ARTIFICIAL INTELLIGENCE BASED SYSTEM FOR FINANCIAL DECISION SUPPORT

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ABSTRACT-The stock market is a complex, non-stationary and chaotic dynamic system. It is a popular investment platform that appeals to a wide variety of masses. While the stock market remains a significant way to earn profit, it is often considered one of the most risky forms of investment due to the underlying nature of the financial domain and a host of various factors that often elude the attention of naïve investors. The stock market is a hostile environment that demands undivided attention to the events that transpire throughout the day along with a certain consideration to the effects of the past and the implications on the future. Hence, many investors, face (or stand a risk) of failure on a daily basis. Therefore, the need of the hour is a Decision Support System (DSS) that takes into account market trends, financial analysis and strategies to identify the best time to purchase stocks and the actual stocks to purchase.

In this paper, we propose development of anArtificial Intelligence based decision support system (DSS) for guiding individual investors to buy and sell stocks. The Financial decision support shall be based on mathematical modeling of the various financial parameters to predict stock prices on a long term basis with a reasonable degree of accuracy and eliminate the behavioral biases of human decisions. This study mainly focuses on the using two Machine Learning Models namely Linear Regression and Artificial Neural Networks (ANNs), we found that the ANNs have better accuracy due to ability to generate non-linear outputs; they can be deployed for deep learning through multiple hidden layers and can solve complex financial regression problems. AI / Machine learning neural networks can revolutionize virtually every aspect of financial and investment decision making. Financial firms worldwide can employ neural networks to tackle difficult tasks involving intuitive judgement or requiring the detection of data patterns which elude conventional analytic techniques.

***Keywords*:Decision Support Systems (DSS), Stock Markets, Artificial Intelligence (AI), Machine Learning (ML), Mathematical Modeling (MM)**

1 INTRODUCTION

Financial decision making is the most critical area in domain of financial economics which has wide ramifications. Financial decision making is a highly empirical discipline; perhaps the most empirical among the branches of economics and even among the social sciences in general play a crucial role in the stability and growth of the global economy.

The empirical nature of financial decision making, like the other social sciences it is almost entirely non-experimental. The primary method of inference for the financial economist is model based statistical inference financial econometrics. While econometrics is also essential in other branches of economics, what distinguishes financial decision making is the central role that uncertainty plays in both financial theory and its empirical implementation.

The current state of financial decision is still dependent on the behavior aspects of human decision making, while the decision making is supported by IT technology such as Business Intelligence (BI) and MIS based systems to assist the decision makers for risk assessment and reward estimation, but the final decision of “GO-NO GO” is still dependent on human intelligence and intuition which come under the purview of Behavioral Finance

Even with advances in data mining and business intelligence, the decision making has a lot of errors which leads to bad financial decisions incurring huge losses to the stake holders. The problem with BI/MIS related systems are they are developed using complex set of preprogrammed rules and do not have any situational awareness nor they are pro-active in nature to change the rules when ground realities change which leads to improper decision making particularly in the financial domain where the ground realities change without any intimation

There is no automated financial decision making system that can replicate human intelligence, intuition and go through wide range of past historical data and take in to account the changing ground realities and take autonomous decisions which are based on proper risk-reward assessment.

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.

In this paper, we propose development of an Artificial Intelligence based decision support system (DSS) for guiding individual investors to buy and sell stocks. The Financial decision support shall be based on mathematical modeling of the various financial parameters to predict stock prices on a long term basis with a reasonable degree of accuracy and eliminate the behavioral biases of human decisions. We propose to develop such a novel system based on Artificial Intelligence/Machine learning and mathematical models which take in to account the fundamental value of the stock and the external factors affecting the stock price. We provide details about the financial decision support model and machine learning algorithms suitable for such a system. The later part of the paper discusses the various parameters that are suitable to be used in the model for predicting the intrinsic value of the stock and also the external macro-economic parameters which affect the stock price. Finally we discuss the advantages of having a financial decision support system for individual investors and provide details of the future scope and work involved in making the Financial DSS.

2 LITERATURE REVIEW

A detailed survey of literature available on DSS for financial domain specifically focusing on stock markets was done. Generally it is found that the usage of DSS in predicting stock prices is not mature and is an evolving field of study.

Anbalagan and Maheswari[1]describe about the usage of a Fuzzy Metagraph (FM) based stock market decision making, classification and prediction are proposed for short term investors of Indian stock market. Simple Moving Average (SMA), Exponential Moving Average (EMA), Moving Average Convergence Divergence (MACD) and Relative Strength Index (RSI) are some of the Technical Indicators which are used as input to train the system which is integrated with Fuzzy Metagraph. This paper develops a Decision support system for day trading based on Technical analysis. Fundamental analysis is not considered in this research work and no long term valuation of stock is done.

Bhandari et al. [2]Their research presents evidence that decision support systems can play an important role in de-biasing behaviorally challenged investors. An empirical study involving 119 participants provides strong evidence for the existence of cognitive biases in investment decision making and demonstrates the effectiveness of decision aids in lowering the negative impact of such biases on the ability of investors to make sound investment decisions. Additionally, such decision aids are shown to be more valuable in decision environments where the bias level is likely to be higher.

The research concludes that decision aids such as feedback and graphs can lower the impact of investment-related cognitive biases and they are more valuable in environments where the bias level is likely to be higher. Overall, this study supports the Social–Economic–Psychological model which underscores the necessity of social, economic, and psychological perspectives to understand the various needs of investors.

Cheng and Chen [3] Their paper mainly forecasts revenue growth rate of firms in stock trading systems by classification techniques and discusses Machine AI techniques to predict the Revenue growth rate of firms to predict stock prices

Dunne[4] In this MS thesis analyses existing and new methods of stock market prediction. This thesis discusses takes three different approaches at the problem: Fundamental analysis, Technical Analysis, and the application of Machine Learning. The paper finds evidence in support of the weak form of the Efficient Market Hypothesis, that the historic price does not contain useful information but out of sample data may be predictive. The thesis demonstrates a common flaw in Technical Analysis methodology and show that it produces limited useful information. Based on the findings, algorithmic trading programs are developed and simulated using Quantopian.

Rechenthin[5]This thesis explores predictability in the market and then designs a decision support framework that can be used by traders to provide suggested indications of future stock price direction along with an associated probability of making that move. Markets do not remain stable and approaches that are highly predictive at one moment may cease to be so as more traders spot the patterns and adjust their trading techniques. Ideally, if these “concept drifts” could be anticipated, then the trader could store models to use with each specific market condition (or concept) and later apply those models to incoming data. The assumption however is that the future is uncertain, therefore future concepts are still undecided. The framework adapts to these market changes by building thousands of traditional base classifiers (SVMs, Decision Trees, and Neural Networks), using random subsets of past data, and covering similar (sector) stocks and heuristically combining the best of these base classifiers.

Rudin[6] This thesis explores the possibility of predicting stock prices before the release of earning statements by companies. The model used is based on Machine learning using EPS (Earnings per Share) parameter and many technical indicators. The model hopes to some guidance on the stock prices to potential investors

Vaidya et al. [7]This paper highlights the above concerns regarding the volatile stock market and discusses the implementation of a DSS taking into account the modern and sophisticated techniques of Data Analytics like Clustering and forecasting models like Holt-Winters. Also, the DSS uses popular supervised learning algorithm used extensively in machine learning and Artificial Intelligence, the Perceptron. While the data analytics form the initial stage of the DSS, the decision-making will be aided by the Perceptron, which would consider the results of the aforementioned analysis and various local stock market parameters and a host of statistical concepts. This will culminate in a comprehensive DSS that will assist the potential investors in the most important aspect of success in the stock market i.e. decision-making.

Yong and Taib[8]This paper presents the continuous effort to explore stock price and trend prediction from finance perspective as well as from the combination of two major IT areas which are AI and Data Mining (DM). These areas have been explored to design a hybrid stock price prediction model with relevant techniques into the Stock Price Analysis and Prediction activities. The paper takes in to account both fundamental and Technical Analysis in to consideration. Artificial neural networks are used for fundamental analysis and statistical techniques are used for Technical analysis.

After doing extensive literature review, we found that there is a strong need for developing a Financial DSS. Our proposed FDSS is based on MM and AI/ML algorithms, to make this system reasonably accurate and useful for individual investors.

3 RESEARCH METHODOLOGY

We provide a novel approach to build a Financial Decision Support System that can be used for predicting the stock prices and can aid an individual investor with decision support. The approach is novel because, Instead of using pre-determined methods like mathematical equations, time-series models and other valuation methods which re-determine the weightage given to financial data, this model uses a machine learning approach using neural networks which adjusts the appropriate weights given to financial data that determine the actual stock price, in other words the model is based on the market reality and collective experience of investors participating in the stock markets.The design of the Financial DSS involves design of System Architecture, Mathematical Modeling of the system and the Machine learning modeling involving various supervised learning algorithms.

The system architecture of Financial DSS consists of:

- Computational System
- Historic Data
- Current Data
- User Interface

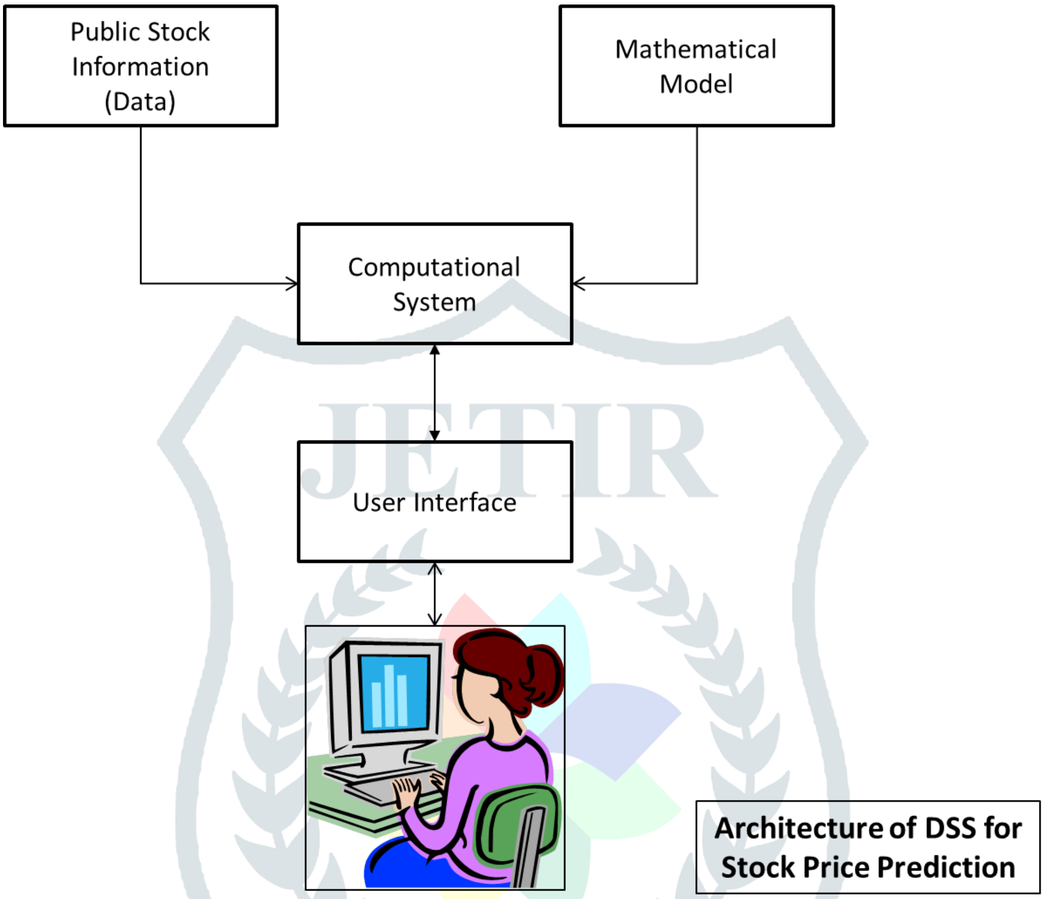

Fig. 1. Architecture of Financial DSS

Computational System: The Computational system consists of the model used for DSS and the machine learning models. The computational system is a general purpose PC which is capable of running mathematical computational software such as Octave / Matlab, the machine learning algorithms receive inputs in the form of financial data files about stocks from public domain

Historic Data: The historic data consists of past financial information about stocks over an extended period of time. Such data is primarily sourced from public sources on the internet. Sites such as Yahoo Finance and Money Control provide historical data on stocks up to 10 years. The data is sourced from these sites and stored in a database to be used by the Financial DSS. Historical data forms an input the machine learning model as a training set.

Current Data: The current data about a particular stock of interest is sourced from the internet on real-time basis by the database based on the query from investor on any particular stock using user interface and forms an input to the "Trained" Machine learning model for real-time stock price prediction.

3.1 Mathematical Model

The mathematical Model of Financial DSS used for Stock price prediction is based on two critical functions:

- Fundamental Value / Intrinsic Value of a Stock
- Macro-Economic Factors

Fundamental Value / Intrinsic Value of a Stock

Fundamental analysis is a method of evaluating a security in an attempt to measure its intrinsic value, by examining related economic, financial and other qualitative and quantitative factors. Fundamental analysts study anything that can affect the security's value, including macroeconomic factors such as the overall economy and industry conditions, and microeconomic factors such as financial conditions and company management. The end goal of fundamental analysis is to produce a quantitative value that an investor can compare with a security's current price, thus indicating whether the security is undervalued or overvalued. The financial parameters groups considered for intrinsic value are listed below:

- Investment Valuation Ratios ($\mathbf{R_v}$)
- Cash Flow Indicator Ratios($\mathbf{R_{cf}}$)
- Liquidity Measurement Ratios ($\mathbf{R_l}$)
- Profitability Indicator Ratios($\mathbf{R_{pf}}$)
- Debt Ratios($\mathbf{R_{db}}$)

The mathematical function that represents the Intrinsic Value of a Share ($\boldsymbol{I_v}$) is given below:

$$\boldsymbol{I_v = \varphi\ (R_v, R_{cf}, R_l, R_{pf}, R_{db})}\ (1)$$

Macro-Economic Factors

A macroeconomic factor is one that is related to the broad economy at the regional or national level and affects a large population rather than a few select individuals. Examples of macroeconomic factors are economic output, unemployment, inflation, savings, and investments, and they are key indicators of economic performance that are closely monitored by governments, businesses and consumers. The macro economic factors considered for the Financial DSS are as follows:

- GDP Growth Rate ($\mathbf{M_{gdp}}$)
- Consumer Price Index ($\mathbf{M_{cpi}}$)
- Interest Rate ($\mathbf{M_i}$)
- Employment Indicators ($\mathbf{M_{em}}$)

The above subset of macro-economic factors is considered as they have a direct impact of the investor sentiments and general health of the economy and stock markets.

The mathematical function that represents the Price of a Share ($\boldsymbol{S_p}$)is given below:

$$\boldsymbol{S_p = \emptyset\ (I_v, M_{gdp}, M_{cpi}, M_i, M_{em})} \qquad (2)$$

3.2 Artificial Intelligence / Machine learning algorithms

The machine learning models used to implement the mathematical equations described in the earlier section can be in two methods:

- Linear Regressions with Multiple Variables
- Artificial Neural Networks

Linear Regression with Multiple Variables

Multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data. Every value of the independent variable x is associated with a value of the dependent variable y. Machine Learning a linear regression model means estimating the values of the coefficients used in the representation with the data that we have available**.**

$$\boldsymbol{h_\theta(x) = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \cdots + \theta_n x_n}(3)$$

Cost Function: We need a function that will minimize the parameters over our dataset. One common function that is often used is mean squared error, which measure the difference between the estimator (the dataset) and the estimated value (the prediction). It looks like this:

$$\boldsymbol{J(\theta) = \frac{1}{2m}\sum_{i=1}^{m}(h_\theta(x^{(i)}) - y^{(i)})^2}(4)$$

Gradient Decent: When there are one or more inputs you can use a process of optimizing the values of the coefficients by iteratively minimizing the error of the model on your training data.

This operation is called Gradient Descent and works by starting with random values for each coefficient. The sum of the squared errors is calculated for each pair of input and output values. A learning rate is used as a scale factor and the coefficients are updated in the direction towards minimizing the error. The process is repeated until a minimum sum squared error is achieved or no further improvement is possible.

When using this method, we select a learning rate (alpha) parameter that determines the size of the improvement step to take on each iteration of the procedure.

$$\boldsymbol{\theta_j = \theta_j - \alpha\frac{\partial}{\partial\theta_j}J(\theta)} \qquad (5)$$

$$\boldsymbol{\theta_j = \theta_j - \alpha\frac{1}{m}\sum_1^m(h_\theta(x^{(i)} - y^{(i)})x_j^{(i)}} \qquad (6)$$

Artificial Neural Networks

Artificial neural networks (ANNs) or connectionist systems are computing systems vaguely inspired by the biological neural networks that constitute animal brains. Such systems "learn" tasks by considering historical data, generally without task-specific programming.

An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in a brain. Here, each circular node represents an artificial neuron and an arrow represents a connection from the output of one artificial neuron to the input of another. Each connection between artificial neurons can transmit a signal from one to another. The artificial neuron that receives the signal can process it and then signal artificial neurons connected to it.

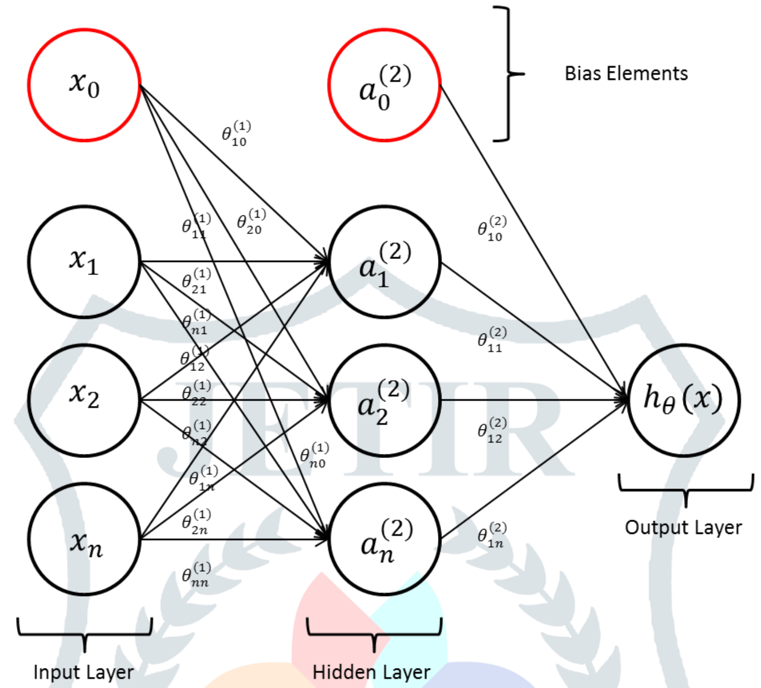

Fig. 2. Artificial Neural Network for Financial DSS

$$a_1^{(2)} = \theta_{10}^{(1)} x_0 + \theta_{11}^{(1)} x_1 + \theta_{12}^{(1)} x_2 \ldots + \theta_{1n}^{(1)} x_3 \quad (7)$$

$$a_2^{(2)} = \theta_{20}^{(1)} x_0 + \theta_{21}^{(1)} x_1 + \theta_{22}^{(1)} x_2 \ldots + \theta_{2n}^{(1)} x_3 (8)$$

$$a_n^{(2)} = \theta_{n0}^{(1)} x_0 + \theta_{n1}^{(1)} x_1 + \theta_{n2}^{(1)} x_2 \ldots + \theta_{nn}^{(1)} x_3 (9)$$

$$h_\theta(x) = \theta_{10}^{(2)} a_0^{(2)} + \theta_{11}^{(2)} a_1^{(2)} + \theta_{12}^{(2)} a_2^{(2)} \ldots + \theta_{1n}^{(2)} a_n^{(2)} \qquad (10)$$

Cost Function of ANN

A cost function is a measure of "how good" a neural network did with respect to its given training sample and the expected output. It also may depend on variables such as weights and biases. The cost function equation is given below:

$$\boldsymbol{J(\theta) = \frac{1}{2m} \sum_{i=1}^{m} (h_\theta(x^{(i)}) - y^{(i)})^2} \qquad \mathbf{(11)}$$

Back propagation Algorithm

Backpropagation is a method used in artificial neural networks to calculate a gradient that is needed in the calculation of the weights to be used in the network. It is commonly used to train deep neural networks, a term referring to neural networks with more than one hidden layer.

Backpropagation, short for "backward propagation of errors," is an algorithm for supervised learning of artificial neural networks using gradient descent. Given an artificial neural network and an error function, the method calculates the gradient of the error function with respect to the neural network's weights. It is a generalization of the delta rule for perceptrons to multilayer feedforward neural networks.

The "backwards" part of the name stems from the fact that calculation of the gradient proceeds backwards through the network, with the gradient of the final layer of weights being calculated first and the gradient of the first layer of weights being calculated last. Partial computations of the gradient from one layer are reused in the computation of the gradient for the previous layer. This backwards flow of the error information allows for efficient computation of the gradient at each layer versus the naive approach of calculating the gradient of each layer separately.

$$Given\ Training\ Set\ \{(x^{(1)}, y^{(1)}), \dots \dots .(x^{(m)}, y^{(m)})\}$$

$$\text{Gradient Computation: } \min_{\theta}\ j(\theta) = \frac{\partial}{\partial\theta_{ij}^{(l)}} J(\theta) (12)$$

$$Set\ \Delta_{ij}^{(l)} = 0\ (for\ all\ l, i, j)$$

$$\delta^{(L)} = a^{(L)} - y^{(i)} (13)$$

$$Compute\ \delta^{(L-1)}, \delta^{(L-2)}, \dots, \delta^{(2)}$$

$$\delta^{(L)} = error\ of\ node\ j\ in\ layer\ l$$

$$\Delta_{ij}^{(l)} = \Delta_{ij}^{(l)} + a_j^{(l)} \delta_i^{(l+1)} \qquad (14)$$

$$D_{ij}^{(l)} = \frac{1}{m} \Delta_{ij}^{(l)} + \lambda\theta_{ij}^{(l)}\ if\ j \neq 0 \qquad (15)$$

$$D_{ij}^{(l)} = \frac{1}{m} \Delta_{ij}^{(l)}\ if\ j = 0 (16)$$

$$\frac{\partial}{\partial\theta_{ij}^{(l)}} J(\theta) = D_{ij}^{(l)} (17)$$

3.3 Selecting Financial Parameters for the Financial DSS Model

As explained in the earlier sections, The Financial DSS model is based on Intrinsic / Fundamental and macro-economic parameters. The below ratios are selected as “Features / Attributes” for the machine learning models. The machine learning model will filer these features and select the most relevant ones for the deciding the final output.

Investment Valuation Ratios

Investment Valuation Ratios looks at a wide array of ratios that can be used by investors to estimate the attractiveness of a potential or existing investment and get an idea of its valuation.

- Per Share Data
- Price/Book Value Ratio
- Price/Cash Flow Ratio
- Price/Earnings Ratio
- Price/Earnings To Growth Ratio
- Price/Sales Ratio
- Dividend Yield
- Enterprise Value Multiple

Profitability Indicator Ratios

Profitability is a key piece of information that should be analyzed when you're considering investing in a company. This is because high revenues alone don't necessarily translate into dividends for investors (or increased stock prices, for that matter) unless a company is able to clear all of its expenses and costs. Profitability ratios are used to give us an idea of how likely it is that a company will turn a profit, as well as how that profit relates to other important information about the company.

- Profit Margin Analysis
- Effective Tax Rate
- Return On Assets
- Return On Equity
- Return On Capital Employed

Liquidity Measurement Ratios

Liquidity is a measure of how quickly a company's assets can be converted to cash. Liquidity ratios can give investors an idea of how capable a company will be at raising cash to purchase additional assets or to repay creditors quickly, either in an emergency situation, or in the course of normal business.

- Current Ratio
- Quick Ratio
- Cash Ratio
- Cash Conversion Cycle

Debt Ratios

The third series of ratios in this tutorial are debt ratios. These ratios give users a general idea of the company's overall debt load as well as its mix of equity and debt. Debt ratios can be used to determine the overall level of financial risk a company and its shareholders face. In general, the greater the amount of debt held by a company the greater the financial risk of bankruptcy.

- Overview of Debt
- Debt Ratio
- Debt-Equity Ratio
- Capitalization Ratio
- Interest Coverage Ratio
- Cash Flow To Debt Ratio

Cash Flow Indicator Ratios

Cash flow indicators focus on the cash being generated in terms of how much is being generated andthe safety net that it provides to the company. These ratios use cash flow compared to other company metrics todetermine how much cash they are generating from their sales, the amount ofcash they are generating free and clear, and the amount of cash they have tocover obligations

- Operating Cash Flow/Sales Ratio
- Free Cash Flow/Operating Cash Ratio
- Cash Flow Coverage Ratio
- Dividend Payout Ratio

GDP Growth Rate

The GDP is the broadest measure of a country's economy, and it represents the total market value of all goods and services produced in a country during a given year. Since the GDP figure itself is often considered a lagging indicator, most traders focus on the two reports that are issued in the months before the final GDP figures: the advance report and the preliminary report. Significant revisions between these reports can cause considerable stock market volatility.

Consumer Price Index

The Consumer Price Index (CPI) is probably the most crucial indicator of inflation. It represents changes in the level of retail prices for the basic consumer basket. Inflation is tied directly to the purchasing power of a currency within its borders and affects its standing on the international markets. If the economy develops in normal conditions, the increase in CPI can lead to an increase in basic interest rates.

Interest Rate

Interest rates play the most important role in moving the prices of currencies in the foreign exchange market. As the institutions that set interest rates, central banks are therefore the most influential actors. Interest rates dictate flows of investment. Since currencies are the representations of a country's economy, differences in interest rates affect the relative worth of currencies in relation to one another. When central banks change interest rates they cause the stock markets to experience movement and volatility.

Employment Indicators

Employment indicators reflect the overall health of an economy or business cycle. In order to understand how an economy is functioning, it is important to know how many jobs are being created or destructed, what percentage of the work force is actively working, and how many new people are claiming unemployment. For inflation measurement, it is also important to monitor the speed at which wages are growing.

4 FINDINGS OF THE STUDY AND IMPLICATIONS

The machine learning model chosen for further development is the Artificial Neural networks over the Linear Regression models as the stock markets seldom behave in a linear way. Also the curve fitting using linear regression is complex and not very accurate for higher order polynomials.The advantage of using artificial neural networks is that it automatically adjusts for the complex curves using the "Hidden" Layer.

The artificial neural network for stock price prediction will be run on a general purpose PC operating WEKA software applicationand the cost function of each simulation with financial data will be evaluated in comparison to the real-time stock prices

The proposed outcome of the Financial DSS for predicting the Stock Prices and assisting individual investors with decision support are multi-fold:

- The more efficient processing of information ensures that predicted stock prices are more closer to the real-time market value eventually may contribute to a more efficient financial system.
- Millions of Individual Investors can make their financial decisions on stocks using this system for a fraction of cost paid to corporate financial consultants
- The applications of AI and machine learning by regulators and supervisors can help improve regulatory compliance and increase supervisory effectiveness.

- Applications of AI and machine learning could result in new and unexpected forms of interconnectedness between financial markets and institutions, for instance based on the use by various institutions of previously unrelated data sources.
- Network effects and scalability of new technologies may give rise to third-party dependencies. This could in turn lead to the emergence of new systemically important players that could fall outside the regulatory perimeter.
- As with any new product or service, it will be important to assess uses of AI and machine learning in view of their risks, including adherence to relevant protocols on data privacy, conduct risks, and cybersecurity. Adequate testing and ‘training’ of tools with unbiased data and feedback mechanisms is important to ensure applications do what they are intended to do.
- Machine learning neural networks can revolutionize virtually every aspect of financial and investment decision making. Financial firms worldwide can employ neural networks to tackle difficult tasks involving intuitive judgement or requiring the detection of data patterns which elude conventional analytic techniques. Unlike other types of artificial intelligence, neural networks mimic to some extent the processing characteristics of the human brain. As a result, neural networks can draw conclusions from incomplete data, recognize patterns as they unfold in real time and forecast the future. They can even learn from past mistakes!

5 CONCLUSIONS

The stock market is an unforgiving place for many individual investors due to the highly volatile and unpredictable nature of the stock prices. The aim of the proposed Financial DSS is to assist the individual investors with analysis and prediction of stock prices with reasonable accuracy. Using Machine learning and Artificial Neural networks the financial data is subjected to deep analysis and valuable insights are generated. The Novel approach of using artificial neural networks to determine the weightage given to each financial parameter and thus predict the stock prices is path breaking methodology in financial decision support research area. The Proposed DSS has considered both Intrinsic and macro-economic parameters which will enable the system to comprehensively predict stock prices.The authors are working on enhancing the machine learning models and fine tuning the financial parameters to more accurately predict the stock prices.

6 REFERENCES

[1] T. Anbalagan and S. U. Maheswari, “Classification and prediction of stock market index based on Fuzzy Metagraph,” *Procedia Comput. Sci.*, vol. 47, no. C, pp. 214–221, 2014.

[2] G. Bhandari, K. Hassanein, and R. Deaves, “Debiasing investors with decision support systems: An experimental investigation,” *Decis. Support Syst.*, vol. 46, no. 1, pp. 399–410, 2008.

[3] C.-H. Cheng and Y.-S. Chen, “Fundamental Analysis of Stock Trading Systems using Classification Techniques,” *2007 Int. Conf. Mach. Learn. Cybern.*, vol. 3, no. August, pp. 1377–1382, 2007.

[4] M. Dunne, “Stock Market Prediction Declaration of Originality,” *Dept Comput. Sci. Univ. Coll. Cork*, vol. 1, no. 1, p. 10, 2017.

[5] M. D. Rechenthin, “Machine-learning classification techniques for the analysis and prediction of high-frequency stock direction,” *Iowa Res. Online*, p. 293, 2014.

[6] C. Rudin, “A Profitable Approach to Security Analysis Using Machine Learning: An Application to the Prediction of Market Behavior Following Earnings Reports,” *15.097 Predict. Mach. Learn. Stat.*, pp. 1–22, 2012.

[7] A. M. Vaidya, N. H. Waghela, and S. S. Yewale, “Decision Support System for the Stock Market using Data Analytics and Artificial Intelligence,” *Int. J. Comput. Appl.*, vol. 117, no. 8, pp. 21–28, 2015.

[8] C. C. Yong and S. M. Taib, “Designing a Decision Support System Model for Stock Investment Strategy,” *October*, vol. I, pp. 6–10, 2009.