with Applications*, 37(7), 4742–4748. <https://doi.org/10.1016/j.eswa.2009.11.020>
5. Guresen, E., Kayakutlu, G., & Daim, T. U. (2011a). "Using artificial neural network models in stock market index prediction". *Expert Systems with Applications*, 38(8), 10389–10397. <https://doi.org/10.1016/j.eswa.2011.02.068>
6. Guresen, E., Kayakutlu, G., & Daim, T. U. (2011b). "Using artificial neural network models in stock market index prediction". *Expert Systems with Applications*, 38(8), 10389–10397. <https://doi.org/10.1016/j.eswa.2011.02.068>
7. Henrique, B. M., Sobreiro, V. A., & Kimura, H. (2019). "Literature review: Machine learning techniques applied to financial market prediction". *Expert Systems with Applications*, 124, 226–251. <https://doi.org/10.1016/j.eswa.2019.01.012>
8. Hsu, M.-W., Lessmann, S., Sung, M.-C., Ma, T., & Johnson, J. E. V. (2016). "Bridging the divide in financial market forecasting: machine learners vs. financial economists". *Expert Systems with Applications*, 61, 215–234. <https://doi.org/10.1016/j.eswa.2016.05.033>
9. Kumar, M., & Thenmozhi, M. (2006, January 24). "Forecasting Stock Index Movement: A Comparison of Support Vector Machines and Random Forest".

- Papers.ssrn.com. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=876544
10. Moghar, A., & Hamiche, M. (2020). "Stock Market Prediction Using LSTM Recurrent Neural Network". *Procedia Computer Science*, 170, 1168–1173. <https://doi.org/10.1016/j.procs.2020.03.049>
 11. Nabipour, M., Nayyeri, P., Jabani, H., Mosavi, A., Salwana, E., & S., S. (2020). "Deep Learning for Stock Market Prediction". *Entropy*, 22(8), 840. <https://doi.org/10.3390/e22080840>
 12. Nabipour, M., Nayyeri, P., Jabani, H., S., S., & Mosavi, A. (2020). "Predicting Stock Market Trends Using Machine Learning and Deep Learning Algorithms Via Continuous and Binary Data; a Comparative Analysis". *IEEE Access*, 8, 150199–150212. <https://doi.org/10.1109/access.2020.3015966>
 13. Nanda, S. R., Mahanty, B., & Tiwari, M. K. (2010). "Clustering Indian stock market data for portfolio management". *Expert Systems with Applications*, 37(12), 8793–8798. <https://doi.org/10.1016/j.eswa.2010.06.026>
 14. Pang, X., Zhou, Y., Wang, P., Lin, W., & Chang, V. (2018). "An innovative neural network approach for stock market prediction". *The Journal of Supercomputing*. <https://doi.org/10.1007/s11227-017-2228-y>
 15. Parmar, I., Agarwal, N., Saxena, S., Arora, R., Gupta, S., Dhiman, H., & Chouhan, L. (2018). "Stock Market Prediction Using Machine Learning". *2018 First International Conference on Secure Cyber Computing and Communication (ICSCCC)*. <https://doi.org/10.1109/icsecc.2018.8703332>
 16. Patel, J., Shah, S., Thakkar, P., & Kotecha, K. (2015). "Predicting stock market index using fusion of machine learning techniques". *Expert Systems with Applications*, 42(4), 2162–2172. <https://doi.org/10.1016/j.eswa.2014.10.031>
 17. Sarkis-Onofre, R., Catalá-López, F., Aromataris, E., & Lockwood, C. (2021). "How to properly use the PRISMA Statement". *Systematic Reviews*, 10(1). <https://doi.org/10.1186/s13643-021-01671-z>
 18. SCHWERT, G. W. (1989). "Why Does Stock Market Volatility Change Over Time?" *The Journal of Finance*, 44(5), 1115–1153. <https://doi.org/10.1111/j.1540-6261.1989.tb02647.x>
 19. Selvamuthu, D., Kumar, V., & Mishra, A. (2019). Indian stock market prediction using artificial neural networks on tick data. *Financial Innovation*, 5(1). <https://doi.org/10.1186/s40854-019-0131-7>
 20. Shen, J., & Shafiq, M. O. (2020). "Short-term stock market price trend prediction

- using a comprehensive deep learning system”. *Journal of Big Data*, 7(1).
<https://doi.org/10.1186/s40537-020-00333-6>
21. Thomas, G. (2016). “*How to Do Your Research Project : a Guide for Students*”(3rd ed., p. 59). Sage. (Original work published 2013)
 22. Ticknor, J. L. (2013). “A Bayesian regularized artificial neural network for stock market forecasting”. *Expert Systems with Applications*, 40(14), 5501–5506.
<https://doi.org/10.1016/j.eswa.2013.04.013>
 23. Vargas, M. R., de Lima, B. S. L. P., & Evsukoff, A. G. (2017). “Deep learning for stock market prediction from financial news articles”. *2017 IEEE International Conference on Computational Intelligence and Virtual Environments for Measurement Systems and Applications (CIVEMSA)*.
<https://doi.org/10.1109/civemsa.2017.7995302>
 24. Viswanathan, M., Ansari, M. T., Berkman, N. D., Chang, S., Hartling, L., McPheeters, M., P Lina Santaguida, Shamliyan, T., Singh, K., Tsertsvadze, A., & Treadwell, J. R. (2012, March
 25. “*Assessing the Risk of Bias of Individual Studies in Systematic Reviews of Health Care Interventions*”. Nih.gov; Agency for Healthcare Research and Quality (US).
<https://www.ncbi.nlm.nih.gov/books/NBK91433/>
 26. Xiao, Y., & Watson, M. (2017). “Guidance on Conducting a Systematic Literature Review”. *Journal of Planning Education and Research*, 39(1), 93–112.
<https://doi.org/10.1177/0739456x17723971>
 27. Yoo, P. D., Kim, M. H., & Jan, T. (n.d.). “Machine Learning Techniques and Use of Event Information for Stock Market Prediction: A Survey and Evaluation”. *International Conference on Computational Intelligence for Modelling, Control and Automation and International Conference on Intelligent Agents, Web Technologies and Internet Commerce (CIMCA-IAWTIC'06)*.
<https://doi.org/10.1109/cimca.2005.1631572>
 28. Zhong, X., & Enke, D. (2019). “Predicting the daily return direction of the stock market using hybrid machine learning algorithms”. *Financial Innovation*, 5(1).
<https://doi.org/10.1186/s40854-019-0138-0>
 29. Zhou, X., Pan, Z., Hu, G., Tang, S., & Zhao, C. (2018). “Stock Market Prediction on High-Frequency Data Using Generative Adversarial Nets”. *Mathematical Problems in Engineering*, 2018, 1–11. <https://doi.org/10.1155/2018/4907423>