alamSYS: Development of Stock Market Price Forecasting System Using Dynamic Mode Decomposition, Long Short-Term Memory with Arnaud Legoux Moving Average Convergence-Divergence Integration

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Introduction

1.1 Background and Rationale

The stock market is a type of market that allows businesses to raise capital by selling stock shares to investors. These shares represent a portion of the company's ownership and entitle the holder to a portion of the company's profits as well as voting rights. The stock exchange also serves as a marketplace for investors to buy and sell these shares, allowing for the efficient trading of company ownership. The stock market plays an important role in the growth and development of the economy by allowing companies to raise capital and investors to buy and sell shares (Chen, 2022; The Economic Times, n.d.).

The stock market, contrary to popular belief, is not a form of gambling. It necessitates a significant amount of analytical thinking and risk management, and the returns are determined by supply and demand for a specific stock, rather than false promises or assurances. In other words, rather than being a scam or a gamble, the stock market is a legitimate platform for investing and generating returns (Schwab-Pomerantz, 2021; Adams, 2022; Summers, 2022).

1.1.1 The Philippine Stock Exchange (PSE)

The Philippine Stock Exchange (PSE), Inc. is the country's official stock exchange market. It is a non-stock company founded in 1992 that manages and operates the country's stock market. Individuals who are registered with the PSE can participate in market exchanges (The Philippine Stock Exchange, Inc., n.d.-a).

Furthermore, the Philippine Stock Exchange Index (PSEI) is the main index of the PSE. (PSEI). The PSEI is a market capitalization-weighted price index composed of the PSE's 30 largest and most actively traded companies. These businesses have been pre-selected based on strict criteria such as liquidity and market capitalization. The PSEI is frequently used as a proxy for the overall performance of the Philippine stock market. (Bangko Sentral ng Pilipinas, n.d.) These PSEI companies are often referred to as blue-chip companies because they are typically large, well-established companies with a track record of strong financial performance. In total the PSE has 286 companies listed as of October 2022, offering investors a diverse range of investment opportunities (Fayed, 2022; The Philippine Stock Exchange, Inc., n.d.-b).

1.1.2 Economic Relevance and Benefits of Stock Market Investment

The stock market is widely acknowledged to play an important role in economic growth because it allocates and provides capital to businesses, which drives economic activity and growth. This is evident from the fact that stock market performance is frequently correlated with the gross domestic product (GDP) of the country. (Trade Brains, 2022; Hall, 2022; Bae & Kang, 2017) Furthermore, historical stock price trends can provide insight into broader economic movements (Campbell, 2021).

In a study conducted by Balaba (2017), they discovered that the stock market

has a positive impact on the Philippines' economy. The study's findings showed that as the stock market rose, the unemployment rate fell. This is because the performance of the stock market leads to job creation, which in turn leads to economic growth. This, in turn, drives economic growth. This relationship was observed in the Philippines from 2007 to 2017.

1.1.3 Benefits of Investing for the Individual

Individuals in the Philippines can trade shares of publicly traded companies on the Philippine Stock Exchange. Investing in the stock market can provide several advantages to an individual, including:

(a) Protects an individual's money from inflation: Inflation in the Philippines was 6.9% as of September 2022 (Trading Economics, n.d.), while savings account deposit interest rates are only 1-3% annually, (Bureau of the Treasury Bangko Sentral ng Pilipinas, n.d.). This means that savings in deposit banks may not keep pace with inflation, potentially reducing an individual's purchasing power over time. (Royal Bank of Canada Direct Investing Inc., n.d.; EdwardJones, n.d.).

(b) Capital growth opportunities: Investing in the stock market can provide individuals with the opportunity for significant capital growth without the need for direct investment involvement in business operations. This may benefit individuals. Students and working professionals, for example, can increase their capital while remaining focused on their studies or careers. (U.S. Securities and Exchange Commission, n.d.).

1.1.4 Utilization of Machine Learning in Stock Market Trading

In recent years, there has been a surge in interest in the use of machine learning. Learning techniques for predicting stock market movement in the short and long term. As a result, numerous studies and practical applications investigating the use of machine learning in stock market prediction have been conducted.

These efforts aim to improve prediction accuracy and assist investors in making informed decisions (Kumbure, Lohrmann, Luukka, & Porras, 2022; Strader, Rozycki, Root, & Huang, 2020; Soni, Tewari, & Krishnan, 2022; Rea, 2020; Guo, 2022). In this regard, one of the common techniques used is the Long Short-Term Memory (LSTM). LSTM is a deep learning model that is widely used to forecast the stock market. A study by Budiharto (2021) found that LSTM was effective in predicting the Indonesian stock market with 95% accuracy using a short-term data. Which suggests that LSTM can be a useful tool for making short-term stock market forecasts.

The use of Dynamic Mode Decomposition (DMD) for predicting stock market price trends has recently gained traction in the financial industry. DMD is a mathematical method for identifying patterns and trends in large data sets, such as stock market data. It is possible to make more accurate predictions about future stock price movements by applying DMD to stock market data. This can help investors make more informed investment decisions and potentially generate higher returns. However, a study by Lu and Tartakovsky (2020) found that DMD is faster than Proper Orthogonal Decomposition, but it is less accurate.

Other studies have shown that DMD can be effectively applied to the Turkish and Indian stock markets to predict market price trends (Savaş, 2017; Kuttichira, Gopalakrishnan, Menon, & Soman, 2017). These studies show that DMD is simple to implement and can be used as a useful enhancer for making stock market predictions.

1.2 Statement of the Problem

Economic growth in the Philippines is expected to slow in the coming years as a result of the global pandemic, high inflation, and low employment rates (Alegado, Lopez, & Calonzo, 2022; Canto & Romano, 2022; Reuters, 2022).

The lack of free and publicly available stock market predictive systems or tools currently creates a gap in the information available to the public when compared to large private individuals or institutions. These large institutions have the resources to spend a significant amount of money on stock market research, giving them a significant advantage in the investing market. Where, the public is disadvantaged by this lack of access to the same information (Kim, 2022).

Furthermore, the lack of publicly available stock market prediction tools can lead to individuals, particularly first-time investors, making unwise investment decisions, resulting in significant losses and discouragement from investing in the stock market. This is a significant issue because the number of local investors in the Philippine Stock Exchange is already quite small, accounting for only about 1% of the total population. In addition, there has been a significant decline in foreign investment in the Philippines in recent years (Business World, 2022), leading to a corresponding decline in investment volume. As suggested in the study of Balaba (2017), this is expected to have a negative multiplier effect on the country's economic development in the future.

As a result, the creation of a publicly available, simple-to-use, and accurate stock market price trend prediction system could aid in closing the information gap and leveling the playing field for individual investors. This system could help to increase transparency and fairness in the stock market by providing the public with timely and reliable information, resulting in more informed and confident investing decisions and, ultimately, a more stable and prosperous market. Furthermore, such a system could help to increase individual investor participation in the market, resulting in a more diverse and stable market overall. (Statista Research Department, 2022; Commission on Population and Development, 2021).

However, despite the clear and functional benefits of investing in the stock market, many Filipinos remain hesitant to do so for the following reasons:

(a) The difficulties that come with learning the fundamentals of effective stock

investing.

(b) The time-consuming nature of technical and fundamental analysis, especially for students and working people on a tight schedule; and

(c) The increased financial risk associated with stock market volatility, as well as the potential for emotional decision-making to jeopardize investments.

These factors *(along with other external and internal factors not listed above)* contribute to a lack of confidence and understanding among potential investors, making it difficult for them to take advantage of the opportunities offered by the stock market.

As such the development of this system, aims to address the following:

(a) The lack of free and publicly available stock market prediction systems or tools.

(b) The time and resources required to study complex traditional market analysis tools, such as fundamental and technical analysis.

(c) The potential for inaccurate market decisions leading to significant investment losses; and

(d) The hesitancy of the Filipino public to begin investing in the Philippine stock market.

1.3 Significance of the Study

The significance of this particular problem lies in the developed system to greatly benefit the stock market, individual investors, and the economy as a whole. Contributions of the system to data-driven investing, financial protection and management, and economic development could provide a valuable resource for investors while also promoting financial stability and growth. Furthermore, the creation of publicly accessible data-driven investing tools or systems may enable

more Filipinos to participate in the market and take control of their own financial future. Overall, this special problem has the potential to have a significant impact on the Philippine stock market and economy.

Specifically, this study is significant for the following reasons:

(a) The development of the alamSYS aims to provide the following benefits to the Filipino people:

1. Access to simplified yet accurate information – The proposed system could provide Filipino investors with fast, accurate, and relevant information necessary for effective decision making in the stock market. Using a deep learning model such as LSTM, the system could provide users with the two most important pieces of information: which stocks to buy, and which stocks to sell. This simplified investing model could help investors to make informed decisions and navigate the stock market with confidence.
2. Provide an application interface to facilitate data-driven market decisions – The system could provide users with an intuitive and user-friendly application interface to facilitate data-driven investment decisions, particularly during times when the market is unpredictable or experiencing a downturn. Whereas traditional market analysis tools may not be sufficient to navigate these challenging conditions, the system's forecasting model could provide investors with the insights and guidance they need to make informed and wise decisions. Which would help to promote confidence and stability in the market, even during times of uncertainty.
3. A platform for accessible stock market investment – The system aims to provide all investors, regardless of their investment knowledge, educational attainment, and societal status, with a platform for participating in the stock market. By offering a simplified yet accurate model for investment decision making, the system could empower users to make informed decisions and invest with confidence. This could help to democratize access to the stock market and promote financial inclusion for all Filipinos.

(b) The development of the alamSYS, aims to provide the following benefits to the future developers or researchers:

1. Extension of functionality to other financial markets – The system can be easily adapted or expanded to address related problems in other financial markets, such as investing in government bonds or personal finance management. This flexibility and versatility could make the system a valuable tool for a wide range of investment and financial management scenarios.
2. Testing of new trading algorithms and other machine learning models – The system provides a platform for introducing and testing new data-driven trading algorithms and machine learning models. This could allow future researchers and developers to continually improve the system and keep it at the forefront of data-driven investing technology.
3. Development of a graphical user interface – To further improve the public accessibility of the system, a user-friendly graphical user interface can be developed as a web or mobile application. This could make the system easy to use and intuitive for all users, regardless of their technical expertise.

(c) The development of the alamSYS could help to stimulate economic recovery and development in the country by increasing the number of local investors. As discussed in previous sections, the benefits of the system could encourage more people to invest in the stock market, leading to a multiplier effect that could benefit the economy in several ways. For instance, the increased participation in the market could lead to the creation of jobs and a lowering of unemployment rates. Additionally, the influx of capital into the market could drive fast developments and innovations in various industries. Finally, the increased consumer spending that results from successful investing, stimulates economic growth as well. Overall, the development of the alamSYS could have a positive and far-reaching impact on the economy of the Philippines.

1.4 Objectives

This special problem aims to develop a system that makes investing easier, more publicly available, data-driven, and more approachable by minimizing both the time required for stock price trend analysis, and potential financial risk by using DMD-LSTM and integrate Arnaud Legoux Moving Average Convergence-Divergence (ALMACD) as a trading algorithm. More specifically, it aims to do following:

(a) Develop a Data Preprocessor. Which includes a Data Collector Module (DCM), which collects the end-of-day historical data of a stock from Mondays to Fridays. The data collected is then processed by the Data Processor Module (DPM), which applies the deep learning model and integrate the trading algorithm to the data. Finally, the processed data is given to the Database Updater Module (DUM).

(b) Develop a RESTful API, referred to as alamSYS, using the combination of Python's FastAPI and MongoDB for API endpoints and database, respectively.

Specifically, this was done by doing the following:

1. Develop the following API endpoints:

   1.1 `Home` – This API endpoint outputs a welcome message. Which should inform the user that they have successfully connected to the alamAPI.

   1.2 `Stocks to Buy` – This API endpoint outputs a list of suggested stocks to buy based from the current market price and the predicted price up-trend.

   1.3 `Stocks to Sell` – This API endpoint outputs a list of suggested stocks to sell based from the current market price and the predicted price down-trend.

   1.4 `Stocks Info` - This API endpoint outputs a list of stocks included in the alamSYS and their corresponding information.

1.5 `ML Model Info` - This API endpoint outputs a list of the Machine Learning Models used in the alamSYS and their corresponding information.

1.6 `Stocks Risks Info` - This API endpoint outputs a list of the stocks included in the alamSYS and their corresponding risks values based on value at risk (%), volatility (%), and drawdown (%).

2. Develop a database that stores the results provided by the DPM, and other essential data such as stock information, deep learning model information, and stock risks information about the stock market that is needed to be provided.

(c) Develop a Stock Market Price Trend Forecasting Deep Learning Models by utilizing the dynamic modes in DMD as an additional input parameter to an LSTM model. Afterwards, integrate the forecasting with ALMACD as a trading algorithm and basis for entry and exit positions.

(d) Finally, develop a mobile-based test application to showcase the main functionalities of the developed RESTful API. Specifically which stocks to buy and to sell for a given period of time.

1.5 Scope and Limitations

This study was limited only within the companies listed in the Philippine Stock Exchange. Specifically, 20 high volume trade stocks from the year 2021 to 2022 were selected, which are as follows: (1) MEG, (2) JGS, (3) BDO, (4) FGEN, (5) ICT, (6) ALI, (7) SMC, (8) TEL, (9) GLO, (10) BLOOM, (11) RLC, (12) MER, (13) AC, (14) PGOLD, (15) LTG, (16) MPI, (17) AP, (18) RRHI, (19) URC, and (20) PSE Index will be included in the system, instead of the total 286 listed under the Philippine Stock Exchange.

Chapter 2

Review of Related Works and Literature

One of the challenges facing investors in the Philippine Stock Market is the limited availability of resources and tools for making market decisions. In contrast, other countries have begun implementing machine learning techniques for stock market prediction and analysis, which allows for more accurate decision-making and reduces the risk of poor investment outcomes. As a result, these countries are likely to experience better returns on their investments.

In this literature review, the following general topics are reviewed, discussed, and synthesized: (a) Integration of Machine Learning based Trading Algorithms; and (b) Utilization of Dynamic Mode Decomposition on the Financial markets.

2.1 Integration of Machine Learning based Trading Algorithms

Stock market analysis is crucial for effective risk management. This involves using various methods, such as technical and fundamental analysis, to make informed decisions for investors and traders. In recent years, the growth of com-

puting power and resources has led to the increasing use of machine learning techniques for stock market prediction and analysis. These advances help companies better predict upcoming market trends and make more informed decisions.

The integration of machine learning algorithms in the stock market is growing, as investors and traders increasingly rely on fast and accurate market information to reduce potential risks and make better decisions. These algorithms allow for more efficient analysis of market data, leading to more informed decisions and improved investment outcomes (Obthong, Tantisantiwong, Jeamwatthanachai, & Wills, 2020).

2.1.1 Comparison of Machine Learning and Deep Learning Models in Stock Market Predictions

To have a better grasp in the accuracy of the different models used in algorithmic trading it is essential that different models are compared against each other.

Combination of Computational Efficient Functional Link Artificial Neural Network (CEFLANN) and Traditional Technical Analysis

This hybrid model combines a classification-based model: CEFLANN and the traditional technical analysis to create a stock trading framework Dash and Dash (2016), which the results show a profit of 24.29%.

Deep Long Short-Term Neural Network (LSTM) with Embedded Layer

In one of the models developed by Pang, Zhou, Wang, Lin, and Chang (2020), it shows that by adding an embedded layer to the LSTM it yields to a stock market price prediction accuracy of 57.2%. However, its accuracy dips to 52.4% when the model is applied to individual stocks.

LSTM with Automatic Encoder

As part of the second model developed by Pang et al. (2020), this model shows a slightly inaccurate stock market prediction, by only having a measured accuracy of 56.9%. However, compared to the first model developed by the group this is 0.1% more effective for individual stocks.

Optimal Deep Learning (ODL)

In the study conducted by Agrawal, Khan, and Shukla (2019) they have created a stock price prediction model using an Optimal Deep Learning (ODL) which combine the concepts of Correlation-Tensor and an Optimal LSTM algorithm. Whereas their results show a mean and highest accuracy of the model as 59.24% and 65.64%.

NMC-BERT-LSTM-DQN-X Algorithm

More recently, a team have applied a combination of three models for forecasting the market trends. Namely, (1) Non-stationary Markov Chain (NMC), (2) Bidirectional Encoder Representations from Transformers (BERT), (3) Long Short-Term Memory (LSTM). Wherein their model shows an accuracy of 61.77%. Furthermore, the team also mentioned that the model produces 29.25% annual return on investment, with a maximum losses rating of -8.29% (Liu, Yan, Guo, & Guo, 2022).

2.2 Utilization of Dynamic Mode Decomposition (DMD) on the Financial Markets

Dynamic Mode Decomposition (DMD) as an emerging data-driven technique which allows spatial-temporal pattern recognition from a complex set of data and was first introduced in the field of fluid mechanics by (SCHMID, 2010).

2.2.1 Chronological Utilization of DMD in the Financial Markets

In (2015) Mann and Kutz proved that DMD can be used as data-driven analytics on the financial market data. Wherein, DMD allows a predictive assessment of the market dynamics, which helps in the capitalization of stock market strategies and decisions to be applied.

Utilization of DMD for Determining the Cyclic Behavior in the Stock Market (2016)

By utilizing the reproducible Koopman modes it made it possible to have extracted four cyclic variations (also reproducible modes) in the stock market, which were previously unknown and have persisted since the 1870s' global economic crisis (Hua, Roy, McCauley, & Gunaratne, 2016; Williamson, 2015).

Utilization of DMD as part of an Algorithmic Trading Strategies for the Turkish Stock Market (2015 and 2017)

The study of Mann and Kutz (2015) in the utilization of DMD for financial stock market prediction has become the foundation of the study by Savaş (2017) on the algorithmic trading strategies with Dynamic Mode Decomposition for the Turkish Stock Market. Wherein, based on their results they found out that the timing of DMD analysis was not significantly accurate, as such they have used a simple moving average with genetic algorithm to improve the market timing of DMD, which prevents 80% of the false trade signals.

Furthermore, this also shows that DMD is an effective alpha model that is easy to implement and use for any algorithmic trading strategy, and the addition of technical analysis tools can further improve its capabilities, especially on the predictive temporal side of the data.

Utilization of DMD-based Trading Strategy in the Chinese Stock Market (2016)

In the study by Cui and Long (2016), they have found that DMD was able to capture the dynamic patterns of the Chinese Stock Market, especially in a sideway trending market.

Their study also shows that the predictive ability of DMD can effectively model the behavior of the Chinese Stock Market, even if there are no clear trends that can be observed.

Utilization of Adaptive Elastic DMD to Improve Momentum Strategies (2021)

A study by Uchiyama and Nakagawa (2021), using Adaptive Elastic Dynamic Mode Decomposition (AEDMD) shows that they were able to estimate the market trend, and were able to demonstrate that the approach is better than existing momentum strategy which are only based on simple past trends.

2.3 Synthesis

Fast and accurate market information is an essential tool for stock market participants. In recent years, the development of machine learning models for the financial markets, such as stocks, has proven to be increasingly effective in predicting future stock prices and trends. The use of Dynamic Mode Decomposition (DMD) in the stock market has also been shown to be effective in predicting stock price trends. The simplicity and elegance of the Koopman Decomposition Operator make it an ideal basis for the development of a Stock Market Price Trend Forecasting System.

Hence, these studies are crucial for the development of the alamSYS. As it can

provide investors with fast and accurate information about which stocks are likely to go up or down, allowing them to make more informed decisions about buying or selling those stocks.

In addition to the potential benefits for investors and traders, the implementation of machine learning techniques in the stock market can also help improve market efficiency and reduce the risk of market manipulation. By providing a more accurate and comprehensive view of market trends, these techniques can help ensure that prices reflect the true value of stocks and other assets, leading to more stable and fair market conditions.

References

Adams, R. (2022, 7). *Is Investing in Stocks Gambling? No, Investing Isn't Zero Sum.* Retrieved October 07, 2022, from https://youngandtheinvested.com/is-investing-in-the-stock-market-gambling/

Agrawal, M., Khan, D. A. U., & Shukla, D. P. K. (2019, 7). Stock price prediction using technical indicators: A predictive model using optimal deep learning. *International Journal of Recent Technology and Engineering (IJRTE)*, *8*, 2297-2305. doi: 10.35940/ijrteB3048.078219

Alegado, S., Lopez, D. B., & Calonzo, A. (2022, 8). *Philippine economic growth slows to 7.4% as inflation bites.* Retrieved October 06, 2022, from https://www.bloomberg.com/news/articles/2022-08-09/philippine-economy-expands-7-4-last-quarter-below-estimate

Bae, K. H., & Kang, J. (2017). *Does the stock market benefit the economy?* Retrieved from https://www.efmaefm.org/0EFMSYMPOSIUM/2017/papers/Does%20the%20Stock%20Market%20Benefit%20the%20Economy%20-%20updated.pdf

Balaba, J. M. (2017). *Does the stock market drive the philippine economy?* Retrieved from https://www.dlsu.edu.ph/wp-content/uploads/pdf/conferences/research-congress-proceedings/2017/RVREBM/RVREBM-I-003.pdf

Bangko Sentral ng Pilipinas. (n.d.). *Stock market.* Retrieved October 06, 2022, from https://www.bsp.gov.ph/Statistics/OtherRealSectorAccounts/stocks.pdf

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). Retrieved from https://doi.org/10.1186%2Fs40537-021-00430-0 doi: 10.1186/s40537-021-00430-0

Bureau of the Treasury Bangko Sentral ng Pilipinas. (n.d.). *19 selected domestic interest rates weighted average in percent per annum for periods indicated.* Retrieved October 06, 2022, from www.bsp.gov.ph/Statistics/Financial%20System%20Accounts/tab19_dir.aspx

Business World. (2022, 5). *Psei sinks further as net foreign selling surges.* Retrieved October 06, 2022, from https://www.bworldonline.com/stock-market/2022/05/24/450559/psei-sinks-further-as-net-foreign-selling-surges/

Campbell, G. (2021, 5). *Does the stock market reflect the economy?* Retrieved October 07, 2022, from https://www.economicsobservatory.com/does-the-stock-market-reflect-the-economy

Canto, J., & Romano, K. (2022, 4). *Philippines economic outlook 2022.* Retrieved October 06, 2022, from https://www.mckinsey.com/featured-insights/asia-pacific/philippines-economic-outlook-2022

Chen, J. (2022, 7). *What is the stock market, what does it do, and how does it work?* Retrieved October 06, 2022, from https://www.investopedia.com/terms/s/stockmarket.asp

Commission on Population and Development. (2021). *Popcom: Number of filipinos in 2021 estimated at 110.8 million, sizes of families trending lower at 4 members.* Retrieved October 07, 2022, from https://popcom.gov.ph/popcom-number-of-filipinos-in-2021-estimated-at-110-8-million-sizes-of-families-trending-lower-at-4-members.

Cui, L. X., & Long, W. (2016, 11). Trading strategy based on dynamic mode decomposition: Tested in chinese stock market. *Physica A: Statistical Mechanics and its Applications*, *461*, 498-508. doi: 10.1016/j.physa.2016.06.046

Dash, R., & Dash, P. K. (2016, 3). A hybrid stock trading framework integrating technical analysis with machine learning techniques. *The Journal of Finance and Data Science*, *2*, 42-57. doi: 10.1016/j.jfds.2016.03.002

EdwardJones. (n.d.). *Why invest in stocks?* Retrieved September 19, 2022, from https://www.edwardjones.com/us-en/market-news-insights/guidance-perspective/benefits-investing-stock

Fayed, A. (2022, 4). *A list of 14 blue chip companies in the philippines.* Retrieved October 07, 2022, from https://adamfayed.com/a-list-of-14-blue-chip-companies-in-the-philippines/

Guo, Y. (2022). *Stock price prediction using machine learning.* Re-

trieved from https://www.diva-portal.org/smash/get/diva2:1672304/FULLTEXT01.pdf

Hall, M. (2022, 9). *How the stock market affects gdp.* Retrieved October 07, 2022, from https://www.investopedia.com/ask/answers/033015/how-does-stock-market-affect-gross-domestic-product-gdp.asp

Hua, J.-C., Roy, S., McCauley, J. L., & Gunaratne, G. H. (2016, 4). Using dynamic mode decomposition to extract cyclic behavior in the stock market. *Physica A: Statistical Mechanics and its Applications*, *448*, 172-180. doi: 10.1016/j.physa.2015.12.059

Kim, T. (2022, 7). *Alternative data for hedge funds: The competitive edge to investing.* Retrieved November 04, 2022, from https://www.similarweb.com/corp/blog/investor/asset-research/hedge-funds-use-alternative-data

Kumbure, M. M., Lohrmann, C., Luukka, P., & Porras, J. (2022, 7). Machine learning techniques and data for stock market forecasting: A literature review. *Expert Systems with Applications*, *197*, 116659. doi: 10.1016/j.eswa.2022.116659

Kuttichira, D. P., Gopalakrishnan, E. A., Menon, V. K., & Soman, K. P. (2017, 9). Stock price prediction using dynamic mode decomposition. In (p. 55-60). IEEE. doi: 10.1109/ICACCI.2017.8125816

Liu, C., Yan, J., Guo, F., & Guo, M. (2022, 8). Forecasting the market with machine learning algorithms: An application of nmc-bert-lstm-dqn-x algorithm in quantitative trading. *ACM Transactions on Knowledge Discovery from Data*, *16*, 1-22. doi: 10.1145/3488378

Lu, H., & Tartakovsky, D. M. (2020, 1). Prediction accuracy of dynamic mode decomposition. *SIAM Journal on Scientific Computing*, *42*, A1639-A1662. doi: 10.1137/19M1259948

Mann, J., & Kutz, J. N. (2015, 8). Dynamic mode decomposition for financial trading strategies.

Obthong, M., Tantisantiwong, N., Jeamwatthanachai, W., & Wills, G. (2020). A survey on machine learning for stock price prediction: Algorithms and techniques. In (p. 63-71). SCITEPRESS - Science and Technology Publications. doi: 10.5220/0009340700630071

Pang, X., Zhou, Y., Wang, P., Lin, W., & Chang, V. (2020, 3). An innovative neural network approach for stock market prediction. *The Journal of*

Supercomputing, *76*, 2098-2118. doi: 10.1007/s11227-017-2228-y

Rea, L. (2020, 8). *Predicting future stock market trends with python and machine learning.* Retrieved October 05, 2022, from https://towardsdatascience.com/predicting-future-stock-market-trends-with-python-machine-learning-2bf3f1633b3c

Reuters. (2022, 9). *Philippine economy to grow more slowly than previously thought in 2022, imf says.* Retrieved October 06, 2022, from https://www.reuters.com/markets/asia/philippines-economy-seen-growing-65-2022-50-2023-imf-2022-09-26/

Royal Bank of Canada Direct Investing Inc. (n.d.). Key benefits of investing in stocks. *Royal Bank of Canada Direct Investing Inc.*. Retrieved from www6.royalbank.com/en/di/hubs/investing-academy/chapter/key-benefits-of-investing-in-stocks/jv7atg13/jv7atg1j

Savaş, M. C. (2017). *Algorithmic trading strategies using dynamic mode decomposition: Applied to turkish stock market.* Retrieved from https://etd.lib.metu.edu.tr/upload/12621107/index.pdf

SCHMID, P. J. (2010, 8). Dynamic mode decomposition of numerical and experimental data. *Journal of Fluid Mechanics*, *656*, 5-28. doi: 10.1017/S0022112010001217

Schwab-Pomerantz, C. (2021, 2). *Is investing in the stock market gambling?* Retrieved October 07, 2022, from https://www.schwab.com/learn/story/is-investing-stock-market-gambling

Soni, P., Tewari, Y., & Krishnan, D. (2022, 1). Machine learning approaches in stock price prediction: A systematic review. *Journal of Physics: Conference Series*, *2161*, 012065. doi: 10.1088/1742-6596/2161/1/012065

Statista Research Department. (2022). *Number of stock market accounts philippines 2021.* Retrieved October 07, 2022, from www.statista.com/statistics/1194840/philippines-number-of-stock-market-accounts-by-type

Strader, T. J., Rozycki, J. J., Root, T. H., & Huang, Y.-H. (2020). *Machine learning stock market prediction studies: Review and research directions* (Vol. 28). Retrieved from https://scholarworks.lib.csusb.edu/jitim/vol28/iss4/3

Summers, B. D. (2022, 6). *Investing vs. gambling understanding risk-adjusted.* Retrieved October 07, 2022, from https://www.forbes.com/

sites/forbesfinancecouncil/2022/06/01/investing-vs-gambling-understanding-risk-adjusted-performance/?sh=1ca2a49957d9

The Economic Times. (n.d.). *What is 'stock market'.* Retrieved October 05, 2022, from https://economictimes.indiatimes.com/definition/stock-market

The Philippine Stock Exchange, Inc. (n.d.-a). *Company information.* Retrieved October 05, 2022, from https://edge.pse.com.ph/companyInformation/form.do?cmpy_id=478

The Philippine Stock Exchange, Inc. (n.d.-b). *Company list.* Retrieved October 05, 2022, from https://edge.pse.com.ph/companyDirectory/form.do

Trade Brains. (2022, 7). *How does the stock market affect the economy?* Retrieved October 07, 2022, from https://tradebrains.in/how-stock-market-affect-the-economy/

Trading Economics. (n.d.). *Philippines inflation rate.* Retrieved October 07, 2022, from https://tradingeconomics.com/philippines/inflation-cpi

Uchiyama, Y., & Nakagawa, K. (2021, 7). Improving momentum strategies using adaptive elastic dynamic mode decomposition. In (p. 388-393). IEEE. doi: 10.1109/IIAI-AAI53430.2021.00068

U.S. Securities and Exchange Commission. (n.d.). *What are stocks?* Retrieved October 07, 2022, from www.investor.gov/introduction-investing/investing-basics/investment-products/stocks

Williamson, J. G. (2015). *Handbook of the economics of international migration.* Retrieved December 15, 2022, from https://www.sciencedirect.com/topics/economics-econometrics-and-finance/global-economic-crisis