LITERATURE REVIEW

Studies Using Artificial Neural Networks to Predict Stock Market Values

The first set of articles includes studies that primarily focus on stock market prediction using artificial neural networks (ANNs). ANNs are computational models based on biological neural networks. In the network, sets of nodes are grouped into layers starting with an input layer and ending with an output layer. Signals are transmitted (propagated) through the connected nodes as they learn based on examples and attempt to reduce the level of prediction error. As the system is working to improve its performance, weights are adjusted for the signals between connected nodes. The following provides a brief description of each ANN-related study's unique research focus and findings.

Jasic and Wood (2004) developed an artificial neural network to predict daily stock market index returns using data from several global stock markets. The focus is on trying to support profitable trading. A method is introduced based on univariate neural networks using untransformed data inputs to provide short-term stock market index return predictions. The study uses the daily closing values of the Standard and Poor's 500 Index (S&P 500), the German DAX index, the Japanese TOPIX index, and London's Financial Times Stock Exchange Index (FTSE All Share). The samples for the S&P 500, DAX, and FTSE Index are from January 1, 1965 to November 11, 1999. The sample for TOPIX covers the period from January 1, 1969 to November 11, 1999 since data from earlier years was not available. The prediction performance for the neural network is evaluated against a benchmark linear autoregressive model and prediction improvement is confirmed when applied to the S&P 500 and DAX indices.

Enke and Thawornwong (2005) use a machine learning information gain technique to evaluate the predictive relationships for numerous financial and economic variables. By computing the information gain for each model variable, a ranking of the variables is obtained. A threshold is determined to select only the strongest relevant variables to be retained in the forecasting models. Neural network models for level estimation and classification are examined for their ability to provide an effective forecast of future values. A cross-validation technique is also employed to improve the generalizability of several models. The models are compared using S&P data from a 24-year period from March 1976 to December 1999. The results show that the trading strategies guided by the classification models generate higher risk-adjusted profits than the buy-and-hold strategy, the other neural network models, and the linear regression models.

categorization. The technique uses supervised learning. Training examples are identified as being part of one category or another. An SVM model represents the examples as points in a space with the goal of creating a gap between the categories that is as wide as possible. New examples are classified based on the category in which they most likely belong. For example, in the context of stock market prediction, according to Schumaker and Chen (2010), SVM is a machine learning algorithm that can classify a future stock price direction (rise or drop).

Lee (2009) developed a prediction model based on a support vector machine with a hybrid feature selection method to predict the trend of stock markets. This proposed hybrid feature selection method, named F-score and Supported Sequential Forward Search (F_SSFS), combines the advantages of filter methods and wrapper methods to select the optimal feature subset from the original feature set. To evaluate the prediction accuracy of this SVM-based model combined with F_SSFS, performance is compared with a backpropagation neural network (BPNN) along with three commonly used feature selection methods: information gain, symmetrical uncertainty, and correlation-based feature selection via paired t-tests. The study focuses on predicting the direction of the NASDAQ index using commodity, currency, and other financial market index data from November 8, 2001 through November 8, 2007. It is shown that the SVM outperforms BPN for stock trend prediction. In addition, experimental results show that the proposed SVM-based model combined with F_SSFS has the highest level of predictive accuracy and generalization in comparison with the other three feature selection methods.

A unique study by Schumaker and Chen (2009) used an SVM in conjunction with textual analysis looking at the impact of news articles on stock prices. They developed a predictive machine learning approach for financial news article analysis using several different textual representations: Bag of Words, Noun Phrases, and Named Entities. Through this approach, they investigated a large number of financial news articles and stock quotes covering stocks listed on the S&P500 during a five-week period from October 26, 2005 to November 28, 2005. They estimated a discrete stock price twenty minutes after a news article was released. Using an SVM derivative specially tailored for discrete numeric prediction, and models containing different stock-specific variables, they showed that the model containing both article terms and stock price at the time of article release provided the closest estimate to the actual future stock price, the same direction of price movement as the future price, and the highest return using a simulated trading engine.

Yeh, Huang and Lee (2011) address problems that arise when using support vector regression to forecast stock market values when dealing with kernel function hyperparameters. Typically, a hyperparameter is a parameter whose value is set before the learning process begins. In their system, advantages from different

Yeh, C. Y., Huang, C. W., & Lee, S. J. (2011). A multiple-kernel support vector regression approach for stock market price forecasting. *Expert Systems with Applications, 38*(3), 2177-2186.

Yu, L., Chen, H., Wang, S., & Lai, K. K. (2008). Evolving least squares support vector machines for stock market trend mining. *IEEE Transactions on evolutionary computation, 13*(1), 87-102.

Zhong, X., & Enke, D. (2019). Predicting the daily return direction of the stock market using hybrid machine learning algorithms. *Financial Innovation*, *5*(1), 4.

APPENDIX
List of Reviewed Machine Learning Stock Market Prediction Articles

Author(s) [publication year]	Machine Learning Method(s)	Primary Market(s) Studied and Data Time Period (Years)
Jasic and Wood [2004]	Artificial neural network	S&P 500, DAX, TOPIX and FTSE 1965-1999
Enke and Thawornwong [2005]	Artificial neural network	S&P 500 1976-1999
Liao and Wang [2010]	Artificial neural network	Shanghai and Shenzhen Stock Exchange 1990-2008
Chavan and Patil [2013]	Artificial neural network	Study reviews nine ANN studies
Chong, Han and Park [2017]	Artificial neural network	Korean KOSPI stock market 2010-2014
Lee (2009)	Support vector machine	NASDAQ 2001-2007
Schumaker and Chen [2009]	Support vector machine	Companies listed in the S&P500 in 2005
Yeh, Huang and Lee [2011]	Support vector machine	Taiwan Capitalization Weighted Stock Index 2002-2005
Das and Padhy [2012]	Support vector machine	National Stock Exchange (NSE) of India Limited 2007-2010
Kim and Han [2000]	Genetic algorithm with artificial neural network	Korea stock price index (KOSPI) 1989-1998
Kim and Lee (2004)	Genetic algorithm with artificial neural network	Korea composite stock price index (KOSPI) 1991-1998