A Neural Networks Adoption Framework for Predicting Stock Market Trends: Case of the Zimbabwe Stock Exchange

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Abstract

The Zimbabwe Stock Exchange (ZSE) is a key institution in the country which falls under the Ministry of Finance.This institution feeds important information into the National Budgets for forecasting and planning. The degree of bias or uncertainty in the information provided will, in turn, distort the planning of critical department or even other arms of the Government. This dissertation seeks to rationalise and advocate for the use of Artificial Neural Networks (ANN) by this key department in predicting, yearly turnovers, as well as daily stock market, counters price's by the stock brokers. The Zimbabwe Stock Exchange currently uses trend analysis based on historical data to compute their predictions. The absence of machine learning in the prediction in the current method being used by the exchange creates a gap and increases the level of bias. The Stock Exchange is mandated by the Government to provide markets and economic forecasts yearly.The forecasted data includes Foreign Direct Investments (FDI), Annual Turnovers and the market Outlook in terms of Listed Counters.The figures provided by the exchange have to be factual and accurate. The research included the set objectives that are detailed in the first chapter. The second chapter is made up of the literature review of Stock Exchanges that has walked the path before and the computational methods using ANN that are the ZSE can consider, benefits and demerits of each type of neural network model are assessed. The third chapter analysed the methodology used in data collection and how the information was gathered. A detailed framework is developed in the fourth chapter and the summary and recommendations are in the last chapter.

KEYWORDS: Neural networks, Stock market, Trends, Stock exchange, Zimbabwe

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1.0. INTRODUCTION

Stock market prediction or stock returns is a vital financial subject that has drawn researchers' attention over the decades. It follows an underlying understanding and assumption that financial data has some predictive relationship to future yields on stock investments. Stock market prediction is the process of analysing and computing a company stock to ascertain its future value or other financial instruments like government bonds and coupons tradeable on an exchange. The predictions of such instruments are important in forecasting annual turnovers; share price movements, portfolio analysis and valuation and pricing could yield significant profits to the investing public and increase the profitability and viability of any exchange. Forecasting is an attempt to predict how a future event will occur while prediction tries to ascertain the degree of accuracy in a given phenomenon (Kimoto, 2014).The main objective of forecasting or any stock predictions is to foretell with accuracy any price movement to enable stock brokers and the investing public who are the decision makers to make better-informed decisions. There are two major approaches to forecasting, namely explanatory (causal) and time series.

The Zimbabwe Stock Exchange is using fundamental analysis in predicting any stock price movements. The fundamental analysis takes a keen look at the company itself its stock valuation; the performance of the company as well as its credit rating including the credibility of its accounts to predict its future stock value. This is a primitive prediction technique and has been replaced with modern prediction techniques such as neural networks based prediction algorithms. Another popular prediction technique is the technical analysis prediction model also known as chartists, this model does not consider the company's financial fundamentals, but rather compute and predict the future price of a stock on past price trends this is known as time series analysis. (Chao, Shen, and Zhao (2011) purport that technical analyst's study patterns, statistical techniques and an example of such are the exponential moving average (EMA).

Technological advancements powered by computer digitalisation have led to the use of the artificial neural network (ANN) in prediction. ANNs are described as a mathematical function that approximates and make use of algorithms. The simplest ANN used for predicting future stock market prices is the feed forward network that makes use of backwards propagation of errors algorithm. This algorithm is used to update the network weights. This kind of networks is known as the backpropagation network. Also widely used in market predictions is the delay neural network (TDNN) as well as the time recurrent neural network (RNN). The types in this group are the Elman, Jordan, and Elman-Jordan networks as noted examples of RNN and TDNN (Shingita Nagata, Kimoto and Asakawa, 2012)

1.2 Background of Study

The Zimbabwe Stock Exchange is a key institution established in 1896 and is mandated to trade in stocks both on the local and international markets. The organisation falls under the Ministry of Finance. This institution feeds important information into the National Budgets for forecasting and planning. The degree of bias or uncertainty in the information provided will, in turn, distort the planning of critical department or even other arms of the Government. This dissertation seeks to rationalise and advocate for the use of Artificial Neural Networks by this key department in predicting, yearly turnovers, as well as daily stock market, counters price's by the stock brokers. The Zimbabwe Stock Exchange (ZSE) currently uses fundamental analysis in its predictions computations.(Kimoto and Akasawa 2011) argue that the absence of machine learning in the

prediction in the current method used by the exchange creates a gap and increases the level of bias. On the global scene, studies in artificial neural networks stock market predictions began around 1996 and numerous researcher and authors continue to exploit the subject. One of the first projects was by (Kimoto and Akasawa 2011) who used ANN for the prediction of Tokyo stock exchange index. They developed a number of learning algorithms and prediction methods for the TOPIX (Tokyo Stock Exchange Prices Indexes) prediction system. The prediction system achieved accurate predictions and the simulation on stocks trading showed an excellent profit. (Mizuno 1998) went on to further apply ANN again to Tokyo stock exchange to predict buying and the patterns in the selling signals with an overall prediction rate of 63%. Phua (1998) developed prototypes and went on to research on neural network working with a genetic algorithm. His work was carried out on the stock exchange market of Singapore and predicted the market direction with an accuracy of 81%. In Europe, the London Stock Exchange that trades famous counters like Dow Jones and the NASDAQ moved way back to the modern computation methods that use artificial neural networks in their predictions. In Taiwan, practical applications of neural networks fuzzy systems included systems for predictions on stocks and foreign exchange. According to (Chen 2012), fuzzy logic time series prediction models improve the efficiency of the neural networks in terms of the time taken to compute and accuracy. This is based on their research carried out on the Taiwan Stock Exchange. The output derived proved to have a marginal degree of error of 2.75% pointing to the high accuracy of predictions by the fuzzy network.

Narrowing down to Africa, In Nigeria, (Akinwale 2009) used a combination of regression neural network and backpropagation algorithm to analyse and predict Nigerian stock market prices (NSMP). The study they carried out forecasted the performance of the neural networks with stock market prices as inputs, and this revealed the outcome from an Artificial neural network had a higher prediction accuracy measures, compared to fundamental analysis and technical analysis. In South Africa, Marwala (2014) noted that the gains coming from the use of nonlinear models currently in use by the Johannesburg stock exchange had not reached a consensus and further studies on stimulating nonlinear model selection, estimation and evaluation approaches are underway. Artificial intelligence techniques are also highly advocated for their adoption. Neural networks and support vector machines are currently under consideration and investigation. Researchers are of the view that artificial neural network techniques can thus be used to produce better predictions of future stock returns or prices.

The study shall look at the Zimbabwean case and endeavour to advocate for the use of neural networks by the local bourse. The investing public stands guided by forecasts done by the Zimbabwe Stock Exchange and other research institutions in the brokerage firms in making investment decisions. Institutional and individual shareholders persistently and continuously flow the predictions done to simulate and decide how best to manage their investment portfolios. It thus becomes imperative that any information or data focused by this important organisation is accurate, factual with minimum bias.(Mcculloth and Pitts 1943) introduced the first artificial network that factored the bias component in computations. In Zimbabwe unforeseen activities such as the introduction of bond notes 2016 (RBZ monetary policy Issue 2/2016), can be dealt with under the bias factor in computations, to increases the prediction accuracy.

1.3 Research Problem

In South Africa, Marwala (2014) noted that the Johannesburg Stock Exchange had high degrees of error and bias in their prediction models due to the use of fundamental analyses on stock computations and proposed the use of ANN. (Aamodt 2015) carried out studies on the comparative prediction models on the Oslo Stock Exchange and noted the effectiveness and efficiency of using ANN. Zimbabwe Stock Exchange uses fundamental analysis which is a primitive way of forecasting daily, monthly and annual turnovers and this has cost the institution much in terms of poor forecasted budgets. Advocating for the use of Neural Networks will reduce significantly the level of bias and increase the accuracy of forecasts. With the use of neural networks, this high degree of bias can easily be a thing of the past, as the neural network has the capacity to learn from previous data through its training data set to compute and adjust the outputs to more accurate figures. Therefore, in summary, the problem outlined in this research is the high degrees of error and bias in prediction models currently used by the Zimbabwe Stock Exchange and hence the need for a framework for the adoption of neural networks in prediction.

1.4 Objectives

The objectives of this research are highlighted below, the study shall analyse the issues to the adoption and develop a framework for neural network use in stock market predictions. The following objectives will be achieved.

The primary Objective

- To the development of a Framework for the adoption of ANN for a prediction on the ZSE.

The secondary Objectives

- To identify the strengths and weaknesses of the current methods used to predict Stock Market Activities on the ZSE
- To identify the causes and find recommendations to the weakness and degrees of error in current market Activities on the ZSE.
- To analyse the impact of using Artificial Neural Networks on the local bourse (ZSE) for predictions and forecasting.

1.5 Research Questions

Research questions to be answered in this research will give an in-depth analysis on how artificial neural networks can be used to predict stock market activities on the Zimbabwe Stock Exchange.

The following questions are to be answered:

- What are the current weaknesses and strengths of the methods used in predictions on the local bourse?
- What are the limitations faced with the method?
- How can the stock exchange adopt artificial neural networks?
- Explain why the degree of bias in prediction is associated with the model in use?

2.0. LITERATURE REVIEW

2.1. Stock Markets

Stock Markets are defined as an area or arena that allows for the convergence of willing sellers and buyers of financial instruments such as equities, commodities, bonds, coupons or any commercial dealings to trade or execute a transaction. An aggregation of buyers and sellers trading in a number of commercial instruments such as stocks, bonds, or currencies is termed a financial market. A stock market in simpler terms is a financial market that trades company shares. (Buffet 2016) views the term stock market as an abstract term; and argues that actual trades are usually executed over an electronic trading platform or even over the counter, at a stock exchange. Transactional trades that are executed over the stock exchanges are referenced through traceable numbers and hence are easily traced. This is made possible through the centralised, integrity and transparent codes and conducts that govern the exchange. This makes the study of stock markets feasible and approachable, unlike for instance other markets such as foreign exchange markets where information and data have to be aggregated from a number of differing decentralised sources.
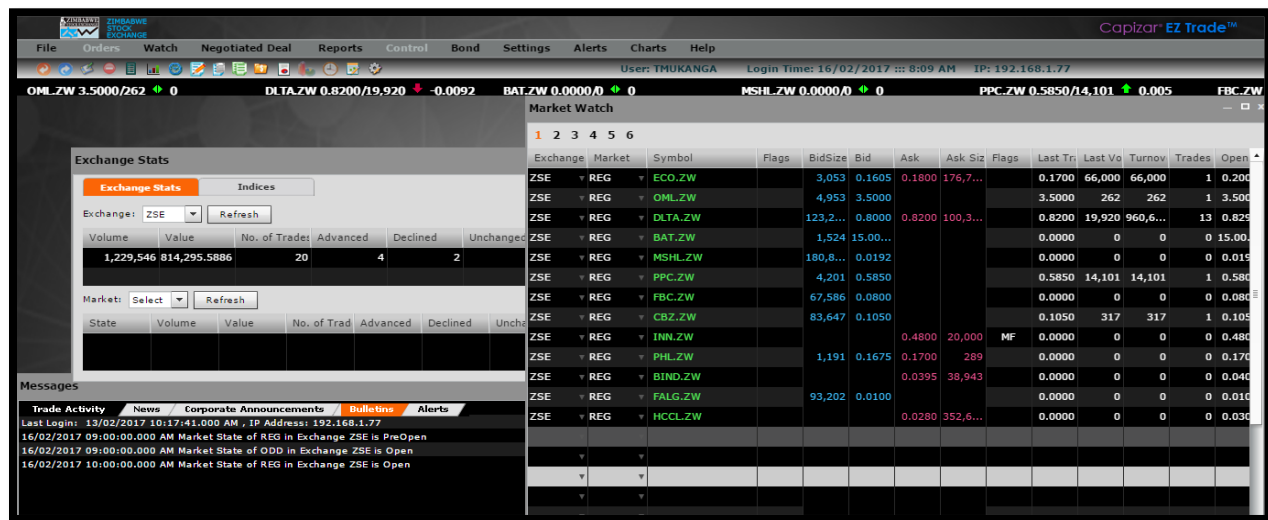
2.2. Stock Exchanges

A stock exchange is an institution mandated by the local act of parliament to allow for buyers and sellers to converge and fulfil trades. (Buffet 2015) defines an exchange as a market that allows for securities to be bought and sold, he notes that the term market in this instance refers to a physical place or building, unlike virtual stock markets that can be online. The transactional activity at an exchange is visible to stock brokers and other market participants. This gives the participants a chance to participate in determining the share price either pushing the price up or down. The fundamental principles of supply and demand govern the operation of the market. A liquid stock is defined as an equity, bond or commodity that has, significant amounts of activity and trade regularly making it disposal and acquisition easy. For less stock that is illiquid, the participants struggle to settle the trades as they are usually no willing buyers and sellers readily available. Stock brokers will thus have to compromises on a less favourable price, to increase the chances of settling the trade. Trade slippage is defined as the variance of the settling price rather than the actual intended price. In a typical market that trades liquid stocks, trades can be fulfilled almost instantly, as a ready buyer usually awaits a sell order as fundamental market principles exist. On most stock exchanges it is relatively easy to gather historical data on most counters or commodities as the transparency and governing securities commissions make it mandatory to archive and keep such data. Analysts and market participate usually need the data they gain from the exchanges to model and forecast price movements. This type of computation is known as technical analysis, based on its reliance on the price movements. After a thorough and detailed explanation of stock markets, there is need to understand the market positions that arise in any given market, thus the next section is going to analyse the market positions that exist.

2.3. Market Positions

Entering the market is simply explained as the process when an individual purchases shares in a company. This exposes the individual to the price changes, where the investment in purchasing the counter may appreciate due to an increased share price or depreciate due to a fall on the counter price. Profitability in the investment is measured as a percentage of increment in the price based on the original purchase price. Profits are realised on the actual sale of the share and this will be at a higher price. Apart from the dividends that a shareholder is entitled to, when the company is performing the other benefit he or she enjoys is on sale at an increased price. The speculative motive is the sole purpose of purchasing shares with the hope that the price will rise and one will

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reap commensurate benefits. (Buffet 2013) explains that shares are purchased during times of depression and argued that farmers are better off during a year of famine that a year of bumper harvest. Profits will then be realised at a later stage when the counter will be more valuable after stabilisation of the market. The stock market has also been described as a gambling game of educated investors who take a keen look at the research and history of a company. They also access the macro fundamentals conditions persisting in a given market before gambling. The level of uncertainty has kept the market unpredictable and the need to predict with a degree of accuracy a key advantage in the mastery of the market. This key issue has driven the researcher to undertake the dissertation on the adoption framework of neural networks on stock predictions on the local bourse.

Figure 2.1: An extract from the ZSE trading system

2.4. Predictions on Stock Exchanges

Artificial Neural Networks can be used to predict stock market activities. The accuracy of predictions using ANN is proving to be more powerful in computation accuracy compared to other computation models and hence the author purports to develop a framework for the adoption of neural networks by the local bourse Zimbabwe Stock Exchange.

2.5. Forecasting / Prediction

Forecasting is an attempt to predict how a future event will occur while prediction tries to ascertain the degree of accuracy in a given phenomenon. The main objective of forecasting stock predictions and price movement is for stock brokers and the investing public who are the decision makers to make better-informed decisions. There are two major approaches to forecasting, namely explanatory (causal) and time series.

2.6. Explanatory forecasting

(Armstrong 2001) argues that, explanatory forecasting assumes a cause and effect relationship between the inputs and output. According to explanatory forecasting, a change in the inputs will, in turn, affect the output of the system in a predictable way, assuming the cause and effect

relationship is constant. An example would be a reduction in the number of transistors supplying power, affecting the sound output in a radio system.

2.7. Time series forecasting

(Jennings& Kulahci 2008) explain that, in time series forecasting a system is treated as a black box and the forecasting tries to discover the factors affecting the behaviour. They argue that the factors affecting the behaviour are not easily identifiable and straight forward, but time series predictions study the patterns and a forecast is computed. There are two reasons behind treating a system as a black box. The first reason is that the system may be difficult to understand, and they insisted that even if it were to be understood it may be extremely difficult to measure the relationships assumed to govern its behaviour. Secondly, the other concern may be only to predict what will happen and not why it happens. The financial time series is one of the least understood areas which has been under scrutiny for some time for reasons that are well known (to improve investment returns).

2.8. The artificial neural network

Artificial neurone models derive their existence based on the simplified model of the biological neurones. This has allowed them to resemble the structure of a biological neurone and how it functions. The artificial neurone is also sometimes referred to as the perceptron model and is similar to the biological neurone.The diagram below illustrates how they are used.
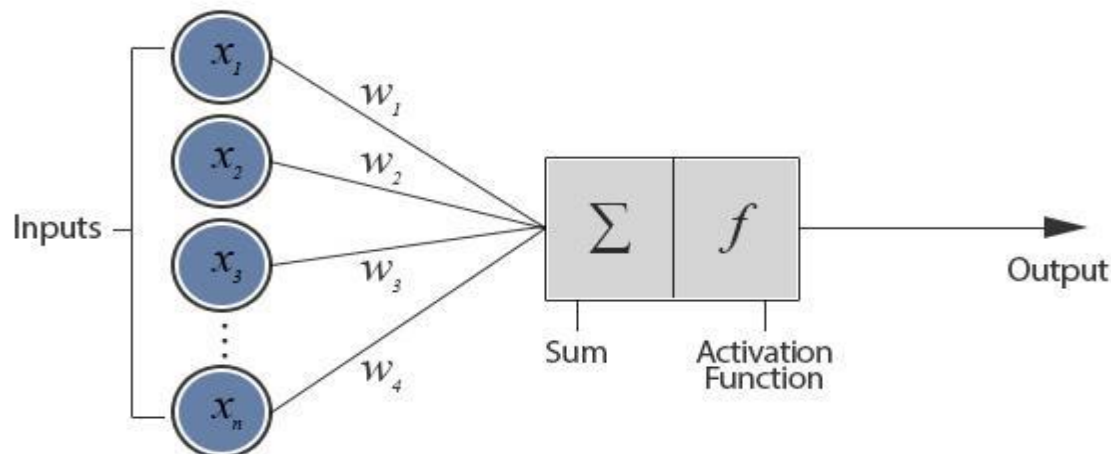

Figure 2.2: The Perceptron Model (Adapted from McCulloth Pitts 1943)

The above illustration shows the simple typical perceptron model will have a number of inputs. Each input is weighed individually. The perceptron model weights are each multiplied with an input and the result will either increase or decrease the input signal that we originally had. An example to illustrate how we can possibly compute a simple perceptron is shown below, if the input is 1 and the corresponding input's weight is set at 0.3 the input will be decreased to 0.3. All the weighted signals from each input are then summed up and the total summation is then passed on and computed with the activation function. A more useful output is obtained based on the computation with the activation function Numerous activation functions are in place for use and vary with the phenomenon under study , these include the step function, stepwise function, linear function, and sigmoid function amongst others but the simplest to use and also viewed as the easy to understand is the step function. A step function has two basic outputs if an output is 1 it means

that the input is higher than a certain threshold, otherwise, the other corresponding output will be 0 meaning its lower than a certain threshold. An example on stock market turnover predictions:

Input 1 (Delta share in 2015) (x1) = 0.6 Input 2 (Delta share in 2016) (x2) = 1.0 Weight 1 (w1) = 0.5 Weight 2 (w2) = 0.8 13

Weights can be calculated based on the company profitability in the prior year Threshold = 1.0

The sum is the result of multiplying the inputs by their weights:

x1w1 + x2w2 = (0.6 x 0.5) + (1 x 0.8) = 1.1

In computations, the perceptron model will simply calculate the input total to the perceptron's activation threshold. In the Delta share price example above the summation from the input (1.1) is higher than the activation threshold (1.0) the result would be the neurone would fire.

This basic computation is applied to most of the models without the hidden layers and is widely used because of its ease of use.

2.9. Learning of a neural network

According to (Buffet 2015), learning is a process of associating different events with their consequences. He argued that learning thus becomes a probable attempt to substantiate the relationship between the cause and effect principle. The main advantage that is derived and enjoyed from machine learning (neural network) compared to the biological neurone (humans) is that machine learning has the ability and capacity to handle, assimilate and act on large amounts of data. The other benefit is that the accuracy and processing time is much faster and reliable in comparison to the human neurone. It has been noted that the figures and data that is generated in stock exchanges usually follow a sequential pattern and trend that once a neural network is trained it can easily note the patterns and learn from the data.

Similar studies in prediction by (Philip 2015) who researched on artificial neural network modelling but in rainfall predictions focusing in the Indian region of Trivandrum revealed important observations.He obtained results for eighty-seven years of that particular region. He went on to train the neural network with the data he had gathered for the first forty years. The neural network went on to compute the remaining forty-seven years. After obtaining the results the next stage was to compare the results with the actual rainfall received. The outcome proved that NN had a high level of accuracy and the percentage margin of error was only four percent. This result did prove that NN had a deterministic nature that could be used for forecasting based on the random information that would have been provided. The approach proved that it could be used in data mining areas where ANN has been used and proved to be a powerful computational tool in research areas.

As a general rule of thumb, the learning process is believed to depend mostly on two (2) fundamental aspects. The first rule is the identification of the main aspects (factors) that could be viewed as having an influence on the system. These factors are to be closely monitored and there is need to keep track of the changes and the evolution of such the factors

In the Stock Market Prediction the factors that need to be constantly kept track of are as follows:

• Rate of Inflation

- Foreign Direct Investments

- Consumers Net Disposable Income

The other important factor is the identification of all the factors of the event horizon under study, the reason being to ensure that the predictions be valid and accurate. In the, turnover prediction, the neural network computes whether daily, weekly, monthly or even annually the total revenue generated by the exchange systems.

2.10. Learning Types

Granger (1992) argues that the process of learning is usually simulated by a numerous algorithms. An algorithm is explained as the concrete steps that can be followed to achieve a solution. These algorithms are usually used to train the artificial neural network under study. It is important to note that algorithms differ and each algorithm has its own merits and demerits. The learning process of a neural network is perfected through altering the network's weights, and continual altering of weights increase the accuracy within a learning algorithm. The main reason for these computations within a probable set is that when the weight matrices are then applied to the neural network the NN will then have the capacity to provide the inputs with an accurate output. This dissertation is advocating for an adoption of a neural network framework that is primarily based on supervised learning.

2.11. Supervised Learning

(Makridakis and Anderson 2014) state that the learning algorithm that falls under supervised learning follows a pattern that stipulates that the desired output from the network is provided for and known. The process of training the inputs to provide the outputs is a complicated process and accuracy is a key desired output. For the purposes of training the neural network to compute an output with a high degree of accuracy simulation will have to be done on already existing data. The fact that we will have provided the network with both an input and output set of data it becomes apparently possible to calculate an error margin based on its expected output. Continuous updating of the weights will reduce the margin of the degree of error.

2.12. Unsupervised learning

(Makridakis and Anderson 2014) In unsupervised learning the network is expected to study the pattern from the input provided for, it is the duty of the neural network to provide the output without any external help. This type of learning paradigm is complex and is usually associated with data mining. Many algorithms take after this form due to their ability to predict an output based on the computations of other similar outputs it will have learnt from.

2.13. Reinforcement learning

(Granger 1992) Reinforcement learning is defined as a mixture and combination of supervised and unsupervised learning .It however takes much from supervised learning as it provides for feedback. Reinforced learning provides a target output as reward and this is given based on system performance. The goal of reinforcement learning is to ensure that we maximize the reward the system gets through the process of trial-and-error. Reinforced learning is achieved as the network is able to apply or recommend a solution basing on its previous lessons learnt.

2.14. Learning through association

(Makridakis and Anderson 2014) argue that learning through associations is viewed as the simplest and most commonly learning process. It makes use of the learning, hinged on the cause and effect principle. Logic gates are usually used to prove the power in associative learning.

2.15. Prediction techniques used in stock markets

Accurate prediction of stock figures are the main goals of an exchange for efficient planning, however it is generally viewed as an mammoth task especially if a nation's economy is being affected by macroeconomic fundamentals that are way beyond the exchange's control such as inflation, interest rates and fluctuations of exchange rate .In the past years, the importance of the price of a stocks has attracted wide interest from the investing public (Okan et al, 2009). This attention is driven by the desire to analyse, forecast and plan investment portfolios. Any investment seeks to recoup an initial return (ROI), profitability and dividend accumulation .It is against this background that prediction is important and a worthwhile activity in any market. Trading volumes, turnovers, capitalisation of exchanges, fluctuations in share prices, market indices and indexes become the guiding forces in any investment decision hence accurate computational prediction models are needed. As documented mostly in economic and financial literature, there is a positive correlation between trading volume and price volatility. (Schwert 2012) evidenced a positive correlation relationship between estimated volatility and the actual current prices against the previously generated volume growth rates. The assessments were done using linear distributed lag and VAR model using the Standard and (Poor S&P) index form the daily aggregate data.

2.16 Primitive techniques used to predict on Stock Markets

Prediction models have evolved over the past years and continue to evolve as markets have proved to be volatile and progressive. The complexity of most recent models has also increased to enable them to deal with ever changing and complex markets. This section of the thesis presents the different models that have been use and still be used by other lagging markets as well as the ones being currently adopted and are in use including the models that are still under research.

2.17 Smoothing

In stock markets the smoothing methods is one of the earlier models that have been used to determine the average value of the trading volume around which the data is fluctuating. (Bartolomei and Sweet 2015) The method takes two typical approaches the moving average as well as the exponential smoothing. Moving averages are calculated by summing up a series of trade volume data and the summation is divisible by the total observations under study. In moving averages the summed number of the total observations is mostly determined arbitrarily with the view to compromise between the responsiveness of the prediction and the stability of the market. Moving average was generally a widely used method for identifying the trends, the reason for their wide use is that they are capable of smoothing out all the random fluctuations. (Newbold and Granger 2015) Exponential smoothing on the other hand is constructed such that the forecast value is a weighted average of the previous observations, this follows the assumption that the weights decrease with the age of each past observations. It can be concluded that exponential smoothing has one or numerous parameters which are used to determine the rate of decrease the return weights or the modelling stock prices. Determination of these parameters can be arbitrarily constructed by other intuitive methods but the predominant method is the least squares method.

2.18 Curve fitting

Curve fitting is associated with graphs. The graph depicts the history of different patterns in time series processes and the characteristic patterns usually repeat themselves over time. (Newbold and Granger 2015) Curve fitting has the tendency to extrapolate such data, and this is viewed as hard to resist. Most of the forecasting methods currently base their use on the premise that such extrapolation is a logical and reasonable thing to do. Data mining is the major component and curve fitting, is defined as the 'art' of drawing conclusions through the study of past information. Curve fitting, when applied to an investment scheme or trading strategy has proved to have shortcomings. The major shortcoming is a lack of consistency often such conclusions and analyses do not prove to be factual one they are implemented.

2.19 Fundamental Analysis

In stock market prediction, fundamental analysis accesses stocks, this method makes uses of the generated revenues, current earnings, future growth, financial return on equity, profit margins and other financial data to access and determine a company's underlying. In stocks markets, fundamental analysis is constructed based on the financial statements and economic positioning of the company under evaluated. This has become the widely accepted theory as it makes use of how the stock market functions using an efficient market hypothesis .According to Warneryd (2001), stock prices always partially reflect a certain degree of accuracy nearly all the need information about the company and its performance. The theory is based on the assumption that every investor has access to public information on the stock prices from the exchange. This problem of "perfect information" is somehow not complete as issues such as insider trading's and dealing may not provide the perfect market information required. The interpretations based on financial statements and economic statistics are usually widely acceptable and available, however there cannot be an assumption that such information is interpreted and understood correctly by all the investing public (Dyckman and Morse, 1986).

Shleifer (2000), states that the interpretation often depends on how the information is viewed and framed and the source of information has a bearing on its accuracy and intended use. Furthermore, it has been noted well-documented stock market anomalies such as the general peak seasons such as expected increases in share prices in December and bearish return in January can affect any fundamental analysis process. The continuation of Friday price trends on Mondays forgoing the other factors that might have occurred over the weekend run counter and pull down the idea of unpredictable and perfectly expected efficient markets (Dimson,1988).When focusing on large groups, the major problem associated with the EMH is that the assumption that is taken that investors act independently of each other: this is a naïve statement as investors do not operate in a vacuum and any rational investor checks on other investments decisions being taken. Fundamental analysis can never be totally viewed as obsolete as it possesses some important aspects in any stock prediction process.

2.20 Technical Analysis

Technical analysis in financial analysis is defined as the process of by which historical data of securities is analysed (prices and volume) with the main aim of determining the probable future prices (Achelis, 2001; Murphy, 1986). The main difference between fundamental analysis and technical analysis is that apart from studying the fundamental company financial information, technical analysis goes deeper to analyse the psychological and other factors emotional factors like investors' age and gender which epitomized in the sometimes can be argued to be irrational behaviour of investors , such instruments can argue that the likelihood that a young man can invest in technological cloud companies are high compared to the generation x people .The technical

analysis makes it easy for studying additional factors apart from the fundamental analysis that deeply studies only the organisation's fundamentals such as price, profits, dividends paid and share prices (Osaze, 2007). Newbold and Granger (2015) argue that the use of technical analysis within investors to make investment decisions has been highly controversial. The efficient market hypothesis, state that investors are actors who act completely rational and these investors have access to all required information needed to value a stock's price during the current period as such, a stock's current price which reflects its value at that time, and is has proved that it has no connection with past prices. Most statistical analyses of technical indicators have criticised such assumptions and have proved their usefulness in predicting trend both in future computations as well as reversals and during share price fluctuations (Brock, 1992). Another limitation of the technical analysis is the subjectivity of this model as it is solemnly upon the investor to choose values for the variables with each tool, regardless of the existence of numerous tools that can be used. Technical analysis leaves it up to the investor to make a decision to pursue a buy or sell signal raised by a technical indicator.

3. Techniques Models Based On Mathematical Computations

A number of techniques that are used in stock computations are purely mathematic. Stock exchanges can make use of these mathematic computations in predictions and the most common models are analysed below.

3.1 Linear modelling

(Fama 2009) state that linear regression is a technique that is based on mathematics. The forecasting models have demonstrated their importance and usefulness in predicting returns mostly in developed markets and of late in developing markets. Linear regression models that have been tested have proved to have prediction accuracy of over 55-65 percent each time they have been applied. It was established that the form of linear modelling known as the random walk hypothesis, is based on the assumption that the best prediction for any future price makes use of the current price, and has the ability to predict the direction of market prices. It may be assumed that at this point the nonlinearities in the studied behaviour of the stock market prices could be as a result of the inability of linear methods to prove significantly that they are superior compared to the generalised random walk hypothesis.

Due to this reason, linear regression methods have proved their inability to give satisfactory results needed by investors. (Fama 2009) further purports that autoregressive-integrated moving average (ARIMA) which is an invariable model, has become a hit in linear models due to this strength and this has resulted in their extensive use in trying to forecast the direction of market prices. The ARIMA model has the ability to transform non-stationary time series data to stationary time series data through a process called differencing. Higher-order statistical techniques and models were found to be more accurate compared to ARIMA models. Chan and Tong (2014) Linear models are said to be simple and as a result, have the ability to simplify a system as complicated as economic or financial market behaviour. It is important to note that, the advantage of linear models lies in the simplicity. These entire ranges of models are only useful as long as their predictions have a minimum margin of error from the expected outcome of the underlying process. As with linear models, there is generally a trade-off between simplicity and the accuracy obtained through the predictions.

3.2 Non-linear modelling

The conventional school of thought is that linear prediction models are very poor in their ability to capture the underlying dynamics in financial time series. Over the past decade, the discovery of non-linear movements in given sets of financial markets data has been greatly emphasised, by numerous researchers and economic analysts. Chan and Tong (2014) are strong advocates for non-linear models. They argue that the ability to predict depends on where we are and that there are 'windows of opportunity for great reduction in forecasting errors'. Numerous researchers have documented the evidence of nonlinearities in stock market returns. The major elements of this have been the ever increasing evidence that the distribution of stock market returns is well represented by a combination of normal distributions (Ryden and Terasvirta 2016) and that, due to this fact, a Markov switching prediction model may be a reasonable characterization of stock returns behaviour.

Non-linear models are complicated in construction and understanding compared to linear models and therefore their use has been relatively low. The reasoning behind this has been the difficulty in determining the suitable model from a diverse range of models which is higher for non-linear models. Most researchers have established a number of methods that can be used to identifying non-linear models such as parametric models such GARCH, non-linear regression model, and non-linear volatility models and nonparametric models. A great debate on the gains coming from the use of nonlinear models has erupted and currently, they have not reached a consensus

4. Techniques based on neural networks

Neural networks (NNs), that in cooperate methods such as artificial intelligence (AI), are increasing becoming very important in use on stock market predictions. (Ryden and Terasvirta 2016) are of the view that NNs in solving prediction problems have proved to have their advantages over statistical and primitive methods that do not make use artificial intelligence, although there is no methodology that has proved to be optimally the best for certain problems. In light of identifying the main benefits and demerits of previous methods in prediction method and applications and to find the relationship between the methodology and problem domains that are different, data models, and results obtained from them, a comparative analysis of selected applications to be used will have to be conducted. A conclusion can be drawn from the analysis that NNs can be used in implementing forecasting of stock prices, returns, and stock modelling.

4.1 Backpropagation and Kohonen

Chan and Tong (2014) state the most popularly used neural network training algorithm in financial and economic forecasting is the back-propagation (BP) algorithm. The backpropagation algorithm is widely applied in classical learning algorithm for most neural networks. The BP has a broad application base and has been used mostly in financial time series forecasting because of its applicability to numerous business problems and its dominant learning ability. It is also important to note that this model has some limitations in predicting, and it can easily fail due to converge to the regional (local) minimum caused by tremendous noise including the complex dimensionality resulting from the stock market data. In light of this limitation and others, a genetic algorithm (GA) has been developed and proposed to overcome the local convergence issue resulting from nonlinear optimisation problems. Researchers have attempted to determine the optimal set of weights and the levels of biases to enhance the accuracy of prediction of the ANN model by using GA.

(Kim and Shin 2009)A multilayer feedforward network has been proposed for prediction purposes but it should have an appropriate pattern of weights to be used in modelling some mapping between sets of input and expected output variables. Figure 2.3 illustrates an example of feedforward network architecture of backpropagation, with three output units that include the hidden layer, which is trained using BP. The shaded nodes depict the processing units. The arrows represent the weights and are shown connecting input and hidden units in the architectures shown.
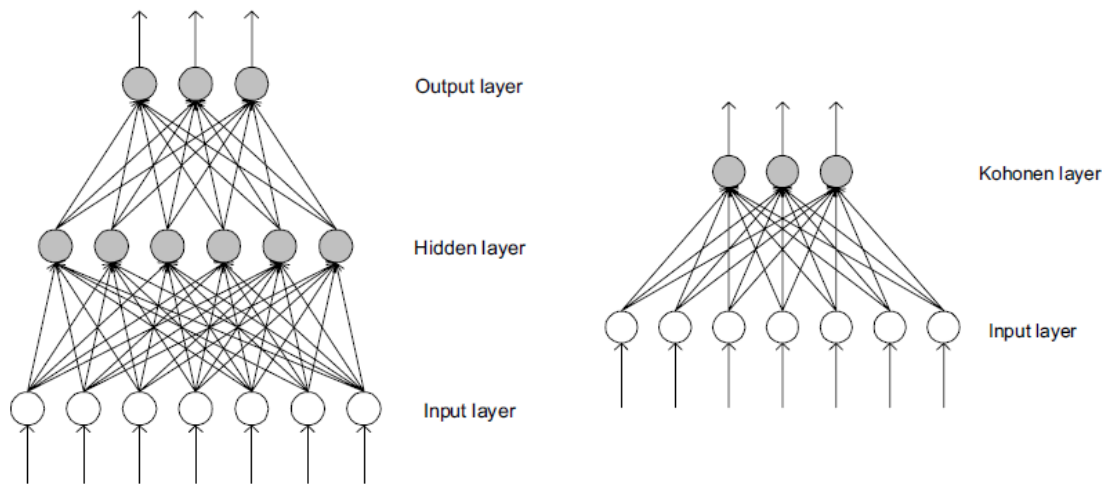

Figure 2.3: Architecture of 2 types of backpropagation network and the Kohonen self-organizing map

The backpropagation learning algorithm is constructed with the ability to search in the space of the pattern of weights, W, the weights are calculated with the input as in the perceptron model explained before. The weights are calculated again in order to find an optimal configuration, W*, with the aim to minimises an error or cost function, E (W). This process is so much important in reducing the degree of error. According to Kim and Shin (2009), the backpropagation algorithm is said to be recursive and consists of two important phases: forward-propagation and backward-propagation.

4.2 Limitations of Backpropagation

In Backpropagation, in neural networks with multiple hidden layers, there is a problem known as vanishing gradients that is caused by the numerous hidden patterns. (Kim and Shin 2009) state that backpropagation makes use of the derivative of the activation function. During updating of weights in the backpropagation algorithm, some weights will only note small updates, due to vanishing gradients. Due to extreme activations that are encountered further down the network, the resultant effect will be amplified to the point where weights can no longer change at all. The outcome of vanishing gradients is that top layers optimise normally, while lower hidden layers require significantly recursive training. According to Kim and Shin (2009), another limitation can be underfitting especially with deep architectures with hidden layers, as they are highly prone to overfitting. Abstraction will be felt in some hidden layers of the multiple layers as the multi-layers create expressive models. Although backpropagation is viewed as powerful model; it has also some of its drawbacks in financial applications which include

- Dropout

(Tashman 2000) argue that due to small changes made in the backpropagation algorithm, overfitting in deep architectures can be reduced. The technique used to reduce overfitting is known as a dropout. During the training process, each hidden node in the multilayers is assigned a probability of being disabled; this is done to an activation value of zero. The important decision whether to drop a node has to be made independently every time a node is computing its output, and the duration of activation is only active until next activation.

- Deactivating

Another drawback is that deactivating, or dropping neurones will reduce the performance of the neural network, as successive nodes are not able to rely on the preceding layer being complete. To further limit this model, it is important to note that it is difficult to predictable which nodes will be disabled (Tashman 2000).

4.3 Restricted Boltzmann Machine

Another model makes use of the Restricted Boltzmann Machines (RBMs) which consists of visible and hidden units to form a bipartite graph. (Yoda and Takeoka 2000) , Theses visible and hidden units are not related and are conditionally independent to the other layers. The RBMs are then trained by the neural network through maximising the likelihood given by the following equation. The RBM is trained through a method developed by Hinton called contrastive divergence. This method is similar to what the feedforward neural network (FFNN) represents within supervised networks (Tashman 2000). Restricted Boltzmann Machine (RBM) is widely used in numerous application areas such as financial systems, construction systems as well as medical systems. They fall under the unsupervised neural network. Apart from the bias nodes, RBMs is made up of two main components: the hidden and the visible layer. The difference with the FFNNs, in the visible and hidden units, is that RBM's are connected by undirected connections. The RBMs have the ability to infer and act on the hidden states from a visible layer, and also vice versa. Intuitively, the conclusion that can be drawn is that the visible layer acts as the input layer, while the hidden layer is viewed as the output layer, although scholars argue that the model is a slightly inaccurate analogy. (Yoda and Takeoka 2000), RBMs are stochastic in nature: Where feed-forward neural networks, neurones deterministically generate activations, the Restricted Boltzmann Machines (RBM) creates probabilities. In order to be able to read the state of a neurone, the probability is used on the sampled based. Sampling is also carried out by the RBMs as they pick a random number between 0 and 1, and then uses the probability which has been between the ranges of zero and one. When computing, if the random number is lower than the probability, it entails the unit should activate with a value of one, and the vice versa is zero. It can be concluded that the RBM is a stochastic binary model that makes use of hidden states.
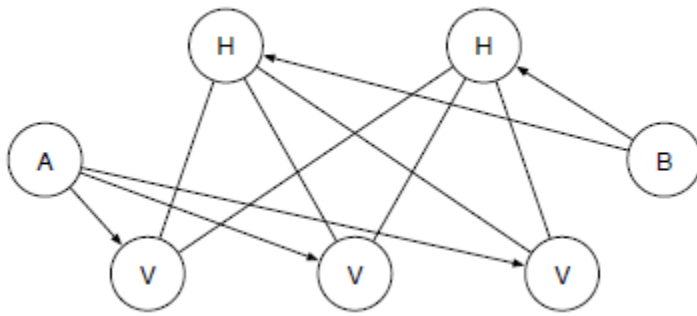
Figure 2.4: Structure of a restricted Boltzmann machine

Visible (V) to hidden (H) connections are undirected.

4.4 Deep Belief Network

(Yoda and Takeoka 2000) claims that deep Belief Networks (DBNs) are made up of several Restricted Boltzmann Machines (RBM)s. They can be termed an extension of RBMs but stacked on top of each other, using directed connections to interconnect between the layers. A simple DBN architecture has been shown in figure 2.6. The visible layers denoted by the (v) are located to the left in the figure, but they are referred to as the bottom layer or the first layer, and hidden layers denoted with (h) are on right. The deep belief network can model has complex problems due to its deep nature and is difficult to compute based on such. Directed connections are known to enable fast inference, at the same time retaining RBM properties on the visible layer.
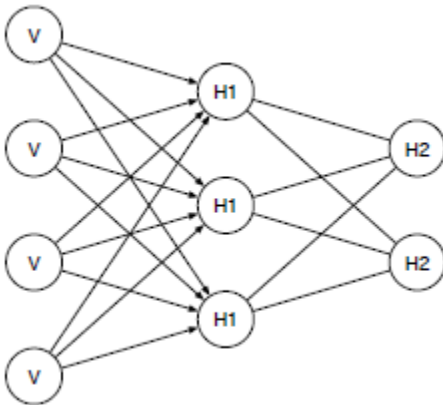

Figure 2.6: A minimal deep belief network. Bias nodes are not shown.

V is the vector input

H1 is the hidden layer 1

H2 is the hidden layer 2

Just like the RBM, the extension to DBNs is generative models that can probabilistically generate input samples in trading data, as well as have the ability to infer hidden features. Unlike most deep models that suffer from the limitations shown on backpropagation. DBNs are unsupervised models and make use of learning as the output is not known. In a greedy layer-wise model used in training the algorithm, was introduced specifically for training the DBNs. This greedy layer-wise model learning algorithm has later been applied to supervised networks due to its increased accuracy in computations (Yoda and Takeoka 2000).

4.5 Limitation of the Deep Belief Network

Chan and Tong (1991) have proved that unsupervised DBNs pre-training only consider two layers at each stage when computing. Its limitation is that on adjusting the weights the time taken and the resources are numerous due to lack of parallelism in computing. Once the weights have converged and have been calculated they are then locked in place, the DBN will have to change the connections back to being directed.

4.6 Recurrent neural network

Elman (1962) studied the Recurrent Neural Network (RNN) and proved it differ with FFNNs because apart from only allowing forwards connections, a Recurrent Neural Network (RNN) has the ability to process feedback signals. This enables the RNNs to keep updating an internal state called a context or memory, and this state, in turn, is considered when predicting future states. As a rule, the temporal dependency is expected to reach arbitrarily far back in time, however current learning algorithms and processing power enforce practical restrictions (Elman 1962).

Recurrent neural networks were introduced in the Elman network as an early example of recurrent models. As shown in figure 2.7, the model is made up of dedicated context units, and these are marked C. Input marked (i), hidden marked (h), bias marked (b) and output marked (O) neurones are also shown.
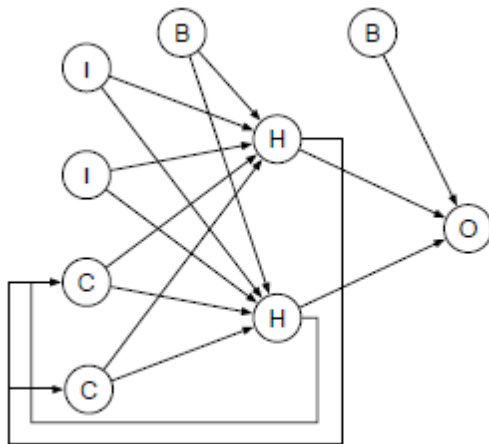

Figure 2.7: The recurrent architecture known as an Elman network

Key

C is the context units.

I is the inputs

B is the bias factor

H is the hidden layers

O is the outputs

4.7 Predicate Logic Tree / Truth-Trees

The truth tree or predicate logic tree is another form of neural network method that can be used in prediction. Truth trees ensure that a sentence has logic. (Yoon and Swales 1998) To ensure that an argument is valid or factual is to say that in every possible case the sentence maintains that the premises are true, the conclusion is true also. Truth trees repress this by ensuring that an argument is valid if and only if it meets a stated condition and when it has no counter-examples, to prove that it is, not possible in any case in which the premises are said to be factual or true and the conclusion false. Predicate logic has the ability to changes everything. In predicate logic the cases are interpretations, and in real life, they are always infinitely of these. Thus it becomes impossible to check through all of them to ensure that there are no counterexamples in the tree. Now, in this case, truth trees become much more than a convenience. They do not only provide the only systematic means but also a factual approach when searching for counter-examples (Yoon and Swales 1998).

An example

Investors prefer Econet shares(x) (Vx)Lxe

Institutional investors prefer Econet (x). Lae

In the above statement, we note that we can quantify the statements and check on the conditions that prove to be true. A careful analysis of a number of these predicate truths will enable conclusions to be reached that can, in turn, be used more in analysis and predicting the future based on quantified statements.

5. Stock Markets and the method that can be used

Stock markets worldwide are tasked with the challenge of predicting with accuracy all their activities. This brings them to the need to choose diligently from a list of computational models to analyse and decide on one that minimises their degree of bias or error. Prediction thus becomes one of the most difficult tasks to perform because in the markets is dependent on a number of affecting factors. (Tashman 2000) argue different models prove their strengths and weakness and the applications differ depending on the markets. The efficient market hypothesis is the weirdest of these models and state that prices of commodities are every changing and the change is haphazard and unstructured as no pattern is adhered to. This is a highly criticised school of thought. However, financial time series advocates that prediction can be done and a lot of models such as fundamental analysis, technical analysis, linear and non-linear models as well as neural networks model can be used. These methods can be used around the globe depending on the markets.

5.1 Global Markets

In the global markets most of them in Europe and Asia, stock market predictions have been going on since the early 17th century. These markets have moved tremendously in market studies and forecasting and have adopted the modern forecasting methods using artificial neural networks. The

biggest stock markets in the world are the New York stock exchange and the NASDAQ both of which have extensively adopted neural networks (ASEA Report 2011). In Japan studies on the adoption of neural networks started in the early 1980's and simulations were carried out on the Tokyo Stock Exchange by Kimoto et al. (1984).They constructed a prediction and forecasting model using simple and generalised modules in artificial neural networks for trading commodities and shares on the bourse of China. Their simulations generated factual and adoptable results as the prediction rate had a low margin of error resulting in its adoption in 1989. Kuan and Jamel, (2006) analysed the idea of using recurrent networks in association with the feed-forward networks on the Tokyo exchange in forecasting the foreign exchange rate data and the results were accurate leading to the adoption.

On the Istanbul stock exchange, Kara and Boyacioglu (2012) forecasted stock market share fluctuations and movement using support vector machines (SVM), from their work they concluded that the model provided relatively accurate results with a marginal degree of error of 5%. Their study on the Istanbul stock exchange proved that the two major different models could both be useful prediction tools. In Canada, a great researcher by the name Olson et al, (2009) compared neural networks in predicting the year 2010 which was the successor year to try and validate his studies. They did his research on the Canadian stock exchange. The results of the predictions done using logistic regression (logit) proved to be accurate with a minimum margin of error of only 2%. They went on to use mean least squares (MLS) methods and techniques. From their conclusions, back-propagation neural networks were the best and outperform other models that they had used for classification purposes. They concluded that neural networks had great computation and processing accuracy. In America on the NASDAQ, Abraham et al went on to use a combination of ANNs with different based features to analyse and study the patterns that we occurring on the counter Dow Jones. The counter started off as being bullish and after consecutive years was turning to be bearish. The idea of using PCA-based methods was to analyse and forecast it expected return in following years. They used an algorithm with the ability to develop a hybrid system based on artificial neural networks for America's stock. Aussem, (2008) proposed wavelet transform algorithm that is artificial NN. This model proved to be highly accurate and lead to its adoption in the next year.

Chen and Shih, (2010) of China, applied RBMs and Backpropagation recurrent networks to predict market activities on the Japanese indices and their findings proved that modern artificial networks models were better the primitive statistical linear and nonlinear models. Almost a decade ago Luang Cha (2016) who worked on the Istanbul Stock made use of a number of Deep Belief neural network model for stock market price forecasting. They compared two models on the same stock exchange based on ANNs and linear models in prediction of the exchanges fluctuating movements in the daily Istanbul indexes and indices. They concluded from their work that ANN model performs far much better than DBNs model.

In India, Famalal (2007) applied a simple neural network based model with the aim of predicting changes in direction of closing prices of counters on the stock exchange market, combining primitive models such as the technical trend deep analysis and fundamental analysis. The artificial neural network-based model called NARX was used to train the network to learn from the data and perform the time series prediction. The exchange that was used was the TAL1T stock of NASDAQ. Walters, (2007) used a stochastic and deterministic time on the same bourse to check the function neural network (NN) with RBMs to forecast and predict the changes in the different stock indices. Their finding displayed better performance and they pushed for the adoption of the model compared with the neural network models.

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5.2 African Markets

Generally, for Africa markets, a lot still needs to be done to harness and adopt the power of Artificial neural networks in stock market predictions. It is against this background that the researcher tried to analyse the feasibility of the adoption of neural networks on the Zimbabwe stock exchange for stock predictions. In Nigeria, fundamental and technical analyses are the main means of predicting stock prices. Nigeria is the biggest market in Africa and boasts of turnovers in excess of US$40 million a week. Fundamental analysis is a generalised way that takes a keen look at the company itself. Analysis of the company's profitability and its general earnings per share. This leaves the researcher with a lot of derivatives to be able to predict any future market prices.

In South Africa, several studies have recently been conducted on neural network modelling in the market. Van Rensburg (2014) made the largest contribution to ANN studies in the stock market and modelling. A very extensive system was modelled by Van Rensburg which modelled the performance of the main market in SA. The Johannesburg stock exchange (JSE) was modelled using NN and based its trading decisions on the major indicators that demonstrated superior performance than fundamental and technical analysis the study thus refuted the use of EMH and pushed for the adoption of ANN. Patel and Marwala (2015) used artificial neural networks to forecast the all share index on the JSE using previous index prices in prior years and they concluded that ANN could be used in predictions. Another study they carried out used fuzzy inference systems and adaptive-neuro fuzzy inference to determine and make financial decisions on the Johannesburg Stock Exchange.

5.3 The Zimbabwean Market

The Zimbabwe Stock Exchange (ZSE) is the only exchange in the country and makes use of fundamental analysis in its stock market predictions. Currently, there is a relatively very low use of NN in computational models and the absence of machine learning in the methods used in prediction creates a gap and increases the level of bias in the outputs. This thesis seeks to rationalise and strongly advocate for the adoption of artificial neural networks by the local bourse to be used in predicting, yearly turnovers, as well as stock market commodities and counters price,'s by the stock brokers.

5.4 Summary of the literature

In this section, related literature has been studied particularly the operations of a stock exchange, some of the available prediction methods at the disposal of stock exchanges. A deep understanding of the prediction methods offered by neural networks was analysed. The chapter ended with a look at the case-based application of these predictions by the global markets, narrowing down to the African markets and the Zimbabwean environment as a whole. The next chapter will focus on the problems the research seeks to address and the methods used to address the problems.

6. RESEARCH METHODOLOGY

6.1 Research Approach

The research approach proposed by the researcher is deductive.

Deductive – Theory to Data

A deductive approach is concerned with "developing a hypothesis based on existing theory, apart from developing a hypothesis a research strategy has to be designed to test the hypothesis (Saunders et al 2012). This is practically applicable to the study at hand as the research seeks to develop a framework that can be adopted by the exchange based on existing data from other exchanges that are making use of neural networks in prediction. It is generally believed that "deductive" is referred to as reasoning from the particular set of given data or information to draw conclusions that are general. This provides the basis of a causal relationship that will now be in existence or the link implied by a particular theory being pointed that will have been proved usually latter referred to as case example and concludes that if a particular case provides to be true then it might be true in many cases. The deductive approach thus can be used to draw conclusions, basing on premises or propositions. 35

6.2 Research Strategy

Levin (1988) argue that they are a number of research strategies available which include narrative, ethnography, phenomenological, grounded theory and case studies The research strategy to be used in this research is case study mainly because of its ability to formulate a framework for the adoption of neural networks for stock market predictions. The study will be based on the Zimbabwe Stock Exchange. The case study is defined as a report of a person, situation or group that has been studied. For the case study, for instance, if it is about an exchange, it describes the behaviour associated with the exchange as a whole, not about the individual entities in the exchange.

The case studies can be developed or produced by following and adhering to a formal research method. Case studies are likely to appear and to be available in formal research portals and venues, as journals and professional conferences where they are presented and published, rather than in popular works. The use of 'case study research' has been in use in numerous disciplines and professions in popular and prominent places for a long time (Saunders et al 2012).

6.3 Study Location

The area of study shall be in Zimbabwe and the targeted individuals are in the financial markets that deal with predictions and computation. The Zimbabwe Stock Exchange has a number of key stakeholders that are directly affected by any bias or error that can be generated from the exchange. The study seeks to develop a framework that is applicable and of use in the Zimbabwean context.

The participants of this research are drawn from the Zimbabwe Stock Exchange (ZSE), Securities and Exchange Commission (SEC), Ministry of Finance (MoF), Stock Brokers, Custodians, Fund Managers and the Investing public. Due to the large numbers of the target group the researcher, therefore, the research made use of cluster sampling as it was apt for the availed time and cost associated with research. The nature and purpose for choosing this population are summarised below:

Figure 3.4: Adapted from www.mapsofworld.com

Table 3.1: Respondents reason for selecting the source

Target respondents/Subjects	Reason for selecting the source
Zimbabwe Stock Exchange **Operations Department** **(Trading and ICT)**	-Access to key trading data -information on local legislation and current computational methods in prediction - Gather information on the position of the Exchange over adopting new prediction methods - To have an understanding on current activities in use
Stock Brokers	-To ask on why they feel the predictions are wrong - Ask about any benefits/challenges -Awareness on the use of Neural Networks and how it can be used in computations
Securities and Exchange Commission	-As the regulator of the capital markets to find out their views and strategies toward the prediction models in use.

	-Inquire on the possibility of endorsing the use of NN in stock market predictions
Ministry of Finance (MoF)	-Government position on the current prediction methods - To find out their views and strategies toward the prediction models in use. -Inquire on the possibility of endorsing the use of NN in stock market predictions
Investing Public	-Identify the concerns they have over the degrees of error in current prediction method - Awareness on the use of Neural Networks and how it can be used in computations

6.4 Sampling

A good research must produce valid and reliable data (Haralambos, 1990). This research drew a sample of respondents found the financial sector in Zimbabwe. The sampled respondents have an in-depth understanding of the capital markets and are key stage holders in the market. The respondents are also decision makers with the ability to influence the adoption of the framework. The selection of respondents was done through stratified sampling in an effort to save resources and the minimum time for the survey.

6.5 Selection of respondents

The principle of stratified random sampling was used to divide the study population into different groups called strata's. The strata were normally mutually exclusive to enhance rich gathering of data. The table 3.2 below shows the major constituents of the financial markets in Zimbabwe and the number of respondents targeted.

Table 3.2: Financial Markets Industry

SECTOR	NUMBER OF RESPONDENTS
1. Zimbabwe Stock Exchange	10
2. Ministry of Finance	5
3. Securities and Exchange Commission	5
4. Stock Brokers	10
5. Investing Public	10

TOTAL	40

The selection of the respondents was based on the key market participants as highlighted by the subject matter experts. The respondents from each sector in the industry were tallied against conversion for comparison purposes as will be detailed in the next chapter.

6.6 Sample Selection of Design

The identified uses were grouped into 4 clusters according to sectors: Zimbabwe Stock Exchange (**N1**), Ministry of Finance (**N2**), Securities and Exchange Commission (**N3**), Stock Brokers **(N4)** and the investing Public **(N5)**. That is **N1+N2+N3+N4+N5= N**, wherein **N** stands for the sector or industry in the Financial sector key to the study. The research also made use of purposive sampling in identifying relevant institutions. At least three members were picked from Zimbabwe Stock Exchange (Trading and Surveillance Department), Ministry of Finance, and Securities and Exchange Commission employers who happen to be regulators of the capital markets as well as Stockbrokers.

6.7 Data Collection

There are five commonly used information gathering techniques that are going to be employed by the researcher, these include:

- Interviewing
- Observation of the organisation's operation
- Research
- Documentation Review

6.8 Observation

Levin (1988) explains observation as the process of closely monitoring or views an event or individual. This method was used because of its significance in noting changes in turnovers. The degrees of inaccuracy could easily be noted by observing the variance between the projected and anticipated figures over the Actual figures. The observations sought to highlight the degrees of error and inaccuracy in these computations that have been subject to research. The observations were also used to complement efforts of other techniques to identify the said benefits of adopting neural networks in stock market predictions computations The advantages derived from this method are present in photographs for the area of trading systems through the use of View only terminals as they allow easy recall of findings. The observation tools used included VOTs, view only Terminals on the trading systems.

Table 3.3: Importance of Observation to study 40

Observations showed exactly what the actual figure of turnovers, stock prices on counters such as Delta (Dlta.zw), Econet (Eco.zw) were. This was independent to the predictions that could initially have been projected by different institutions. The actual versus the forecasted showed huge variances advocating for computational models that would produce more accurate findings. Furthermore, the technique made the researcher to be in touch with the actual environment. The findings from observations were useful for providing a comparison basis with the forecasted/predicted values

6.9 Interviews

(Saunders et al 2012) defines interviews as a meeting of individuals physically to consult. The technique was very useful for collecting and capturing issues that could not be gathered through mere observation. Interviews proved worthwhile particularly to get the story behind the inaccuracies in the predictions carried out on the Exchange. Also of great importance was the response of the Zimbabwe Stock Exchange officials. Other issues captured where from the investing public and why they are in favour or against the adoption of NN in the stock market prediction models. This approach had advantages in that the researcher managed to identify bias or exaggeration through verbal and nonverbal cues.

The interviewer also engaged Zimbabwe Stock Exchange officials, Department Trading, some investing public and the stock brokers who deal directly with clients. This was essential as it enabled the gathering of first-hand information on challenges, opportunities and limitations of adopting a new computational model for predictions. In the efforts of gathering first-hand information, the researcher made use of two types of interviews: structured and unstructured. The essence was to allow for flexibility and guiding responses were necessary.

The structured interview made use of a standardised set of questions to obtain data that could be aggregated for statistical analysis. Identical questions were asked to participants especially with the emerging conversions. The focus was on conformity and non- conformity with provisions to the stock market activities. Other important aspects probed include finding out the reasons behind the shift from norms as well as challenges being encountered during operation. Thus, the hidden and open realities of the matter could be gathered through this manner as different participant's views and opinions were noted. This helped to provide a strong basis for cross comparisons. ZSE officials provided useful information for addressing issues in relation to the existing legal and

policy frameworks which guide the development of a new framework. Unstructured interviews helped to solicit in-depth information as participants expressed their views freely. This enriched the research qualitative base.

6.10 Importance of Interviews to study

Interviews allowed the interviewee to respond freely and openly to questions as they could describe and answer the questions in their own way. When interviewing the Trading Manager and ICT Manager the interviewer (analyst) managed to follow up on interesting comments made by the interviewee. Interviews allowed the interviewee to feel part of the project. Analysis of the answers from the interviewee was also viewed through body language. The analyst had a free hand and he managed to extract almost all the information from the concerned people but then as it was a very time-consuming method, thus other methods such as document review were adopted.

6.11 Informal Interview

Saunders *et al.* (2012) explains informal interviews as a casual meeting of individuals to the consultant. This was used because of its unbiased nature, especially when soliciting information from the general public. The essence was to measure attitude, feelings and expectations in relation to the degrees of error in stock predictions. The participants were identified using convenience sampling.

6.12 Research

A useful fact-finding technique is to research the stock market predictions. Stock Market Journal, reference books and internet (including user groups and bulletin boards) are good sources of information. They can provide information on how others have solved similar problems. This saved time as solutions already existed. The researcher managed to see how other have solved similar problems or met similar requirements and was up to date with current developments.

6.13 Document Reviews

(Saunders et al 2012) explains document reviews as a simple process of analysing the past and current records on a specific study topic. A review of publications, case studies and literature in Stock markets and how other countries were able to use Neural Networks in computations enabled the researcher to gather important information on his quest to develop a framework for the adoption of Neural networks on the Zimbabwe Stock Exchange. Critical information was available and the researcher managed to gather important information through document reviews.

6.14 Challenges encountered

The major challenge that was faced is resistance. This was so because the topic is too sensitive and linked to aspects of change to the existing procedures and ways of doing things. As such, junior employees generally resisted responding to research questions. In this context explanation of the purpose of the study and production of student identity as well as supporting documents helped to establish effective rapport. More still, the researcher's dressing raised suspicions, and the latter ended up having casual dressing. More so, institutional politics was a major hindrance during data collection. Time factor on the part of the key informants challenged the research to an extent that some informal arrangements were made with the participants.

7. RESEARCH - DATA ANALYSIS

Data analysis is the process of carefully looking at the data and information available and making accurate findings, deducing the meaning of the raw data that was under study. Data Analysis thus becomes an important process in the research process as data is made factual and thus can be of use in adding any decision to be made. A spreadsheet was created using Excel to enter themed codes from research tools. Data from questionnaires, structured and unstructured face to face interviews was explored to pick the rate of recurrence of responses, distribution trends, statistical interaction and significant difference of responses between the respondent. Responses from the key informant interviews were used to validate the responses of the general investing public. Data from these interviews and questionnaires was analysed using the thematic approach whereby key issues from the various responses were grouped together under a familiar topic and examined. Feedback meetings with some of the key informants were held so as to eliminate errors of bias or misconception of respondent's views and also to authenticate the themes developed.

7.1 Validity and Reliability

The mixed methodology study was predominately used in this dissertation. This increased the validity of the study data as numerous techniques were employed in the study. The reliability of the data is furthered strengthened by the fact that data was obtained from individuals interviewed in the field and with practical experience in the field.

8. Presentation and Analysis of Data

8.1 Introduction

This chapter is made up of all the research findings, following the study that was carried out at Zimbabwe Stock Exchange. This chapter presents the findings obtained during application of the research methodology used. The presentation of the findings is done in a manner that allows for the reader to easily relate to the findings and allows the reader to visualise the data. The qualitative method of data gathering is the technique that was used during the research and the findings were discusses in the section to follow below.

This chapter is more significant as it presents the strategy for the development of a framework that will be analysed in the next chapter.

8.2 Data Coding

Coding is a process of organising and sorting data for simplicity reasons (Saldana, 2013). Data coding is done so as to get rich and better data patterns that will be used in the analysis and categorising of present patterns to relate them to data (Boyatzis, 2010). Coding is the third phase in data analysis using content analysis (Krippendorff, 2004). Data coding can be done using either software's e.g. MAXQDA software package or can be done manually.

The research used manual codes because they are easy to understand in analysing data. The data will be manually coded by highlighting the sentences and come up with tags a process known as tagging. Subsequently, there are many types of data coding techniques which include:

- Descriptive coding: it encapsulates the crucial theme of the expert

- Process coding: coding of a saying that incarcerates an action

- In vivo coding: coding using the accomplice own language

- Pattern coding: coding for themes or patterns in data

- Simultaneous coding: relating several codes to the same text

- Structural/ Axial coding: coding of theoretical phrase signifying a topic of analysis

Nonetheless, an axial or structural coding will be used to code the data in this research.

8.3 First phase of data analysis

Expert interviews were analysed using coding. Firstly, samples of fifteen interview questions were designed for guidance in the analysis of gathered data and also bundling of the stated materials. The main aim of this clustering and designing of questionnaire guide was to separate the interview materials into eloquent units of sentences grounded on questions to be responded (Taylor-Powell, 2013). Therefore, interview materials were detached from the precise perspective of a single interview and rearranged following topics of concern (Zepke, 2001).

Furthermore, documents that were coded firstly yielded a lot of codes. Fifteen questions were for guidance, but as the interviews took place, the questions went beyond the expected fifteen. Coding exercise was done many times to make sure no concept was missed. During interviews, responses were written down and consequently, the coding of the data then took place. The researcher went through each response to determine the codes associated with each response if any. Opinions, feelings, behaviour, as well as the knowledge of the respondents pertaining development of neural network systems, were coded. At first, they were more than 100 codes, which gave the researcher a suspicious mind to redo the data coding. The second time the codes were more than 65 and they were then compressed to remained with 12 since time to deduce all the 100 codes was not available due to insufficient time.

8.4 Second phase of data analysis

Two types of codes can be found when coding i.e. pre-set coding and emergent codes. Pre-set code is a code which has as little as 10 codes or a range between 40 to 50 codes while on the other side; emergent codes are those ones that emerge when the data is being read and analysed. They include ideas, meanings, concepts as well as actions. Data should be coded without losing its meaning (Saldana, 2013). Therefore, the codes were obtained from the actions posed by the respondents during the interviews. Meanings of some of the responses posed were noted down and coded accordingly. This made it easier for the researcher to determine the trends in the codes and recorded the codes down. The majority of the codes emerged codes.

8.5 Deducing the Codes

After the data gathering using interviews and observation, a number of codes were obtained. Same responses in the data were tagged and grouped to come up with more than 90 codes. Some codes emerged as the data were kept on coded. The initial codes found from the data gathering were more than 100 codes and dealing with such a large number can be tiresome and very cumbersome, hence, the codes were reduced and compressed to remain with 12 codes. Likewise, the codes could be tagged during the coding process and the tags are recorded in the table below which illustrates rank, type of codes as well as the tags for each code found in the findings.

Table 4.1: Data coding Ranks

	Codes	Tags in %
1	Regulatory Approvals	85
2	Policy Development	65
3	Cost Implications	75
4	Employee knowledge acquisition	90
5	Trainings/ employee development	45
6	Cost cutting	75
7	Contracts and Standards	70
8	Quality service	60
9	Roles and responsibilities	80
10	Risks	91
11	Organizational performance	35
12	Need for experts	91

9. Summary, Recommendations and Conclusion

This chapter will present the summary of objectives and aim, recommendations and conclusion from the findings in chapter 4. Additionally, recommendations for areas of future study can be presented in this chapter. The table below shows the summary of the objectives and aim of the study as well as the research results obtained.

Table 5.1: Summary of objectives and aims of the study

Aim and Objectives	Research results
Aim: To come up with a framework that can be used in adopting neural networks for prediction on the Zimbabwe Stock Exchange	Done successfully
Objective 1: To come up with a framework	Framework created based on the findings and the key terms in chapter 4.

Objective 2: To identify the strengths and weaknesses of the current methods used to predict Stock Market Activities on the ZSE	Respondents identified the weakness and strengths of the current prediction models.
Objective 3 To identify the causes and find recommendations to the weakness and degrees of error in current market Activities on the ZSE	Factors were discovered and recorded.
Objective 4: To analyse the impact of using Artificial Neural Networks on the local Bourse (ZSE) for predictions and forecasting	The impact of using ANN was analysed.

10. Summary of Findings

The findings show that quite a lot of things were discussed and written down. The findings show the following information was obtained:

The prediction method that is predominately currently in used by the Zimbabwe Stock Exchange is trend analysis basing mostly on historical data, theses have proved to have limitations in computationally accuracy and are also time-consuming. A lot of manual processes in the calculations do not only prove to be very risky but also tend to be biased depending on the individual doing the computations. Furthermore, findings show that there are different factors that affect, the decision to adopt neural networks in stock market predictions as well as factors that influence effective development on the system in the financial markets sector in Zimbabwe. The factors that affect adoption are- risk sharing, reduction in operational costs, lack of experienced manpower within the business, the absence of experts in an organisation as well as irregular personnel demand.

From the findings obtained the following critical factors in the decision to adopt neural networks in the prediction of the market lies predominating on acquiring the relevant regulatory approvals from the Securities and Exchange Commission (SEC) as well as Government Ministry of Finance (MoF). Legislative and relevant Statutory Instruments have to be put in place and gazetted to enable the implementation. Additionally, the findings showed that there are different factors that influence the adoption of neural networks for prediction on the Zimbabwe Stock Exchange and these include the ability to recognize the tendering procedures when contracting a vendor, the capacity to develop policy directives and regulatory framework for the development, the ability to assess the costs and needs of an organization and lastly the ability for a contract execution and monitoring.

It was also found out that the factors that affect the adoption of neural networks are operational costs, competition, the type of business an organisation is into, and lastly organisational policies. A framework was designed from the themes obtained in the key findings. The themes found in the research being roles and responsibilities, performance of an organization: the reasons indicated by the respondents were that the ZSE is failing to accurately predict the market activities due to the

primitive computational methods and hence they was a general feeling that a better and more appropriate prediction model would be welcome however issues to do with the appropriate skill were raised Employee development: the employees from the vendee side, as well as the vendor side, should be well trained for the development to be a success. Roles and responsibilities should be managed for the adoption of neural networks to be a success, a lot of failures are as a result of staff having too many roles in an organisation and even if that person has the know-how to the product. Knowledge acquisition: all the employees should acquire as relevant knowledge as possible for the effective utilisation of neural networks on the Stock Exchange

11. Conclusion

The findings showed that the neural networks can be adopted on the Zimbabwe Stock Exchange for prediction of stock market activities. A framework have been designed will add in the step to step approach of such a key development having ascertained why there is any need to develop a neural network based model, also there is need to realize value over time from the system adoption since value is dynamic, unlike time, ascertain the benchmark of the prediction model to be adopted, as well as the vendor selection strategy. The ZSE should try by all means to choose a prediction model that the business will cope with in terms of accuracy so that it will be able to realise the benefits gained from adopting the model

12. Recommendations of the study

From the findings of the study, it can be anticipated that all market participants (i.e. ZSE, investing public, Government, CDC and SEC) in the industry should play a role of having a clear understanding concerning the neural network based prediction systems for the betterment of the financial markets. Effective neural networks systems permit the ZSE to supply agreeable quality, service and low costs prediction systems within a certainly reasonable time frame. The Zimbabwe Stock Exchange should always get the best deal for less on the right time for operational efficiency.

Leaders in the companies should give IT personnel the priority to do the development of systems and take leading roles in the ICT-related processed of the organisation and be able to have some chief information officers (CIO) strategist within the company. Information Technology should be taken seriously as it is the backbone of many organisations in this era. People in the IT should be found at the board meeting and decision making positions so that IT is well represented at all levels in an organisation. From the findings, it is indicated that IT systems development is a failure in exchanges that have CEOs making ICT decisions for the organisation. It was discovered that many failures to the adoption of systems were due to improper decision-making by superiors of the organisation who are having dual roles or more than one role in an organisation.

Additionally, they should be accountability, integrity and transparency to make sure no development of such a complex prediction system will fail. As found in the findings, the majority of prediction based models fails because of lack of accountability. Transparency is lacking to the extent that outsourcing of these prediction based systems is done on basis of trust which at the end of the day is compromising business operations of companies trusted end up delivering sub-standard work; hence causing failures. This is mainly done to maximise on the vendor side whereby they will charge extra money to debug the erred systems. So it is recommended that transparency is being used and accountability taken into action. There should be a Project Manager in charge of development such that when something goes wrong, that person will be in responsible and answerable to anything.

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In this era were IT projects have emerged to be the talk of the day both locally and globally, Stock exchanges should take their time and embrace technology for prediction has many benefits to an exchange as found in the research. Stock Exchanges should put their focus on information systems services outsourcing and also the vendors should seek to deliver quality service within a 'blink of eye' meaning in a short period of time.

13. LIMITATIONS AND FURTHER RESEARCH DIRECTIONS

It is believed that the findings of this research study will add value to the body of information already in existence and will be able to build the basis for forthcoming academics and scholars. The following are the areas suggested for further research:

a. While the present study concentrated on present steps that the Zimbabwe Stock Exchange should take in the adoption of neural networks, future academics should concentrate on the outcomes and effectiveness of such a model if adopted in its entirety

b. Forthcoming researches should strive to inaugurate the extent to which neural networks adoption for prediction can be used in other sectors of the economy not only the financial markets. Lastly, future studies should seek to develop a framework that will address the adoption of neural networks not only on the Zimbabwe Stock Exchange but for African Stock Exchanges (ASEA).

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