Impact of Social Media Sentiments and Economic Indicators in Stock Market Prediction

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Abstract— Nowadays, stock market is the one of the major sources of raising resources for India and is act as a key driver for economic growth of a country. The stock market forecasting is a very difficult and highly complicated task because it is affected by many factors such as economic conditions, political events and investor's sentiment etc. The stock market series are generally dynamic, nonparametric, noisy and chaotic by nature. The primary objective of this research paper is to examine the relationship between Social Media Sentiments, Gold Prices, Exchange Rate and Crude Oil Prices in Indian stock market prediction. The sentiment analysis along with wisdom of crowds can automatically compute the collective intelligence of future performance in the stock market and others. The proposed method utilizes collective sentiments from social media for stock market prediction. Experimental results show that there is some causal relationship between public sentiment and stock market indices to provide useful investment decisions in the right direction. Further, the results show the significant relationships among economic indicators and stock market index.

Keywords- Sensex; Nifty; Bombay Stock Exchange; Gold Price; Crude Oil ; Exchange Rate; Sentiment Analysis; Wisdom of Crowd

I. INTRODUCTION

Stock markets play a vital role in growing industries and commerce of a rustic that eventually have an effect on the economy. Its importance has been well acknowledged in industries and investors views. The stock market prediction is one of the important issues in stock market research because of its challenging characteristic.

The investors rigorously watch the performance of stock markets by observing the composite market index, before investing funds. The market index provides a historical stock exchange performance, the yardstick to check the performance of individual portfolios and additionally provides investors for predicting the future trends within the market.

Over the years, numerous studies [1, 2, 3, 4, 5, 6] and research have been focused for finding the stock market forecasting. However, forecasting stock market remains a difficult and highly challenging one. There are many factors affecting stock market such as economic conditions, political events and investor's sentiment etc.

Indian stock market is greatly influenced by three economic indicators, such as gold price, exchange rates and crude oil price. Increasing oil prices can increase the production cost which is able to have an effect on income and can decrease stock costs. Investors are showing fewer issues within the stock markets and investment in yellow metals as a result of increasing trend in gold costs on account of no concern and no future loss. Again, rate of exchange fluctuations can have an effect on international trades, so influence the securities market.

The government of India has given up the administrated worth mechanism in oil sector and connected the domestic oil costs with international oil costs. Oil worth as external issue actually affects the Indian economy, particularly the Indian currency where American dollar is that the acceptable currency in International market, therefore it became the matter of analysis investigation. The impact has been assumed with respect to rate of exchange of rupee to dollar alone.

The 'wisdom of crowds' equipped with text mining and sentiment analysis will automatically generate collective intelligence of future performance on a numerous areas such as sports outcome, hotspot forums prediction [7], stock market price prediction, election results and box office sales prediction. Over the past few years, important progress has been achieved in exploitation Twitter [1] as a further supply of knowledge. The sentiment lexicon is the important resource in many sentiment oriented applications.

Many researchers are done the long and short-term relationships among stock price level and gold worth in developed and developing countries. Empirical results show that gold worth will greatly have an effect on the securities market. The exchange rate fluctuations can have an effect on international trades, thus influence the exchange. At an equivalent time, rate of exchange fluctuations can directly affect the profits, thereby impact the stock costs. The primary objective of this research paper is to examine the dynamic relationships between Social Media Sentiments, Gold Prices, Exchange Rate and crude oil Prices in Indian stock market.

The rest of the paper is structured as follows: Section II briefly discusses the review of related works. The materials and methods adopted are presented in Section III. The empirical results and analysis are discussed in Section IV and Section V concludes the paper.

II. RELATED WORKS

A. Economic Indicators Selecting a Template

The impact of economic fundamentals on stock costs or stock returns has been a long debated issue amongst the academicians and professionals. The previous empirical works on the link between macro economic factors [8] and stock returns will be divided into two broad ways. The impact of macroeconomic factors on stock market was shown in the first category. The second category focused on the relationship between the stock market volatility and macroeconomic factors.

The authors Ibrahim Tuhran in [9] analyzed the dynamic relationship between oil prices and exchange rate of thirteen emerging countries. During the study there's an obvious depreciation of the native currency against the United States of America dollar and therefore the co-movements has multiplied. The results show that oil worth movements get a multiplied importance when the money crisis, as oil costs rise there's an obvious depreciation of the native currency against the United States of American dollar.

Mohammad Shaidan Shaari [10] examined the effects of crude oil price index, consumer price index and exchange rate on Malaysian stock market. The authors Ademola Ojebiyi and David Olugbenga Wilson [11] proposed a model to indentify the relationship between oil prices and exchange rate, where there is a negative relationship between exchange rate and oil prices.

The work proposed by Syed Abul Basher and et.al [12] showed the dynamic relationship between real oil prices, exchange rate, market stock prices, and interest rates. The result reportable within the paper offered some support for higher oil costs poignant exchange rates within the short run. Specifically positive oil shock results in immediate visit the trade weighted charge per unit. On the opposite hand oil costs respond negatively to associate sudden increase in oil offer associated oil costs respond positively to an surprising increase in demand.

A.Hidhayathulla and Mahammad Rafee [13] developed a model to show the relationship between crude oil price and rupee, dollar exchange Rate. Oil worth and imports area unit rising continuously and this pushes up the demand for dollar that strengthens the dollar against rupee and Indian rupee is continuously decreasing. This erodes buying power of Indian currency within the international market. The domestic oil offer augmentation and management over oil demand appears to be viable policy choice to overcome rate of exchange depreciation and its consequences. Amalendu Bhunia [14] investigates the cointegration relationships among crude oil price, domestic gold price and selected financial variables (exchange rates and stock price indices) in India.

The impact of macroeconomic variables (interest rate, house price and gold price) on Iran stock was examined by Mahmood Yahyazadehfar and Ahmad Babaie in [15]. The authors in [16] have made a study to examine the co-movements of selected macro-variables such as gold price, stock price, real exchange rate and the crude oil price. The result of the study reported that there is a co-integration relationship between the variables. S.Kaliyamoorthy and S.Parithi [17] have examined the relationship between gold price and stock market.

Thai-Ha Le and Youngho Chang [18] have examined a study on dynamic relationships between the price of oil, gold and financial variables in Japan. The authors in [19] have proposed a method to evaluate the long-term relationship between BSE and Macro-economic variables such as exchange rates, foreign exchange reserve, inflation rate and gold price. The study result reveals that exchange rate and gold price influences the stock prices in India

Macroeconomics is considered as important factor for investing in India. It is proved that macroeconomics bring significant impact to the stock price. From the Sensex and Nifty, it is indicated that increase in inflation lead to higher stock price which is higher rate of return. In contrast, increase in exchange rate cause lower price of stock which result in lower return.

A considerable variety of studies on the connection between crude oil price, gold price, exchange rates and stock worth indices are undertaken. Solely a number of studies have examined the connection between crude oil price, gold price, exchange rates with stock market normally and Indian stock exchanges above all. The existence of oil value, gold value exchange rates and stock value indices of stock exchange in India are hardly out there. Therefore, this research paper aims to examine the changes of exchange rates or increase in daily oil value, gold value and its impact on stock value indices in India.

B. Social Media Sentiments

Usually, the stock market prediction is to be done with either technical or fundamental indicators. The technical indicators are quantitative measure and is obtained from the historical data such as simple moving average, exponential moving average etc.,. The fundamental analysis is to be performed with the non historical quantitative information such as macroeconomic indicators and the majority of the data is of unstructured nature. Therefore, it is essential to extract the information from unstructured sources and perform the analysis to make use of them in the prediction work.

Yet, major works [20, 21, 22, 23, 24, 25] done with sentiment analysis mainly focuses on the product review, movie review and blogs[29]. On the other hand, the lexicon developed for one domain misclassifies information in another domain. Since, they are domain dependent.

Various kinds of forecasting models based on soft computing[25],[26],[27] have been proposed to improve prediction accuracy in the stock market forecasting. Furthermore, the investors not aware much of the stock market behavior and they do not know which stock investment yields more profit. To know the stock market progress they want to analyze all relevant information from the news sources and magazines. The natural language processing and machine learning are playing major role in the prediction of the stock price.

Likewise, the face book and Twitter [21],[23] are most popular social media [28] and has high influence in the stock market prediction. The content of the Twitter was used to predict the stock market movement in the Dow Jones [1], [2] as well as Indian stock index. Based on the list of six different states of mood such as calm, alert, sure, vital, kind and happy were used in the analysis. The authors found that happy and calm had a high correlation with the stock market prediction.

Using Naïve Bayeisan (NB) [24] approach the movement of the stock price was done based on news articles sentiment mining sentiment from micro blogging data to perform stock market forecasting has already presented promising results. Mao in [1] used a random sample of public tweets with a sentiment to decide the tweet as "bullish" and "bearish" the stock market. They showed that their sentiment indicators and frequency of financial terms are significantly predicting the stock market returns. The bag of words approach was combined with J48 [7], [26] to predict the stock market movement based contents.

III. PROPOSED WORK

A. Data Sources

The discussion forums and blogs are not rapidly progressing to spread the data but stock market requires the communication medium as rapidly spreadable nature. Rather than forums and blogs, the news channels and twitter are emerging their progress in rapid manner. So the proposed system gathers the data from twitter and money control news sources.

The proposed system uses the set of data for Indian stock market index (Sensex, Nifty), exchange rate of Indian rupee versus US Dollar (INR/USD) and Crude oil index (WTI). The sentiment data was collected from Twitter and Money Control [30].The required data are obtained from [30] for the period from January 2, 2013 to July 31, 2014.

B. Gold Price(GP)

Gold could be a substitute investment avenue for Indian investors. Because the gold worth rises, Indian investors tend to speculate less in stocks, inflicting stock costs to fall. Therefore, a negative relationship is predicted between gold worth and stock worth. So this important macroeconomic variable has additionally been enclosed during this research.

C. Exchange Rate(ER)

US dollar ($) has been taken to be the foreign currency against that the Indian monetary unit charge per unit is taken into account. This can be as a result of the America dollar has remained to be the foremost dominating foreign currency used for commercialism and investment throughout the amount of this study. Generally, a decreasing currency causes a decline available cost attributable to expectations of inflation.

D. Crude Oil Price(COP)

Crude oil is an essential input for production and thus, the worth of oil is enclosed as a proxy for real economic activity. Moreover, increase in oil costs ends up in higher transportation, production and heating prices that have negative impact on company earnings. Rising fuel costs also raise alarm concerning inflation and diminish consumers' discretionary disbursement. Therefore, the financial risk of investments will increase once there's wide fluctuation in oil costs. Therefore, for oil commercialism countries like India, a rise in oil worth can cause a rise in production costs and thence to small future income, resulting in a negative impact on the exchange. Therefore, a rise within the worth of oil within the international market suggests that lower real economic activity all told sectors which is able to cause stock worth to fall.

E. Senitment Analysis

The SentiWordNet is a lexical resource in which every synset of WordNet resource is associated with three numerical scores such as positive, negative and neutral. The semantic information obtained from this resource is incorporated with the technical indicators to forecast the stock price movement.

The raw data collected from the twitter and money control is preprocessed and sentiment score is to be calculated for every word using (1) and (2).

$$sent_{pos} + sent_{neg} + sent_{neg} = 1 \qquad (1)$$

$$sent_{overall} = \sum_{i=1}^{n} \frac{sent_{pos}{}^i - sent_{neg}{}^i}{n} \qquad (2)$$

The overall sentiment and sentiment bullishness is calculated using (3), (4) and (5).

$$Positive \ (Pos), if \ sent_{overall} \geq +1 \qquad (3)$$

$$Negative \ (Neg), if \ sent_{overall} \leq -1 \qquad (4)$$

$$Sentiment \ Bullishness \ Index(SI) = \ln\left[\frac{1 + N^{Pos}}{1 + N^{Neg}}\right] \qquad (5)$$

Where N^{Pos} is the total number of positive (Pos) sentiment postings, while N^{Neg} is the total number of negative (Neg) postings. For example, bullish market sentiment is indicated by rising price of stock and falling price of stock indicates the bearish market sentiment. The Sentiment Bullishness Index is more than 0 is bullish, while 0 is neutral and less than 0 is bearish.

IV. EMPERICAL RESULTS AND ANALYSIS

A. Correlation Analysis

The correlation is used to find out the strength of relation between the macroeconomic variables (Gold Price, Exchange Rate and Crude Oil price) and stock market index (Sensex and Nifty). A value close to -1 or +1 indicates a good mathematical fit to a linear model and at the same way the value close to 0 indicates poor fit to a linear model. The value close to +1 denotes a high degree of linear relationship and the value close to -1 denotes a low degree of linear relationship between variables. Although the value = 0 denotes there exists no linear relationship between them.

B. Unit Root Test :

The Augmented Dickey – Fuller Test (ADF) is used to identify the time series is stationary or not. If the critical value is above the calculated values, then the time series is stationary, subsequently null hypothesis is rejected.

H₀: Series is stationary

H₁: Series is non-stationary

If there are two variables, x_i and y_i which are both non-stationary in levels but stationary in first differences, then x_i and y_i would become integrated of order one, I(1), and their linear combination should have the form in (6), (7)

$$z_i = x_i - ay_i \qquad (6)$$

The ADF test uses a regression of the first differences of the series against the series lagged once, and lagged difference terms, with optional constant and time trend terms.

$$\Delta y_i = a_0 + a_1 t + \gamma y_{i-1} + \sum b_i y_{i-1} + e_i \qquad (7)$$

Where Δ is the first-difference operator, a_0 is an intercept, a_1t is a linear time trend, e_i is an error term, and i is the number of lagged first-differenced terms such that e_i is the white noise. The test for a unit root has the null hypothesis that signifies $\gamma = 0$. If the coefficient is significantly different from zero, the hypothesis that y_i contains a unit root is considered as rejected. If the test on the level series fails to reject, the ADF procedure is then applied to the first-differences of the series. Rejection leads to the conclusion that the series is integrated of order one, I (1). A limitation of the ADF test is its assumption that the errors are statistically independent and have constant variances.

C. Granger Causality Test:

If the probability value is less than alpha (0.05) then the Granger causality test [29] rejects the null hypothesis. The proposed system uses 5% of level of significant; hence alpha is to be assigned with 0.05. If the probability value is smaller than alpha then the null hypothesis is rejected and there will be a significant relationship between variables.

$$y_i = a_0 + a_1 y_{i-1} + \ldots + a_p y_{i-p} + b_1 x_{i-1} + \cdots + b_p x_{i-p} + U_i \qquad (8)$$

$$x_i = c_0 + c_1 x_{i-1} + \ldots + c_p x_{i-p} + d_1 x_{i-1} + \cdots + d_p y_{i-p} + V_i \qquad (9)$$

Testing $H_0 : b_1 = b_2 \ldots = b_{p = 0}$ against H_1: Not H_0 is a test that x_i does not Granger cause y_i . Similarly, testing H_0 : $d_1 = d_2 \ldots = d_{p = 0}$ against H_1: Not H_0 is a test that y_i does not Granger cause x_i is in the above (8) and (9)

D. Descriptive Statistics Analysis:

The proposed model for this research is as follows in (10), (11).

$$Sensex = \alpha + \beta_1 GP + \beta_2 ER + \beta_3 COP + \beta_4 SI + \qquad (10)$$

$$Nifty = \alpha + \beta_1 GP + \beta_2 ER + \beta_3 COP + \beta_4 SI + \varepsilon \qquad (11)$$

Where ε is an error term, α is a constant and $\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients of independent variables GP, ER , COP and SI respectively. The closing price of Sensex and Nifty are the dependent variables.

The Table I show the correlation analysis among GP, ER, COP, Sensex and Nifty. The GP, ER and COP are adversely correlated with stock market index is shown in the Table I as follows. The Table II shows the correlation analysis between stock index (Sensex, Nifty) and Sentiment Bullishness Index (SI) as well as Sentiment Volume (SV). The obtained results show that there is a positive correlation exists between the stock index and sentiments. The result of Augmented Dickey Fuller Test results are reported in the Table III as follows.

TABLE I.   CORRELATION ANALYSIS OF STOCK INDEX AND ECONOMIC INDICATORS

	Sensex	Nifty	GP	ER	COP
Sensex	1				
Nifty	0.99	1			
GP	-0.216	-0.272	1		
ER	-0.196	-0.261	0.918	1	
COP	-0.043	-0.041	0.906	0.924	1

TABLE II.   CORRELATION ANALYSIS OF STOCK INDEX AND SENTIMENTS

	Sensex	Nifty	SI	SV
Sensex	1			
Nifty	0.99	1		
SI	0.361	0.238	1	
SV	0.413	0.402	0.632	1

TABLE III.   RESULTS OF AUGMENTED DICKEY FULLER TEST AT LEVE AND 1ST DIFFERENCE

	ADF Test at level		ADF Test at 1st difference	
	Test statistics	*Prob-value*	*Test statistics*	*Prob-value*
Sensex	-1.786	0.364	-4.614	0.001
Nifty	-1.767	0.481	-4.813	0.000
GP	-0.764	0.726	-4.312	0.000
ER	-0.616	0.812	-4.012	0.006
COP	-0.916	0.615	-4.316	0.002
SI	-0.978	0.634	-4.425	0.002
SV	-0.863	0.571	-4.167	0.001

Granger causality test has been conducted to identify the causal relationship between Social Media Sentiments, GP, ER, COP and the Indian stock market index. The Table IV below reports Granger causality test results and the null hypothesis has been tested on the basis of the Prob-value. If the Prob-value is less than the critical Prob-value at 5% than the null hypothesis is rejected and there will be a significant relation between the variables. There may be three kind of relationship among the variables unidirectional, bidirectional no relationship among the variables.

TABLE IV.   RESULTS OF PAIR WISE GRANGER CAUSALITY TEST

Null hypothesis	F-statistic	Prob-vlaue	Decision	Type of Causality
GP ⭡ Sensex	0.9286	0.617	Accept	No causality
Sensex ⭡ GP	12.672	8.E-05	Reject	Unidirectional
ER ⭡ Sensex	3.931	2.E-03	Reject	Unidirectional
Sensex ⭡ ER	0.2514	0.8261	Accept	No causality
COP ⭡ Sensex	3.4089	0.0421	Reject	Bidirectional
Sensex ⭡ COP	16.8107	4.E-05	Reject	Bidirectional
GP ⭡ Nifty	1.6421	0.3214	Accept	No causality
Nifty ⭡ GP	3.7631	0.0231	Reject	No causality
ER ⭡ Nifty	3.128	1.E-09	Reject	Unidirectional
Nifty ⭡ ER	1.213	0.624	Accept	No causality
COP ⭡ Nifty	18.234	6.E-02	Reject	Unidirectional
Nifty ⭡ COP	1.3621	0.5832	Accept	No causality
GP ⭡ ER	0.928	0.526	Accept	No causality
ER ⭡ GP	8.216	4.E-02	Reject	Unidirectional
GP ⭡ COP	2.679	0.764	Accept	No causality
COP ⭡ GP	1.2461	0.627	Accept	No causality
ER ⭡ COP	0.4726	0.5214	Accept	No causality
COP ⭡ ER	0.4627	0.4213	Accept	No causality
Sensex ⭡ Nifty	97.08	4.E-06	Reject	Bidirectional
Nifty ⭡ Sensex	89.62	2.E-03	Reject	Bidirectional
Sensex ⭡ SV	16.234	2.E-02	Reject	Unidirectional
Sensex ⭡ SI	7.08	3.E-06	Reject	Bidirectional
SV ⭡ Sensex	1.4726	0.5214	Accept	No causality
SI ⭡ Sensex	19.62	3.E-06	Reject	Bidirectional
Nifty ⭡ SV	8.234	3.E-03	Reject	Unidirectional
Nifty ⭡ SI	5.09	1.E-04	Reject	Bidirectional
SV ⭡ Nifty	3.4726	0.1214	Accept	No causality
SI ⭡ Nifty	17.72	4.E-05	Reject	Bidirectional

Note. Decision rule: reject H0 if Prob-value < 0.05, ⭡ = does not Granger cause.

V.   CONCLUSION

Indian stock market index is represented by Sensex and Nifty. The primary objective of this research paper is to examine the relationship between Sentiment indicators, Gold Prices, Exchange Rate and Crude Oil Prices in Indian stock market. Increasing crude oil prices can increase the production cost which is able to have an effect

on income and can decrease stock costs. Investors are showing fewer issues within the stock markets and investment in yellow metals as a result of increasing trend in gold costs on account of no concern and no future loss. Again, rate of exchange fluctuations can have an effect on international trades, so influence the securities market.

The proposed research work performed the correlation analysis, ADF test and Granger causality test to examine the impact of Social Media Sentiments, Gold Price, Exchange Rate, and Crude Oil Price on Indian stock market index. There is an adversarial relationship between Gold Price, Exchange Rate, and Crude Oil Price with the Indian stock market index. The Granger causality shows the result that Crude Oil Price and Exchange Rate cause stock market index to change. The Gold price gets influenced by stock market index. Furthermore, the results show that stock price change is the Granger cause of social media data volume and sentiment indicators (Positive and Negative). But social media data volume is not Granger cause of stock price change while sentiment indicator is the Granger cause of stock price change.

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