SOFT COMPUTING APROACHES TO STOCK FORECASTING: A SURVEY

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ABSTRACT

Soft computing techniques has been effectively applied in business, engineering, medical domain to solve problems in the past decade. However, this paper focuses on censoring the application of soft computing techniques for stock market prediction in the last decade (2010 - todate). Over a hundred published articles on stock price prediction were reviewed. The survey is done by grouping these published articles into: the stock market surveyed, input variable choices, summary of modelling technique applied, comparative studies, and summary of performance measures. This survey aptly shows that soft computing techniques are widely used and it has demonstrated widely acceptability to accurately use for predicting stock price and stock index behavior worldwide.

INTRODUCTION

The inherent desire of man to see the future since the beginning of time is exemplified in the desire of stock market investors' quest to accurately as possible predict the future prices of stock for profit and make better informed investment decisions. The main aim of stock market predictions is usualy to achieve accurate prediction of the future prices/indices of the stock market, doing so with the least possible amount of data, with the most uncomplicated model possible (Atlasakis, 2009).

Armed initially in the early days of stock market forecasting with the statistical methods of autoregressive conditional heteroscedasticity (ARCH) model (Engle's, 1982), generalized ARCH (GARCH) model (Bollerslev's 1986), Box and Jenkins's (1976) autoregressive moving average (ARMA) model, and the autoregressive integrated moving average model (ARIMA) amongst others.

However, the various factors such as high dimensionality of the data, inherent chaotic and volatile nature of the market, politics and even natural disasters makes the prediction of stock prices an arduous and complicated task; leading to the advent of soft computing techniques in the 90s, which has made available a plethora of soft computing methods that has attempted and successfully predicted the future prices, movement or index of the stock markets all over the world.

This work examines over 110 published works that used soft computing techniques in the last seven years (2010 - todate) to forecast stock prices or stock indexes. The first table lists the respective stock markets authors have used and cited in their works. The second table lists input variables (independent variables) to the stock market model. The third table summarizes specific methodologies and model parameters used in each paper to forecast stock markets. The fourth table demonstrates modeling benchmarks of each author's specific approach, as well as any comparisons/discussions made against other techniques; such techniques include artificial neural networks (ANNs), linear and multi-linear regression (LR, MLR), ARMA and ARIMA models, genetic algorithms (GAs), random walk (RW), buy and hold (B & H) strategy, and/or other models. The last table summarizes performance measures used to evaluate each surveyed model (Atlasakis et al., 2009). The rest of this paper is structured as follows: Section 2, presents the survey stock market. In Section 3, presents the input variables used in the models. Section 4, shows the different modeling techniques/ models used in survey articles.. Section 5 reveals how the authors benchmarked their models with other models. Section 6, the performance measures in each articles surveyed and Section 7 concludes the paper.

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SURVEYED STOCK MARKET FROM WHERE AUTHORS OBTAINED DATASETS

From Table 1, it was observed from the random collection of journals used for this survey, studies carried out on the Asian stock markets took the forefront. Surveys carried out on the Indian stock market leads the pack Dase and Pawar(2010), Kunwar and Ashutosh (2010), Nitin et al. (2010), charkravaty and Dash (2012), Sujata et al. (2012), Sureshkumar and Elango (2012), Santosh et al. (2013), Choudhurg et al. (2014), Rajashree and Pradiptakishore(2014), Narendra and Eswara (2014), Subhabrata et al. (2014), Babita et al. (2014), Anish and Majhi(2015), .Narendra and Eswara (2015), Jyoti and Jitendra (2015), Anbalayan and Mheswari (2015), Preethi et al. (2015), and Rajashree and Pradiptakishore (2016).

Followed closely on the Asian market is the Chinese stock exchange with the works of: Zhe and Jue(2010), Qinghua wen et al., (2010), Yixin and Zhang (2010), Li-Ping et al.,(2011), Lie and Qung(2011), Chong and Olivia(2011), Kang and Sun (2011), Jian-Zhou et al., (2011), Wei shen et al. (2011), Wensheng et al. (2012), Luo and chen(2013), Chuangxia et al.,(2013), Wen et al., (2014), Donglin et al., (2014), ZheGao et al, (2014), Yudie du et al. (2014), Huanhuan et al. (2014), Chunpeng and Liyun (2015), Yong Hu et al. (2016). Still from the Asian market, from the Taiwan Stock Exchange are: Chie_jie lu (2010),Chih-_fong and Yu-cieh (2010), Chun-I et al, (2010), Ching-Hsue et al, (2010), Cheng a et al. (2010), Liang-Ying a,b et al. (2011), Tsung-Jung et al.,(2011), Feng and Choub(2011), Chih-Ming Hsu(2011), Olivia and Sheng (2011), Chin-Yuan et al.,(2011), Chang-Fan (2011), Shie-jue et al.,(2012),Liang-Ying(2013), Wen Fenghua et al.,(2014),Kao-Yi and Gwo-Hshung (2015 and 2016).

The African markets are represented in the survey by the Nigerian stock exchange has these works selected Akintola et al.,(2011), Adebiyi et al., (2011, 2012), Ajao and Wemambu (2012), Adebiyi (2012), Neenwi et al., (2012), Adetunji et al., (2013), Olayiwola and Basira(2013), Neenwi et al. (2013), Abubakar and Adeboye(2013, 2014), Godknows and olusanya(2014), Ayodele et al.,(2014), Adebiyi et al., (2014), Huanhuan et al., (2014), Acheme David et al., (2014) and from Gabon is the work of Andrea Nemeli et al., (2015).

The American Markets also featured Johan et al.,(2010), Pei-Chann and Chang(2011), Ju-Jie et al.,(2011), Erkam et al.,(2011), Mighel and pedro(2011), Chih-Fong et al.,(2011), Yinkak (2011), David Enke et al., (2011), Ju-Jie et al.,(2012), Sureshkumar and Elango (2012), petr and filippo (2013), Yuling Lin et al., (2013), and Michael et al., (2015).

The European Markets represented includes the works of Y. Wu et al., (2010) and Chan and Franklin (2011), of the Australian Stock Market, Enric et al.,(2014), of the Belgium market, works from German, Japan, Romania, Switzerland, United Kingdom (Maik et al.,(2012), James and Mark(2012)), and Turkey were also reviewed.

Table 1: List of surveyed stock markets

Stock Market	Article
Ahmedabab stock market	Jay et al (2013)
Asia stock market	Wensheng et al. (2012)
Australia stock market	Y. Wu et al. (2010) and Chan et al. (2011).
Bangladesh stock market	Muhammad et al. (2010), Mustain et al. (2015),
Belgium stock market	Enric et al. (2014)
China stock market	Zheet al. (2010), Qinghua wen et al. (2010), Yixin and Zhang (2010), Li-Ping et al. (2011), Lie and Qung(2011), Chong and Olivia(2011), Kang and Sun (2011), Jian-Zhou et al. (2011), Wei shen et al. (2011), Wensheng et al. (2012), Luo and chen(2013), Chuangxia et al. (2013), Wen et al. (2014), Donglin et al. (2014), ZheGao et al. (2014), Yudie du et al. (2014), Huanhuan et al. (2014), Chunpeng et al. (2015), Yong Hu et al. (2016)
Egypt stock market	Osman et al. (2014)
Gabon index market	Andrea et al. (2015)

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Germany stock market	Michael et al. (2013)
Greece stock market	Atsalaki et al. (2011)
Hawaii stock market	Michael et al. (2012)
Hong Kong stock market	Senthamarai et al. (2010) and Chan et al. (2011).
India stock market	Dase et al. (2010), Kunwar et al. (2010), Nitin et al. (2010), charkravaty and Dash (2012), Sujata et al. (2012),Sureshkumar et al. (2012), Santosh et al. (2013), Choudhurg et al. (2014), Rajashree et al. (2014), Narendra et al. (2014), Subhabrata et al. (2014), Babita et al. (2014), Anish et al. (2015), Narendra et al. (2015), Jyoti et al. (2015), Anbalayan et al. (2015), Preethi et al. (2015), and Rajashree et al (2016).
Iran stock market	Esmaeil et al. (2010), Shahrokh et al. (2012), Asadi et al. (2012), Ahmad et al. (2013), Frookh et al., (2013), Reza et al. (2015), Mohammad (2015)
Japan stock market	Shangkun et al. (2011)
London stock market	Maik et al. (2012), James and Mark(2012),
Malaysia stock market	Azadeh et al. (2010), and Shu and Shok(2014).
Morocco stock Market	Salim Lahmiri(2014),
New York stock market	Daniel et al. (2010),
Nigeria stock market	Akintola et al.(2011), Adebiyi et al. (2011, 2012), Ajao et al. (2012), Neenwi et al. (2012), Adetunji et al. (2013), Olayiwola et al. (2013), Neenwi et al. (2013), Abubakar et al. (2013, 2014), Godknows et al. (2014), Adebiyi e et al. (2014), Ayodele et al. (2014), Huanhuan et al. (2014), Acheme et al. (2014),
Romania stock market	Catalina-Lucia(2015).
Singapore index	Adam et al, (2015),
South Korea Market	Park and Shin(2013),
Switzerland stock market	Maik et al. (2010), Angeva (2015),
Taiwan stock market	Chie_jie lu (2010), Chih-fong et al. (2010), Chun-I et al. (2010), Ching-Hsue et al. (2010), Cheng et al. (2010), Liang-Ying et al. (2011), Tsung-Jung et al. (2011), Feng et al. (2011), Chih-Ming (2011), Olivia and Sheng (2011), Chin-Yuan et al. (2011), Chang-Fan (2011), Shie-jue et al. (2012), Liang-Ying (2013), Wen Fenghua et al. (2014), Kao-Yi and Gwo-Hshung (2015 and 2016).
Thanjavur stock market	Preethi and santhi(2012).
Toronto stock market	Jeffrey et al. (2010), Callen (2010),
Turkey stock market	Malek and Derya(2010), Yakup et al. (2011), Sakir et al. (2015), Nerandra et al. (2015),
USA stock market	Johan et al. (2010), Pei-Chann and Chang(2011), Ju-Jie et al. (2011), Erkam et al. (2011), Mighel and pedro (2011), Chih-Fong et al. (2011), Yinkak (2011), David et al. (2011), Ju-Jie et al. (2012), Sureshkumar and Elango (2012), petr and filippo (2013), Yuling Lin et al. (2013), and Michael et al. (2015).
Vietman Index Stock	Duc-Hien and MAnh-Thanh(2014),
Wiley stock market	Esmaeil et al. (2012)

INPUT VARIABLES

Table 2 represents the differing input variables the used by the authors in the various articles. It is observed that most work surveyed used technical indicators for the stock forecasting, fewer works used the fundamental indicators. Adebiyi et al (2011) is an exception with a hybrid of 21 input variables, combining fundamental and

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technical data as inputs. The average number of variables (often technical data) used in the surveyed works ranges between four and nine.

Worthy of note are the works of Nitin et al 2010 who used the prices of daily open, high, low and close of SENSEX, BSE IT, BSE Oil & Gas, BSE 100 and S& P CNX Nifty. Johan et al, 2010 combined 9,853,498 tweets posted by approximately 2.7M users + DJIA closing-values from Yahoo! Finance to forecast stock price index, Şakir et al., 2015 also used gold price, oil price, interest rate, consumer price index (CPI), exchange rate, money supply and BIST volume to predict the BIST 100.

Table 2: Input variables used in different articles

Article	Input Variables
Adebiyi et al. 2011	21 input variables, including Technical analysis variables (Two Opening price, daily high price, daily low price, closing price and trading volume), fundamental variables(Price per annual earning, return on asset of trading, return on equity, management quality, investors confident, inflation rate, political factor and government policy) and experts' opinion variables
Adebiyi et al. 2012	Seven Technical indicators, Six Fundamental Indicators, and five Experts view (Total 18).
Adebiyi et al. 2014	Historical daily stock prices (open price, low price, high price, close price, and volume traded).
Abubakar et al. 2013	NSE All Share index (NSE_ASI), NGN/USD exchange rate (NGN_USD), NSE Market Capitalization (NSE_MCAP), Volume (VOL_CLOSING), Value (VAL_CLOSING).
Abubakar et al. 2014	NSE All Share index (NSE_ASI), NGN/USD exchange rate (NGN_USD) 9, NSE Market Capitalization (NSE_MCAP), Volume (VOL_CLOSING), Value (VAL_CLOSING)
Acheme et al. 2014	The Moving Average Convergence/Divergence (MACD), Relative Strength Index (RSI), Stochastic Oscillator (SO) and On-Balance Volume (OBV).
Adetunji et al. 2013	Stock moving average convergence/divergence, stock stochastic oscillator, closing momentum, stock relative strength index, stock on-balance volume, and the 5 and 10 days closing moving average.
Ahmad et al. 2013	NASDAQ (Intel, National Bank shares and Microsoft daily closed (last) stock price,)
Ajao et al. 2012	Daily data on Standard and Poor (S&P) index
Akintola et al. 2011	Closing price, Highest price, Lowest price, Volume.
Anbalaga et al. 2011	Technical Indicators (Simple Moving Average (SMA), Exponential Moving Average (EMA), Moving Average Convergence Divergence (MACD) and Relative Strength Index (RSI))
Anish et al. 2015	Ten indices from DJI & S&P500

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Anjeza 2015	Investor sentiment and four macro indicators (real GDP growth, CPI inflation, unemployment rate and term spread)
Asadi et al. 2012	Technical index
Atsalakis et al. 2011	Closing prices, opening prices,.
Azadeh et al. 2010	Historical market prices and technical analysis
Babita et al. 2014	Eight Technical indicators
Narendra et al 2014	Sunspot data, electricity price data, and stock market data,
Narendra et al. 2015	Ten data set from Indian NSE
Catalina-Lucia et al. 2015	opening, closing, highest and lowest price respectively of SNP stock from Bucharest Stock Exchange,
Cheng et al. 2010	Technical analysis
Chan 2011	Financial Report text (2000 financial reports with 28,000 sentences)
Chih-Fong et al. 2010	Fundamental indexes (Financial and macroeconomic variables).
Chih-Fong et al. 2011	Taiwan Economic Journal (TEJ) Data set.
Chih-Ming Hsu 2011	Technical and fundamental indices
Charkravarty 2012	The Standard's & Poor's 500 (S&P 500), the Bombay stock exchange (BSE) and Dow Jones industrial average (DJIA).
Chi-Jie Lu 2010	Forecasting variables
Ching-Hsue et al. 2010	Technical Analysis
Chin-Yuan et al. 2011	Taiwan Capitalization Weighted Stock Index.
Chin-Yuan et al. 2011	Technical indices(Moving Average(MA), Bias(BIAS), Relative strength index(RSI), Nine days stochastic lines (KD), Moving average convergence and divergence(MACD).
Chong 2011	72,221 micro blog postings for 1909 stock tickers and 3874 distinct authors
Choudhury et al. 2014	Top 102 stocks of the NSE stock market (India)
Chun-I et al. 2010	Taiwan Stock Indices
Daniel et al. 2010	Las Vegas sports betting markets, Trade Sports (now In trade), and Hollywood Stock Exchange (HSX).
David et al. 2011	The closing of the Shenzhen Integrated Index (SZII) and opening of the Dow Jones Industrial Average Index (DJIAI)
Donglin et al. 2014	The daily data including ASPI, All Share Total Return Index (ASTRI), Market Price Earnings Ratio (PER), and Market Price to Book Value (PBV) of the Colombo Stock Exchange
Duc-Hien et al. 2014	Stock market index (opening price, high price, low price, closing price).
Enric et al. 2014	Training Quote data, Training new data, and test plan
Erkam et al. 2011	Technical analysis and fundamental analysis (bond yields, bond prices, contact volumes etc.)

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Esmaeil et al. 2010	Technical index
Esmaeil et al. 2012	Stock index opening or closing price, as well as the daily highest and lowest values,
Feng et al. 2011	Two primary technical index
Frookh et al. 2013	NASDAQ historical quotes, namely Intel, National Bank shares and Microsoft daily closed (last) stock price.
Godknows et al 2014	technical analysis indicator
Hemanth et al. 2012	Closing data from Bombay Stock Exchange Sensex
Javad et al. 2015	Tehran Stock Exchange (Book Value, net EPS, forecasted EPS, ROE, ROA, P/E, Percentage of dividends, ratio of dividend to price, the Beta, CFO, operating profit (loss), profit in cash, dividend growth, rating liquidity, firm size, ratio of book value to market value, ratio of market value to book value, total equity at the end of fiscal year, net assets, annual stock returns).
Jay et al. 2013	Closing value of S&P CNX Nifty 50 Index
Jian-Zhou et al. 2011	………………
Johan et al. 2010	9,853,498 tweets posted by approximately 2.7M users + DJIA closing-values from Yahoo! Finance.
Ju-jie et al. 2012	The closing of the Shenzhen Integrated Index (SZII) and opening of the Dow Jones Industrial Average Index (DJIAI)
Kao-Yi et al. 2015	17 financial ratios
Kao-Yin, et al. 2014	17 financial ratios
Kunwar, et al. 2010	NIFTY data (Indian NSE)
Lei et al. 2011	Shangai Composite Index
Liang-Ying 2013	Two technical indicators
Liang-Ying et al. 2011	Technical analysis
Li-Ping et al. 2011	Kernel Principal Component Analysis (KPCA)
Luo et al. 2013	20 shares from Shanghai Stock
Melek, 2010	six macroeconomic variables and three indices
Michael et al. 2012	………………
Michael et al. 2013	……………..
Michel et al. 2015	………………
Miguel, 2011	Standard & Poor's (S&P) 500 index
Muhammad, 2010	The textual message base and corresponding exogenous feedback
Mustain et al. 2015	Six macroeconomic variables and three indices
Nitin et al. 2010	Prices of daily open, high, low and close of SENSEX, BSE IT, BSE Oil & Gas, BSE 100 and S& P CNX Nifty.

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Olayiwola, 2013	Stock prices of Nigerian breweries from 2008 to 2012
Osman et al. 2014	Two input variables
Park, 2013	The stock prices of LG Chem and KIA Motors, WTI intermediate oil price, other external factors, etc.
Preethi, 2012	Open, High, Low, Close values of the daily shares are input.
Qinghua et al. 2010	Closing price and technical indicators
Rajashree et al 2016	Open, low, high and closing stock index prices from (S&P500) and Bombay Sensex
Reza et al. 2015	Six macro-economic variables and three indices
Neenwi et al. 2013	Technical data from Banks On The Nigerian Stock Exchange
Olatunji et al. 2013	Closing price of the stock
Şakir et al. 2015	Gold price, oil price, interest rate, consumer price index (CPI), exchange rate, money supply and BIST volume
Salim 2014	Obtained approximation(Low frequency), detailed component (high frequency)
Senthamarai et al. 2010	High, Low, Close values of the daily share
Shahrokh et al. 2012	Technical index
Shangkun et al. 2011	News text data and time series data
Shie-Jue et al. 2012	Closing prices of the previous day
Shu, 2014	Annual stock market capitalization, gross domestic product, inflation rate, interest rate, and exchange rate volatility
Suanu et al. 2012	Stock index and its corresponding index futures, technical indicators(RSI, MACD, Trend, Momentum)
Subhabrata et al. 2014	Financial return on investments and movement of market indicators.
Sujata et al. 2012	7 samples from the respective datasets and three technical indicators.
Sureshkumar et al. 2012	TCS Company's previous close, open price, high, price, low price and close price
Tsung et al. 2011	Candidate input features.
Wei Shen et al. 2011	BIAS6, OBV and PSY12
Wen et al. 2014	Predictive value for each component
Wensheng et al. 2012	Independent Components (ICs)
Y. Wu et al. 2010	Sales to total assets, lagged stock return (lagEx-Return) and volatility variables (lagSIGMA)
Yakup et al. 2011	Ten technical indicators
Yixin,Zhang2010	Technical indicators (Moving average (MA), Random indicator (KDJ), Moving Average Convergence/Divergence (MACD), Relative Strength Index (RS1), On Balance Volume (OBV), BIAS, Increase scope).
Yong Hu a et al. 2016	Fundamental analysis, technical analysis
Yudie Du et la. 2014	3 input nodes

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| Yuling LIN et al. 2013 | Selected subset of financial indexes |
| ZheGao et al. 2014 | Sets of predictors and super predictors |

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MODELLING TECHNIQUES/MODELS

Table 3 provide the analysis of the modelling techniques used in the surveyed journals, it shows that most of the data samples used in the surveyed paper were pre-processed before they were inputted into the prediction model, the table 3 revealed that over 50% of the journals pre-processed their data while some did not show if the data used for the prediction were pre-processed or not. This shows that data pre-processing plays an important role in stock prediction. The input data size varies greatly in the surveyed papers; ranging from 6343 data samples in the work of Abubakar et al., 2014, and as low as 228 inputted data sample size in the work of Melek et al, 2010. In all cases, the whole of the data samples are divided into training, testing and checking/validation data. Also, the surveyed papers reveals that the dominance of Artificial Neural Networks (ANN) model for stock price prediction stand out, and followed by it variant Adaptive Neuro-Fuzzy Inference System as presented in the table below.

Table 3: Summary of modelling techniques

Article	Data Preprocessing	Sample size	Model used	Network Layers	Membership functions	Validity Set	Training Method
Adebiyi et al. 2012	(0,1)	1781	FFNN	18:26:01	sigmoid		Back propagation Alg.
Adebiyi, et al. 2011	(0,1)	3000	BPN	21:26:01	sigmoid	21	FNN
Abubakar et al. 2013	Yes	570 days	SMO	_____	_____	163	SVM
Abubakar et al. 2014	Yes	6343	FFNN	4:02:01	_____	399	EBP
Acheme et al. 2014	No	D: 2months	Fuzzy	_____	Gauss, triangular	____ ____	FLC
Ahmad et al. 2013	(0,1)	640	hybrid ANN, ANFIS	_____	_____	160	FNN
Adetunji et al. 2013	(-1,1)	D:~2 years	ANN	9:05:01	Sigmoid, hyperbolic, tangent	Yes	ANN,BN
Ajao et al. 2012	No	D: 4years	ARCH	_____	_____	Yes	Myriad
Akintola et al. 2011	(0-1)	D: 15months	FFNN	4/4/4/1	Step, Sigmoid	25%	BPN
Anbalagan 2015	No	623513	FM	_____	DSS	20%	BSE
Anjeza 2015	No	32 months	PTR	_____	_____	____ _	LSM
Anish 2015	Yes	3168	FFLANN	_____	sigmoid, gauss	500	RecursiveLeastSquare
Asadi et al. 2012	No	620	ANN	2/4/4/1	sigmoid, Tanh	500	PELMNN
Atsalakis et al. 2011	No	2060	ANFIS	_____	Bell, gauss, gauss2, triangular, trapezoidal	60	WASP

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Ayodele et al. 2014	No	5680	ANN	10:17:01	triangdm	5000	LSM
Azadeh et al. 2010	No	___	_____	_____	_____	____	_____
Babita et al. 2014	No	500	hyb.BFNN,NGSA-II	_____	Guass	144	LSM
Narendra et al. 2014	Yes	744	hyb. ANN, ARIMA	4:02:01	sigmoid	20	MAE, MSE
Narendrae t al. 2015	Yes	500	hyb. ARIMA, GARCH	_____	Gaussian	50	ANN
Catalina-Lucia 2015	No	6000	ANN	_____	_____	200	MSE
Chan et al. 2011	Yes	28,000 Sentences	Hidden Markov Model (HMM)	_____	Viterbi Algorithm	2000 Reports	ML
Cheng et al. 2010	Yes	D:1 year	ANNs	_____	triangular	2 months	NN
Charkravarty et al. 2012	(0,1)	800	FLANN	7:2:4:4:1	Guassian	600	ANN
Chih-Fong et al. 2011	No	210	MLP	1:01:01	_____	72	NN
Chih-Fong et al. 2010	Yes	D:1 year	BPNN	6:12:18	_____	_____	ANN
Chih-Ming Hsu 2011	No	3540	hyb. SOMNN,GP	4:01:01	Guassian	_____	GP
Chi-Jie Lu 2010	Yes	781	BPNN	3:04:03	Guassian	235	ICA
Ching-Hsue et al. 2010	Yes	D: 6 years	ANN	____	_____	____	AI
Chin-Yuan et al. 2011	No	D: 36 months	FNN	2:01:01	_____	3 months	PSO, RLS
Chin-Yuan Chang 2011	Yes	D:3 year	ANN	_____	Sigmoid	7 months	LSM
Chong et al. 2011	Yes	3 months	Sensitivity Analysis	__		____	
Choudhur yet al. 2014	No	102	SVM	_____	_____	____	SOM
Chuangxia et al. 2013	No	58751	HAR-CJ-M	____	_____	1199	ARV
Chun-I et al. 2010	No	D: ~1 year	NNGBM	_____-	_____	_____	LSM
Daniel et al. 2010	No	___	BJNN	____	_____	_____	_____

Dase et al. 2010	No	_____	ANN	___	_____	__	NN
DOnglin et al. 2014	Yes	D:2 years	BPNN	3:03:03	____	20%	MAPE
David et al. 2011	No	216	hyb. ESM, ARIMA, BPNN	12:09:12	_____	48	BPNN
Duc-Hien et al. 2014	No	2409	ANFIS	____	Gaussian	200	Fuzzy
Enric et al. 2014	Yes	36 months	SVM	_____	_____	12 months	EMP
Erkam et al. 2011	No	43194.05	hyb. ANN, RNN	____	_____	16889.1	DAN2
Esmaeil et al. 2012	Yes	503	hyb. FMAS	1:3:2:4	Gaussian	91	SOM-Clustering
Esmaeil et al. 2010	No	400	Fuzzy logic, ANNs	___	Triangular	71	CGFS
Frookh et al. 2013	Yes	800	SVR	_____	_____	160	FNN
Godknows et al. 2014	Yes	D:16 years	ANN, ARIMA	_____	_____	1 year	EMP
Hemanth et al. 2012	Yes	Daily	ANFIS	4:2:2:2:1	_____	10 days	Neuro Fuzzy
Javad et al. 2015	No	2047	ANN	4:05:01	_____	15%	EMH
Jay et al. 2013	Yes	3000	ANN	1:10:10	_____	540	NN
Jian-Zhou et al. 2011	Yes	204	BPNN	_____	_____	20%	WDBP
Johan et al. 2010	No	D:~10 months	Sentiment Analysis	____	_____	20 days	Fuzzy NN
Ju-Jie et al 2011	No	216	hyb.ESM, ARIMA, BPNN	12:09:12	_____	48	GA
Agrawal et al. 2013	Yes	D: 4 years	NN	_____	___	30	Hybrid
Kao-Yi et al. 2015	No	124	ANNs	_____	_____	50	ANP
Kao-Yin et al. 2014	No	75	ANN	_____	_____	20	ANP, DEMATEL
KAo-Yin et al. 2016	No	512	FLANN	__	Gausssian	171	Fuzzy NN
Kunwar et al. 2010	Yes	500	NNs	_____	_____	100	MAPE, MSE, RMSE
Lei-Qiang2011	Yes HLP	24 groups	ANN	_____	____	4 groups	HLP
Liang-Ying 2013	No	D: 12 months	ANFIS	4:2:2:2:1	BELL	2 Months	FIS
Liang-Ying et al. 2011	Yes	D: 12 months	ANFIS	4:2:2:2:1	Gauss	2 months	LSM

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Li-Ping et al. 2011	(1, -1)	D: 6 years	SVM	_____	____	1 year	KPCA
Luo et al. 2012	No	D:~1 year	PLR and weighted SVM	_____ _	_____	10%	NN Toolbox in Matlab R2007b
Melek et al. 2010	No	228	ANFIS	6:9:9:9:1	gbell, gauss	106	RMS
Michael et al. 2012	No	Daily	ANN	___	_____	_____	SVM
Michael et al. 2013	No	3478	SVMs	____	_____	50%	BNS, Chi2
Michel et al. 2015	No	81%	NN	_____	_____	15%	Ensemble
Miguel et al. 2011	No	D: 60 months	MSE	_____	_____	_____	SOP
Muhammad et al. 2010	No	D:30 days	_____	_____	_____	7 days	_____
Mustain et al. 2015	No	500	ANN, ANFIS	1:3:3:1	Sigmoid	30	____
Nitin et al. 2010	Yes	1218	ANN, ARIMA	5:05:01	_____	30	BP Alg.
Olayiwola et al. 2013	No	141.49	ARIMA	_____	_____	6.48	MA
Osman et al. 2014	Yes	D:~4 years	ANFIS	4:2:2:2:1	____	13 days	GA, FS
Park et al. 2013	No	403	ANN, SVM	_____	_____	103	SSL
PREETHI et al. 2012	No	____	ANFIS	_____ _	_____	_____	LSM, BPN
Qinghua et al. 2010	(-1, 1)	1050	SVM	_____	_____	50	ANN
Rajashree et al. 2016	No	512	SERNFIS, RCEFLANN	2:6:3:3:3:6:2	Gaussian	171	ANFIS, MDHS
Reza et al. 2015	Yes	162	GANN, GRNN	7:4:5:7	_____	32	BNNMAS
Neenwi et al. 2013	No	D: 2 years	ANN	4:02:03	_____	149	GFF
Olatunji et al. 2013	No	2130	ANN	3:06:02	_____	30%	BPNN
Şakir et al. 2015	No	D: 30 months	ANN	7:9:7:2	_____	8 months	Gradient Descent
Salim 2014	No	3910	ANN	2:04:01	_____	782(20%)	BPNN
Shahrokh et al. 2012	Yes	620	Levenberg–Marquardt(LM) algorithm	3:02:01	_____	120	ARIMA, BP, SVM
Shangkun et al. 2011	Yes	D:18 months	SVM	_____	_____	8 months	SP

Shie-Jue et al. 2012	No	D:12 months	Fuzzy	9:4:1:1	_____	2 months	LSM
Shu et al. 2014	No	D: 264 months	VAR, GARCH	_____	_____	____	_____
Suanu et al. 2012	No	30 days	ANN	_____	Triangular, Trapezoidal, Gaussian	50%	Fuzzy logic
Subhabrata et al. 2014	No	225	SOM	_____	_____	____	SVM
Sujata et al. 2012	No	4000	FLANN	6:2:2:2:1	Gaussian	450	Fuzzy log., BP
Sureshkumet al. 2012	Yes	508	ANN	_____	_____	153	MLP
Tsung et al. 2011	Yes	D:12 months	ABC-RNN	_____	_____	50%	ANNs
Wei Shen et al. 2011	No	30	RBFNN	3:03:01	_____	10	AFSA
Wen et al. 2014	No	1150	SVM	_____	_____	383	SSA
Wensheng et al. 2012	Yes	1000	NLICA, NN	7:8:9:10	_____	200(20%)	BPN
Wu et al. 2010	No	887	Bankrupty	_____	_____	237	Random Sample(RS)
Yakup et al. 2011	No	900	ANN, SVM	10:03:01	_____-	153	PNN
Yixin et al. 2010	Yes	4255	BPNN	3:03:01	_____-	27	MACD
Yong Hu et al. 2016	No	200 days	GA, GP	_____	_____	20 days	EC
Yudie et al. 2014	No	D:14 months	D&C	3:05:01	_____	6 months	ARIMA, GM, BPNN
YuKak 2011	No	_____	Social Media	_____	_____	_____	ICS
Yuling LIN et al. 2013	No	880	SVM	_____	_____	5%	SVM
ZheGao et al. 2014	No	433	Hybrid HC-SVR	_____ _	_____	____ _	SVR

MODELLING BECNHMARK

Table 4 presents how each article benchmarked its work against other techniques/models to gives further clarity to the table 3 above. From the table below most authors that use ANN models benchmarked their work with ARMA model possibly because it is a statistical technique.

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Article	ANNs	LR/MLR	ARMA	RW	ARCH	NB	HAR-CJ	SVR	NSGA-II	RBF	BP	OTHERS
Adebiyi et al. 2012	*											
Adebiyi, et al. 2011	*		*									*
Abubakar et al. 2013	*					*						
Abubakar 2014	*	*	*									*
Acheme et al. 2014					*							*
Ahmad et al. 2013							*	*				
Adetunji et al. 2013	*											
Ajao 2012				*	*							
Akintola et al. 2011	*											
Anbalagan 2015	.*			.*				*				
Anjeza 2015												.*
Anish et al. 2015	*.											.*
Asadi et al. 2012	.*											
Atsalakis et al. 2011	.*											.*
Adebiyi et al. 2014	.*		*.									
Azadeh et al. 2010												.*
Babita et al. 2014									.*	*.		
Narendra et al. 2014			.*		.*							
Narendra et al. 2015	*.		.*									
Catalina-Lucia et al 2015	.*		*.									
Chan et al. 2011												.*
Cheng et al. 2010	*.		.*		*.							
Charkravarty et al. 2012	.*											.*
Chih-Fong et al. 2011	.*											.*
Chih-Fong et al. 2010	.*											
Chih-Ming Hsu 2011	.*		*.									
Chi-Jie Lu 2010	.*		.*									
Ching-Hsue et al. 2010	.*		*.		*.							
Chin-Yuan et al. 2011	.*		*.		.*			*.				

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Chin-Yuan et al. 2011	.*								*.
Chong et al. 2011									*.
Choudhury et al. 2014	*.		*.		.*				
Chuangxia et al. 2013					.*		*.		
Chun-I et al. 2010								*.	.*
Chunpeng 2015									.*
Daniel et al. 2010									.*
Dase et al. 2010	.*								.*
Donglin et al. 2014	.*							.	
David et al. 2011	.*		.*						
Duc-Hien et al. 2014	.*								*.
Enric et al. 2014									.*
Erkam et al. 2011	*				*.				
Esmaeil et al. 2012	.*								.*
Feng et al. 2011	.*								.*
Esmaeil et al. 2010	.*								.*
Frookh et al. 2013	.*		.*						
Godknows et al. 2014	.*		.*						
Hemanth et al. 2012	.*								.*
Huanhuan et al. 2014	.*								.*
Javad et al. 2015	.*								.*
Jay et al. 2013	.*		.*						
Jian-Zhou et al. 2011	.*							.*	
Johan et al. 2010									.*
Ju-Jie et al. 2012	.*		.*						
Ju-Jie Wang et al. 2011	.*		.*						
Agrawal et al. 2013	.*								.*
Kao-Yi et al. 2015	.*								.*
Kao-Yin et al. 2014	.*								.*
KAo-Yin et al. 2016	.*								.*
Kunwar et al. 2010	.*								.*
LEi et al. 2011									
Liang-Ying 2013			.*		.*				

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Liang-Ying et al. 2011	.*		*.		.*							
Li-Ping et al. 2011	.*											.*
Luo et al. 2013	.*											.*
Melek et al. 2010	.*											.*
Michael et al. 2012	.*											.*
Michael et al. 2013												
Michel et al. 2015												
Miguel et al. 2011												
Muhammad et al. 2010												
Mustain et al. 2015												
Nitin et al. 2010	.*		.*									
Olayiwola et al. 2013			.*									.*
Osman et al. 2014	.*											.*
Park et al. 2013	.*											.*
Qinghua et al. 2010	.*											.*
Rajashree et al. 2016	.*											.*
Reza et al. 2015	.*										.	
Neenwi et al. 2013	.*											.*
Olatunji et al. 2013	.*											.*
Şakir et al. 2015	.*											.*
Salim 2014	.*		*.									
Senthamarai et al. 2010												
Shahrokh et al. 2012	.*											.*
shangkun et al. 2011	.*											.*
Shie-Jue et al. 2012			.*		.*							
Shu et al., 2014					.*							.*
Suanu et al. 2012	.*											.*
Subhabrata et al. 2014	.*		.*		.*							
Sujata et al. 2012												
Sureshkumar et al. 2012												
Tsung et al. 2011	.*											.*
Wei Shen et al. 2011												
Wen et al. 2014	.*											

Wensheng et al. 2012	.*										.*
Wu et al. 2010											
Yakup et al. 2011	.*										.*
Yixin et al. 2010	.*										.*
Yong Hu a et al. 2016											
Yudie Du et al. 2014	.*		.*		.*						
Yulinget al. 2013	.*										
ZheGao 2014	.*							.*			

PERFORMANCE MEASURES

Table 5 below shows the performance measures used by the different authors to evaluate their works in determing the accurate level of their predictive modeles. The most common is mean square error (MSE).

Table 4: Comparative Analysis of Soft computing Techniques used.

Table 5 : Performance Measures used in different articles

Article	Model Performance Measure
Adebiyi et al. 2012	MSE
Adebiyi et al. 2011	MSE
Abubakar et al. 2013	Precision (P) and Recall (R)
Abubakar et al. 2014	MSE, Correlation Coefficient (r), RMSE and MAE
Acheme et al. 2014	
Ahmad et al. 2013	MSE and MAPE
Adetunji et al. 2013	MSE
Ajao et al. 2012	
Akintola et al. 2011	Mean Relative Percentage Error(MRPE)
Anbalagan et al. 2015	BSE
Anjeza 2015	PTR, PSTR
Anish et al. 2015	MAPE
Asadi et al. 2012	RW Model
Atsalakis et al. 2011	_____
Ayodele et al. 2014	MSE
Azadeh et al. 2010	_____
Babita et al. 2014	Radial Basis function network(RBFN) and NSGA-II
Narendra et al. 2014	MAE, MSE
Narendra et al. 2015	MAPE, RMSE, MaxAPE, and MAE
Catalina-Lucia et al. 2015	MSE
Chan et al. 2011	Overall Accuracy (OA)
Cheng et al. 2010	Forcasting Accuracy Evaluation and Stock Return

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Charkravarty et al. 2012	MAPE, RMSE
Chih-Fong et al. 2011	Return on investment(ROI)
Chih-Fong et al. 2010	_____
Chih-Ming Hsu 2011	CE, RMSE, MAE, and MAPE
Chi-Jie Lu 2010	TnA
Ching-Hsue et al. 2010	RST and GA
Chin-Yuan et al. 2011	RMSE
Chin-Yuan et al. 2011	
Chong et al 2011	UnderReaction Coefficient (URC), precision, recall and F- measures
Choudhury a et al. 2014	_____
Chuangxia et al. 2013	_____
Chun-I et al. 2010	_____
Chunpeng et al. 2015	_____
Daniel et al. 2010	RMSE, Calibration and discrimination
Dase et al. 2010	_____
DOnglin et al. 2014	MAE, RMSE, MAPE
David et al., 2011	MAE, RMSE, MAPE, ME and DA
Duc-Hien et al. 2014	NMSE, MAE and Directional symmetry(DS)
Enric et al. 2014	_____
Erkam et al. 2011	MSE and MAD
Esmaeil et al. 2012	_____
Feng et al. 2011	Directional symmetry (DS),Correct up-trend (CP) and correct down-trend (CD)
Esmaeil et al. 2010	_____
Frookh et al. 2013	MSE
Godknows et al. 2014	RMSE, MAE and NMSE
Hemanth et al. 2012	_____
Huanhuan et al. 2014	_____
Javad et al. 2015	RMSE
Jay et al. 2013	RMSE and MSE
Jian-Zhou et al. 2011	MAE, RMSE and MAPE
Johan et al. 2010	MAPE
Ju-Jie et al., 2011	MAE, RMSE, MAPE, ME and DA
Agrawal et al. 2013	_____
Kang et al. 2011	_____
Kao-Ying et al. 2015	ANNs
Kao-Yin et al . 2014	_____

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KAo-Yin et al. 2016	_____
Kunwar et al. 2010	Sum of Squares Error Function.
LEi, et al. 2011	_____
Liang-Ying 2013	RMSEs
Liang-Ying et al. 2011	RMSE
Li-Ping et al. 2011	_____
Luo et al. 2013	_____
Melek et al. 2010	_____
Michael et al., 2012	_____
Michael et al. 2013	_____
Michel et al. 2015	_____
Miguel et al. 2011	MSEs
Mohammad et al. 2015	_____
Muhammad et al. 2010	_____
Mustain et al. 2015	RMSE and R2
Nitin et al. 2010	AAE, RMSE, MAPE and MPSE
Olayiwola et al. 2013	_____
Osman et al. 2014	_____
Park et al. 2013	_____
Preethi et al. 2015	MAE, RMSE
PREETHI et al. 2012	_____
Qinghua et al. 2010	MSE and SCC
Rajashree et al. 2016	_____
Reza et al. 2015	_____
Neenwi et al. 2013	MSE
Olatunji et al. 2013	R2, RMSE, MAD, AND MAPE
Şakir et al. 2015	_____
Salim 2014	MAE, RMSE, MAD
Senthamarai et al. 2010	_____
Shahrokh et al. 2012	RW Model
Shangkun et al. 2011	_____
Shie-Jue et al. 2012	RMSE
Shu et al. 2014	_____
Suanu et al. 2012	_____
Subhabrata et al. 2014	_____
Sujata et al. 2012	MAPE and RMSE
Sureshkumar, et al. 2012	_____
Tsung et al. 2011	RMSE, MAE, MAPE and THEIL U

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Wei Shen et al. 2011	_____
Wen et al. 2014	_____
Wensheng et al. 2012	RMSE, MAD, RMSPE and DS
Y. Wu et al. 2010	_____
Yakup et al. 2011	_____
Yixin et al. 2010	_____
Yong Hu et al. 2016	RMSE, ACCURACY, MAPE, MAE, HIT RATE AND R2
Yudie Du et al. 2014	MAPE
Yuling et al. 2013	HIT RATIO
ZheGao et al. 2014	RMSE, NMSE, MAE, and DS

CONCLUSION

The articles surveyed in this work have used soft computing techniques to predict stock prices and index, with different approaches such as single modeling technique, hybrid technique and ensemble.. Input data, forecasting methodology, model comparisons and measures used for performance evaluation were analysed. This survey shows stock price prediction accuracy does not rely solely on the technique being employed, but on the context, data preprosessing, how the techniques are combined amongst myriads of other factors. This paper would guide future researchers to know the entent of the used of soft computing techniques to predict stock prices which inform the choice of technique to use and improve upon.

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