The study of impact of inflation and interest rate on SENSEX

Submitted

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BY

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RESEARCH GUIDE

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DECLARATION

I, Diptanshu Gautam, do hereby declare that the Dissertation Project entitled **Study of Interest rate and Inflation rate on *SENSEX*,** has been undertaken by me as part of my studies in the Post-Graduation Diploma in Management. I have completed this study under the guidance of **Amit Kumar Singh, Faculty of Finance Elective, Christ Institute of Management, Delhi NCR**.

I also declare that this work has not been submitted for the award of any degree, diploma, associateship or fellowship or any other title in this Institute or any other College/University.

Place: Ghaziabad Delhi NCR (Name & Signature of the Candidate)

Date: Diptanshu Gautam

Register No: 1510108

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I am indebted to many people who helped me accomplish this research paper successfully.

I thank Mr. Amit Kumar Singh, for his support and guidance during the course of my Dissertation. I remember him with much gratitude for his patience and motivation, but for which I could not have submitted this work.

I thank my parents for their blessings and constant support, without them this dissertation would not have seen the light of day.

Diptanshu Gautam

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<u>Certificate</u>

I, Diptanshu Gautam, roll numbered 1510108 certify that the Dissertation entitled "***A study of inflation rate and interest rate***" is done by me and it is an authentic work carried out by me. The matter embodied in this project work has not been submitted earlier for the award of any degree or diploma to the best of my knowledge and belief.

Signature of the Student
Date:

Certified that the dissertation entitled "____________________" done by the above student is completed under my guidance.

Signature of the Guide Date:
Name of the Guide: Designation:

Introduction

The universe is subject to entropy, which means randomness. This randomness is seeing wherever there is huge pile of data, it could be universe or stock market. The innate ability of the market to remain randomized has attracted many people to try and understand and figure out the pattern which might help understand the core aspects of market such as stock market, interest rates, inflation rate, currency exchange market, derivatives market, etc.

The financial liberalization paved a new way for growth, development and volatile atmosphere to the Indian economy especially in terms of stock market. The Indian stock market has emerged as the most active stock market of the world during the last decade or so.

It has also attracted the investors across the globe by expanding the horizons. It resulted in increase in terms of number of listed companies, shareholders, volume of trade and market capitalization. The smoothing development process in Indian stock market continues to be remarkable.

From 3,740 points on March 31st 1999, with in nine years; Bombay Stock Exchange (BSE) Sensitivity Index (SENSEX) had reached to 21,000 points in January, 2008. In India, only about two per cent of the total population does involve in stock markets operations. But the entire economy gets affected directly or indirectly, if something happens in the stock markets. It shows clearly that there is a strong correlation between stock markets and real economy

The major issue which is and has always been is the inability of any model or equation to predict the market to a considerable extent. There are many models such as VAR, multi-regression models, Predictive modeling, Dividend discount model, which all have worked to a greater extent to explain the behavior of market or any stock in the market. They all have their limitations and pros.

This study is a continuation of the micro economic study of a company which was done in summer internship project. The study done prior to this have considered the microeconomic aspect of a company by carefully analyzing the past stock quotes, the ratios such as price-earnings ratio, Enterprise Value, Dividend Payout ratio, and tools such as β for determining the sensitivity of the stock with the market In the given time period to estimate the stock quote of the company for the subsequent future.

It mainly used fundamental analysis to determine the valuation of the stock price range for the same. In this study the author shall try to understand the macroeconomic aspect of the nation and its impact on the stock exchange market. There are many macroeconomic factors such as, inflation rate, repo rate, reverse repo, interest rate, risk free rate, GDP, GNP, NNP, SLR Cash Reserve Ratio, etc.

The author shall be focusing on only two factors such as interest rate and inflation rate of the country for past 25 years, and then a study will be done based on the result and analysis. It will help the reader understand the effect of rates on the exchange market, and its variation pattern in the historical quotes. It will also help reader develop a better sense of judgement is to how shall the market respond to the change in any monetary or fiscal policies and shall make a better investment decision.

Every financial market or any company especially financial company responds to the change n interest rate and inflation rate and adjust their strategy accordingly such that their growth is not hindered due to any change in the market. In order to know this the corporate must understand both microeconomic and macroeconomic aspect of the corporate and the financial market. The author has already done a microeconomic study of a company previously.

Now, By studying the macroeconomic factors namely interest rate and inflation rate, he shall be able to understand not just fluctuation in market but also possible fluctuation in the stock quote of his desirable company. Various study have been done in the topic using various technique such as hypothesis testing, ANOVA, ANCOVA, multiple regression analysis, VAR.

Although most of the study were relevant in their own manner, but every other study had limitations of their own.

This study aims at minimizing the limitation and at the same time adapting the uncovered topic such as recession and its after effect on the economy and its effect on the market. For example, the study done by T. Muthukumaran, V.K. Somasundaram in 2008, did empirical study on the effect of interest rate on the SENSEX using hypothesis formulation, and multiple regression but came to result that it has no result whatsoever on the SENSEX.

The issue with this study was that he only covered a limited amount of data and did not check whether the sample is consistent with past data or not, because if it’s not the entire study will fail as it denies one of the major property of the sample from population, i.e.

- Homoscedasticity
- Consistency
- Unbiasedness
- Relevance

It does not follow unbiasedness and consistency because the history says that interest rate does affect the stock quote exchange market, but his study says contrary so, the study has this big limitation of sampling error.

There is a long-term equilibrium relationship among the macroeconomic variables and stock market indicators as shown by the studies of Golaka C Nath and Dr. Y.V. Reddy (2004) and Soumya Guha Deb and Jaydeep Mukherjee (2008) examined that there is strong causal flow from the stock market development to economic growth.

A bi-directional causal relationship is also observed between real market capitalization ratio and economic growth. It is also observed that there is high correlation between exchange rate and gold prices and it highly affects the stock prices.

Good investors always look for investing in an efficient market. In an inefficient market, few people are able to generate extra ordinary profit causes of confidence losses of general people about the market. In such cases, if the rate of interest paid by banks to depositors increases, people switch their capital from share market to bank. This will lead to decrease the demand of share and to decrease the price of share and vice versa. On the other way, when rate of interest paid by banks to depositors increases, the lending interest rate also increases lead to decrease the investments in the economy.

Statement of the problem

In the modern financial world, it is very evident from past data and current scenario that, the market is dependent on both macroeconomic and microeconomic factors. It affects the market in a much greater sense. Systematic factors affect the long run return on financial asset. It implies that securities market must have a relationship with real and financial sector of the economy. There is two way of looking this issue namely, 1) The effect of long term variable on security market 2) Macroeconomic variable on security market namely equity.

Although there is much research done in this topic in different decades and with different methods and factors in consideration, especially regarding shot term and long term relationship between macroeconomic variable and stock market. There seem to be some gap in the study in this fast changing and developing economy.

The present study aims at filling the gap with the latest changes in Indian economy. It aims at analyzing and evaluating the relationship and effect of interest and inflation rate on SENSEX.

Objective of the study

- To identify the relationship between interest rate and inflation rate
- To deduce the relationship and effect of interest rate and inflation rate on SENSEX
- To draw the causal nexus between interest rate, inflation rate and SENSEX.

Review of literature

An Analytics study of interest rate and stock return in India done by Dr. T. Muthukumaran and Dr. V.K. Somasundaran tried to estimate the causal relationship between interest rate and stock interest in India. The data used in this study was taken from SENSEX website and RBI website and various another officials databank. The research done was of the empirical form and hypothesis testing was done on the monthly data from April 1997 to March 2014.

The models used by him were Augmented Filler test, Phillips-Peron test, Kwaitkowski Schdimt Test to find the unit roots in time series. He then did a hypothesis mainly Chi-Square to test the dependency of the growth of interest rate on stock market. The correlation coefficient calculated by him was -0.17 which is negatively poor. He also used KPSS test to test the stationery objectivity of the variable with dependent variable. He thus concluded that growth of the interest rate has no effect on the stock return.

The study of relationship between interest rate and stock price: Empirical evidence of developed and developing nation by Mohammad Abdul Alam[2009] used the tools to test the stationarity of the market returns and regression analysis to test the fluctuation.

In his unit root test of multiple countries and various tests, he concluded that there is an extensive dependency of the factors such as interest rate on the stock price. In market efficiency test, checked on 99% confidence level with all 10 degree of freedom, thus conclusively proving that none of the market is efficient in weak form.

This study examines the market efficiency of fifteen countries and also looks about the effect of interest rate on share price and changes of interest rate on changes of share price. The randomness of stock return is the basic assumption of Efficient Market Hypothesis that is violated for all countries' Stock Exchange, means these markets are not efficient in weak form. In overall, the theoretical argument of negative relationship between stock price and prevailing interest rate is not rejected.

Individual country result is mixed for both developed and developing countries. Interestingly, for Malaysia it is found that Interest Rate has no relation with Share price but Changes of Interest Rate has negative relationship with Changes of Share Price.

Eight countries like, Australia, Canada, Chile, Germany, Jamaica, Mexico, Spain, and Venezuela has significant negative relationship between Interest Rates and Share price but no relationship between change of Interest Rate and change of Share Price. So, except Philippine all other countries show significant negative relationship either Interest Rates with Share price or Changes of Interest Rate with Changes of Share Price or both.

The probability of F test for no fixed effects cannot be accepted at 0.000 significant levels both for one way and two way fixed effects model, that means there are fixed effects. At a very low (0.0001) significance level, it is found that Interest Rate (X1) has significant relationship on Share price (Y1) and the coefficient of independent variable, -2.08 for one way fixed effect and -0.95 for two way fixed effects, shows there is a negative relationship between the two variables. The coefficient of determination (R2) indicates that 37% of the total variation in the dependent variable is account for by the independent variable by one way fixed effect, while 56% of the total variation in the dependent variable is account for by the independent variable by two way fixed effects.

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According to alias Bobasu in Quantifying the Impact of Fiscal Policy on Economic Growth in the Romanian Economy: A Bayesian Approach, The empirical analyses relies on a simple VAR model which accounts for influences running in both direction, namely from fiscal shocks to real economy but also vice versa.

The results and the interpretation of the impulse response functions should be however interpreted with cautious given the limitation of the data sample. Moreover, the estimated could be affected by omitted variables taking into account that the Romanian economy underwent many structural changes during the analyses period of time.

The government sector's ability to contribute to the stabilization of macroeconomic fluctuations is relatively low in Romania due to the relatively small size of automatic stabilizers as compared to other European economies. Due to small fiscal stabilizers, the Romanian economy would therefore need higher discretionary fiscal stimulus (higher structural deficit) during recession periods in order to stimulate the economy to return to its potential level.

According to Doron Nissim in his empirical study on the Effect of Changes in Interest Rates on Accounting Rates of Return, Growth, and Equity Values, he has broken the equity values into different fundamentals such as taxation point of view and also, such as P/E ratio and dividend per share component to critically examine the point where the share or equity value is mostly affected by the interest rate.

The study is to check whether the negative correlation between interest rate and stock price is due to its fundamentals or other external factor which tend to change or alter the dependency of the factors on the equity value, or growth rate or stock return. The effects of changes in both real and nominal interest rates are investigated so that the effects of changes in expected inflation (that has been the focus of much of the research on interest rates and stock returns) are isolated.

Accordingly, the paper evaluates the Modigliani and Cohn conjecture that investors do not understand the effect of changes in expected inflation on firms. The results show that both real and nominal rates are positively related to subsequent profitability and growth, at least in the near term. So, increases in interest rates are followed by higher profitability and growth.

In this paper the author has tried to link the interest rate with the fundamentals of the stock returns using dividend discount models and residual earning models etc to estimate the effect of the interest rate on fundamentals of stock price. Specifically, interest rate changes are positively associated with unexpected accounting rates of return and net asset growth that together determine future earnings and book values.

But the positive correlation between interest rate changes and unexpected earnings and book value only partially offset the negative effect of the change in the required return. Hence, the overall effect of changes in interest rates on residual earnings and value is negative.
The directional effects are similar for changes in the expected inflation and real components of nominal interest rates. So, nominal profitability and nominal net asset growth increase in the near term, on average, in response to increases in expected inflation or increases in real rates.

But, again, the increase in earnings from these effects is not sufficient to cover the increase in the required return. Accordingly, our analysis indicates that, contrary to the traditional view, equities do not provide hedge against changes in inflation (nor against changes in real interest rates).
The implications for equity valuation come with a qualification.

The analysis deals only with effect in the year of the interest rate change and the three subsequent years, with no indication of the long-run effect on residual earnings. This four-year period captures the capital gain or loss effect with respect to assets in place but not the effect of value added by new investments after this period (under changed hurdle rates).

In the paper written by Ionnou Chattaziantoniou and David Duffy of Stock Market response to Monetary and fiscal policy, A structural VAR model is used to study the effect of fiscal and monetary policy on the stock exchange: a multi country evidence. Using various contemptuous relationship between the variable in the model, it was concluded that it cannot be generalized for all the country as the monetary and fiscal policy are different for different country the financial market varies from time to time.

For eg, in UK interest rate came to be independent of stock exchange, for US it turned out to be negatively related to the subject and the stock market return.

In addition, results suggest that fiscal and monetary both react in a countercyclical manner in response to the price level but they fail to react to a GDP shock. The common countercyclical response of both fiscal and monetary policy to the price shock shows that the two policies are being used in a complementary manner, consistent with the findings of Wyplosz (1999), Melits (2000), as well as, Van Aarle et al. (2003)

Evidence suggests that income shocks exert a positive effect of the German stock market, whereas price shocks have the opposite impact. There is no evidence that the stock market exercises any effects on the other variables. Turning to the responsiveness of the policy tools, German fiscal policy is not shown to react to any of the variables, with the exception of inflation. On the other hand, monetary policy is shown to be more reactive. Money supply acts in a countercyclical manner to a GDP shock. Additionally, countercyclical monetary policy is evidenced through the positive reaction of the interest rate to innovations in both GDP and the price level.

The paper written by Hamdan Ali Impact of interest rate on stock market a Pakistani stock exchange market study suggests that interest rate has a negative impact on the stock exchange market in the Karachi Stock Exchange. He used regression predictive modelling analysis to create a linear regression line with dependent variable as stock exchange and independent variable as interest rate. The coefficient of determination comes out to be 2% which is very less which suggests that only 2% of the variation in Stock market is explained by the change in interest rate.

Also, the Karl-Pearson Correlation Coefficient comes out to be -0.25 which is a moderate correlation, which is a bit ironical to coefficient of determination, but it could be explained by the unaccounted internal indirect effects which negates the effect of interest rate in the stock market.

The paper by Martin Fieldsten discuss mainly the reason of failure of increase of rise of stock market in the decade of rising inflation. This abnormal behavior from the theory and unexpected turn of events was not due to some unexplained behavior of the investors but was due to the basic features of the US tax laws, particularly historic cost depreciation and nominal capital gain.

The higher effective rate of tax on corporate income caused by historic cost depreciation and the tax on the artificial capital gains caused by inflation both reduce the real net yield that investors receive per unit of capital. Although the real net yield on bonds is also reduced, for many shareowners, this is outweighed by the fall in the equity yields.

Of course, the increase in the effective tax rate caused by inflation has not been the only adverse influence on the level of share prices during the last decade. The slowdown in productivity growth, the higher cost of energy, and the increased international competition have all reduced pretax profitability. Although there is no clear evidence of a permanent fall in profitability.

The paper written by Johnny M Campbell Stock return and its term Structure too suggested an inverse relation between the two variable, although he concluded by saying that the 20-year treasury bill rate move somewhat independently and has less effect on stock market. the expectations theories for bills, bonds and stocks can be rejected at high levels of confidence.

When realized excess returns on these assets are regressed on information variables which measure the state of the term structure, the fitted values are far from constant. Instead, they vary with a standard deviation for the 1959-1978 period of almost 1/4% per month on an annualized basis for bills, 6% for bonds and 17% for stocks. Over the same period average bond returns were 1 1/2% a year less than bill returns and 5% less than stock returns.

The paper written by Hian Chen of Lund University, The interaction between interest rate and stock exchange—a comparison between China and US. The methodology used in this research is similar to that of Mr Somasundaram, differing in the part that he also used Structured VAR model, i.e. vector Autoregressive model to plot or to interpret the time varying property of the stock market with interest rate.

His results were classified based on the tools he used in his paper, Impulsive Response function response was used to test the stability of the time span in the time series analysis used SVAR model. He concluded from the test that interest rates and stock returns have simultaneous impacts on each other based on the SVAR models with a long-run restriction. Apparently, interest rates shock has a strong impact on stock returns in China, where a 79 basis points increase in SHIBOR caused by interest rate shock lead to an immediate decrease in stock returns of around 33 basis points and then an increase of 8.7 basis points in the third month. The small positive impact dies out eventually in the long run.

The effect of stock returns on interest rates is weaker than the impact of interest rates on stock prices, but sustains longer.

From variance decomposition, it tries to proves the contribution to the movement in each dependent variable given by shocks to itself and from other variable. In this paper he concluded that, the interaction relationship between china and US is confirmed. The interdependence in the world's two largest economy i.e. USA and China was confirmed in the paper through variance decomposition and SVAR model.

Although, the extent of interaction in china is much less than that of US, nonetheless, it was significant enough to be caught in the experiment.

Study Area

For the simplicity of the content only two major macroeconomic factors i.e. interest rate and inflation rate has been chosen for the study. Simplification is not only reason for this restriction. The major influence part of the influence of the investments in macroeconomic factor is governed by these two factors. Also, if the dependency of the two factors can be studied then as per many studies it is possible to at least make a sound and logical direction in which the market will move thus creating a wide opportunity for an investor to maximize its profit.

Interest rate generally is main driving factor in controlling the risk-free rate and since inflation rate can also be related with it. The purchasing power and investment strategy is also directly related to these factors. In other words, we can say that major part of monetary and fiscal policy revolves around this. So, just by studying these gives a brief idea as to how the market

Sources of data

- Secondary data

The data collected is from the RBI website and world bank website also from the SENSEX website. All data collected were made public hence, no special permission is required before using the data.

Research Methodology

The author would be using descriptive research to infer some hypothesis formation, thus adapting conclusive research in the later section of the paper. The research will start with correlation and simple regression models to find the vague relationship between two variables, if at all it exists.

The author shall also use Time series analysis econometric model namely, () because the factors used in it are of time varying and are also not said to be stationary in the precious study, thus ***unit root test*** becomes essential to this study to understand and check the stability of the time frame with respect to the variables, and also its effect on each other and self-fluctuation.

Since past data is being studied in this research so technical analysis becomes essential to draw any logical conclusion from this data. The author shall start with checking the ***Autocorrelation function and Partial Autocorrelation function*** for the data and thus deducing which of the models out of AR, MA and ARMA model is appropriate for the analysis. After this stationarity of the data will be confirmed for the confirmation of any white noise which might occur in the data thus rendering the analysis futile.

If the data will be found non-stationary which is very likely, the data would be made stationary in order to do time series analysis. In order the check for non-stationarity or presence of *unit root* **Augmented Dickey-Fuller Test, Phillips-Peron(PP)** and **KPSS** test is done on the data set.

After this a **Multivariate AutoRegressive Integrated Moving Average Model** would be done on the data set to deduce the relation and impact of the independent variable on the dependent one. The lag factor would also be incorporated in the modelling to include any autocorrelated factor from each variable.

The models have been tested for different confidence interval for comparison purpose but the study has been done on 95% confidence interval only.

Tables and Charts to study

Month	Sensex	Interest	Inflation
Jan-96	2931.84	12	9.688581
Feb-96	3391.99	12	8.99654
Mar-96	3366.61	12	8.591065
Apr-96	3826.72	12	8.87372
May-96	3724.97	12	9111.830508
Jun-96	3812.52	12	9.333333
Jul-96	3536.94	12	8.823529
Aug-96	3514.61	12	8.306709
Sep-96	3239.48	12	8.888889
Oct-96	3163.78	12	8.51735
Nov-96	2890.5	12	8.46395
Dec-96	3085.2	12	8.722741
Jan-97	3382.47	12	10.41009
Feb-97	3651.91	12	11.11111
Mar-97	3360.89	12	10.75949
Apr-97	3841.11	11	10.03135
May-97	3755.1	11	9.259259
Jun-97	4256.09	10	7.317073
Jul-97	4305.76	10	6.606606
Aug-97	3876.08	10	5.60472
Sep-97	3902.03	10	4.664723
Oct-97	3803.24	9	4.941861
Nov-97	3560.29	9	5.49133
Dec-97	3658.98	9	4.87106
Jan-98	3224.36	11	6.285714
Feb-98	3622.22	11	9.714286
Mar-98	3892.75	10.5	9.142858
Apr-98	4006.81	10	8.262108
May-98	3686.39	9	8.19209
Jun-98	3250.69	9	10.51136
Jul-98	3211.31	9	12.39437
Aug-98	2933.85	9	14.80447
Sep-98	3102.29	9	15.04178
Oct-98	2812.49	9	16.34349
Nov-98	2810.66	9	18.63014
Dec-98	3055.41	9	19.67213
Jan-99	3315.57	9	15.32258
Feb-99	3399.63	9	9.375
Mar-99	3739.96	8	8.638743
Apr-99	3325.69	8	8.947369
May-99	3963.56	8	8.355091
Jun-99	4140.73	8	7.712082
Jul-99	4542.34	8	5.263158
Aug-99	4898.21	8	3.163017
Sep-99	4764.42	8	3.1477
Oct-99	4444.56	8	2.142857
Nov-99	4622.21	8	0.923788
Dec-99	5005.82	8	0
Jan-00	5205.29	8	0.466201
Feb-00	5446.98	8	2.619048
Mar-00	5001.28	8	3.614458
Apr-00	4657.55	7	4.830918
May-00	4433.61	7	5.542169
Jun-00	4748.77	7	5.011933
Jul-00	4279.86	8	5.238095
Aug-00	4477.31	8	4.95283
Sep-00	4090.38	8	3.99061
Oct-00	3711.02	8	3.496504
Nov-00	3997.99	8	2.745996
Dec-00	3972.12	8	2.739726
Jan-01	4326.72	8	3.480278
Feb-01	4247.04	7.5	3.24826
Mar-01	3604.38	7	3.023256
Apr-01	3519.16	7	2.534562
May-01	3631.91	7	2.283105
Jun-01	3456.78	7	2.5
Jul-01	3329.28	7	3.393665
Aug-01	3244.95	7	4.044944
Sep-01	2811.6	7	5.191874
Oct-01	2989.35	6.5	4.72973
Nov-01	3287.56	6.5	4.231626
Dec-01	3262.33	6.5	4.888889
Jan-02	3311.03	6.5	5.15695
Feb-02	3562.31	6.5	4.94382
Mar-02	3469.35	6.5	5.191874
Apr-02	3338.16	6.5	5.16854
May-02	3125.73	6.5	4.6875
Jun-02	3244.7	6.5	4.656319
Jul-02	2987.65	6.5	4.157549
Aug-02	3181.23	6.5	3.887689

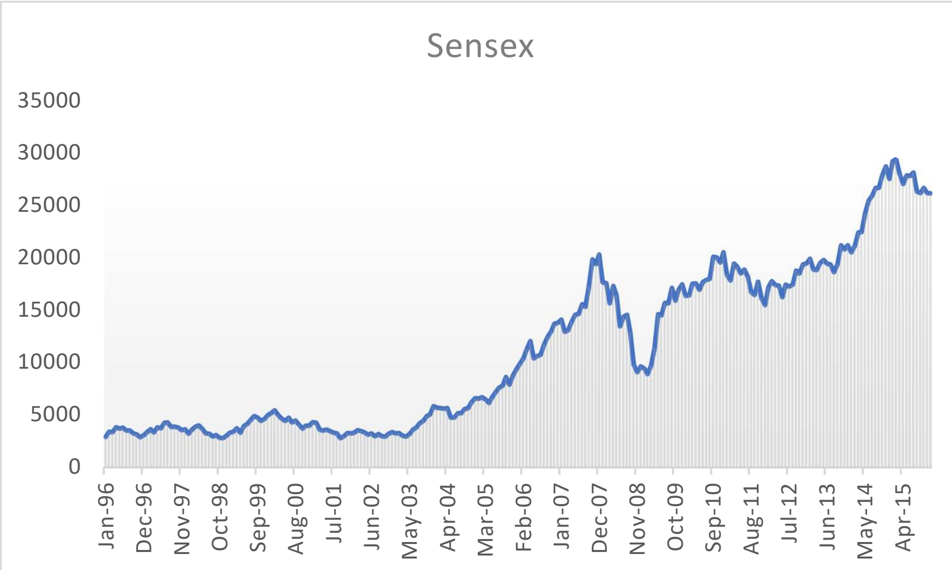
Date	Sensex	Interest	Inflation
Sep-02	2991.36	6.5	3.862661
Oct-02	2949.32	6.5	4.301075
Nov-02	3228.82	6.25	4.059829
Dec-02	3377.28	6.25	3.601695
Jan-03	3250.38	6.25	3.198294
Feb-03	3283.66	6.25	3.426124
Mar-03	3048.72	6.25	3.862661
Apr-03	2959.79	6.25	4.059829
May-03	3180.75	6	5.117271
Jun-03	3607.13	6	4.661017
Jul-03	3792.61	6	4.411765
Aug-03	4244.73	6	4.158004
Sep-03	4453.24	6	3.099174
Oct-03	4906.87	6	2.886598
Nov-03	5044.82	6	3.285421
Dec-03	5838.96	6	3.067485
Jan-04	5695.67	6	3.719008
Feb-04	5667.51	6	4.347826
Mar-04	5590.6	6	4.132231
Apr-04	5655.09	6	3.49076
May-04	4759.62	6	2.231237
Jun-04	4795.46	6	2.834008
Jul-04	5170.32	6	3.018109
Aug-04	5192.08	6	3.193613
Sep-04	5583.61	6	4.609219
Oct-04	5672.27	6	4.809619
Nov-04	6234.29	6	4.572565
Dec-04	6602.69	6	4.166667
Jan-05	6555.94	6	3.784861
Feb-05	6713.86	6	4.365079
Mar-05	6492.82	6	4.166667
Apr-05	6154.44	6	4.166667
May-05	6715.11	6	4.960318
Jun-05	7193.85	6	3.740157
Jul-05	7635.42	6	3.320313
Aug-05	7805.43	6	4.061895
Sep-05	8634.48	6	3.448276
Oct-05	7892.32	6	3.632887
Nov-05	8788.81	6	4.182509
Dec-05	9397.93	6	5.333333
Jan-06	9919.89	6	5.566219
Feb-06	10370.24	6	4.372623
Date	Sensex	Interest	Inflation
Mar-06	11279.96	6	4.571429
Apr-06	12042.56	6	4.571429
May-06	10398.61	6	4.652825
Jun-06	10609.25	6	5.925406
Jul-06	10743.88	6	7.269146
Aug-06	11699.05	6	6.332198
Sep-06	12454.42	6	5.938375
Oct-06	12961.9	6	6.398648
Nov-06	13696.31	6	6.917439
Dec-06	13786.91	6	5.950735
Jan-07	14090.92	6	6.528648
Feb-07	12938.09	6	6.722689
Mar-07	13072.1	6	7.563025
Apr-07	13872.37	6	6.722689
May-07	14544.46	6	6.666667
Jun-07	14650.51	6	6.61157
Jul-07	15550.99	6	5.691057
Aug-07	15318.6	6	6.451613
Sep-07	17291.1	6	7.258065
Oct-07	19837.99	6	6.4
Nov-07	19363.19	6	5.511811
Dec-07	20286.99	6	5.511811
Jan-08	17648.71	6	5.511811
Feb-08	17578.72	6	5.511811
Mar-08	15644.44	6	5.46875

Apr-08	17287.31	6	7.874016
May-08	16415.57	6	7.8125
Jun-08	13461.6	6	7.751938
Jul-08	14355.75	6	7.692307
Aug-08	14564.53	6	8.333333
Sep-08	12860.43	6	9.022556
Oct-08	9788.06	6	9.774436
Nov-08	9092.72	6	10.44776
Dec-08	9647.31	6	10.44776
Jan-09	9424.24	6	9.701492
Feb-09	8891.61	6	10.44776
Mar-09	9708.5	6	9.62963
Apr-09	11403.25	6	8.029197
May-09	14625.25	6	8.695652
Jun-09	14493.84	6	8.633094
Jul-09	15670.31	6	9.285714
Aug-09	15666.64	6	11.88811
Date	Sensex	Interest	Inflation
Sep-09	17126.84	6	11.72414
Oct-09	15896.28	6	11.64384
Nov-09	16926.22	6	11.48649
Dec-09	17464.81	6	13.51351
Jan-10	16357.96	6	14.96599
Feb-10	16429.55	6	16.21622
Mar-10	17527.77	6	14.86487
Apr-10	17558.71	6	14.86487
May-10	16944.63	6	13.33333
Jun-10	17700.9	6	13.90728
Jul-10	17868.29	6	13.72549
Aug-10	17971.12	6	11.25
Sep-10	20069.12	6	9.876543
Oct-10	20032.34	6	9.815951
Nov-10	19521.25	6	9.69697
Dec-10	20509.09	6	8.333333
Jan-11	18327.76	6	9.467456
Feb-11	17823.4	6	9.302325
Mar-11	19445.22	6	8.823529
Apr-11	19135.96	6	8.823529
May-11	18503.28	6	9.411765
Jun-11	18845.87	6	8.72093
Jul-11	18197.2	6	8.620689
Aug-11	16676.75	6	8.426967
Sep-11	16453.76	6	8.988764
Oct-11	17705.01	6	10.05587
Nov-11	16123.46	6	9.392265
Dec-11	15454.92	6	9.340659
Jan-12	17193.55	6	6.486486
Feb-12	17752.68	9.5	5.319149
Mar-12	17404.2	9.5	7.567567
Apr-12	17318.81	9	8.648648
May-12	16218.53	9	10.21505
Jun-12	17429.98	9	10.16043
Jul-12	17236.18	9	10.05291
Aug-12	17429.56	9	9.84456
Sep-12	18762.74	9	10.30928

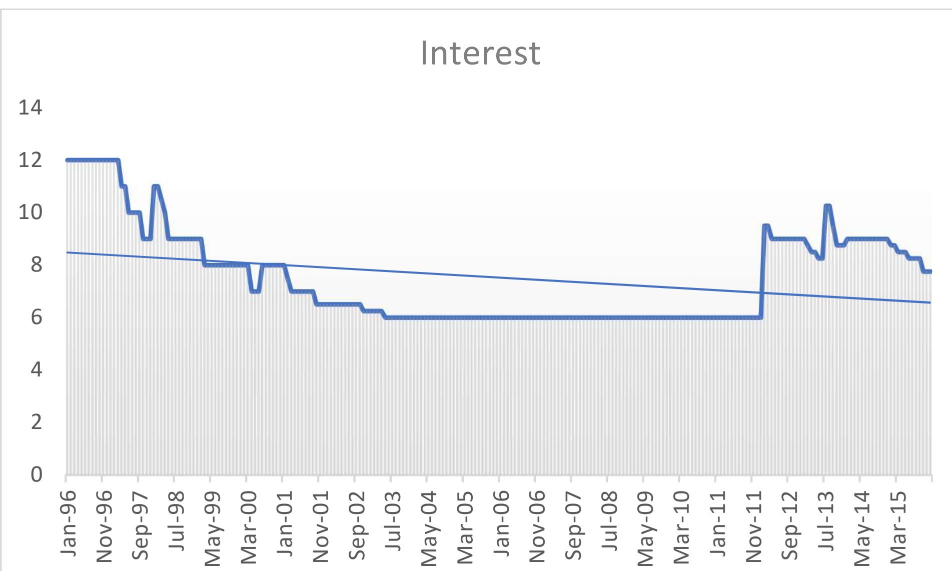
Oct-12	18505.38	9	9.137055
Date	Sensex	Interest	Inflation
Nov-12	19339.9	9	9.59596
Dec-12	19426.71	9	9.547739
Jan-13	19894.98	9	11.16751
Feb-13	18861.54	8.75	11.61616
Mar-13	18835.77	8.5	12.0603
Apr-13	19504.18	8.5	11.44279
May-13	19760.3	8.25	10.2439
Jun-13	19395.81	8.25	10.67961
Jul-13	19345.7	10.25	11.05769
Aug-13	18619.72	10.25	10.84906
Sep-13	19379.77	9.5	10.74766
Oct-13	21164.52	8.75	10.69767
Nov-13	20791.93	8.75	11.05991
Dec-13	21170.68	8.75	11.46789
Jan-14	20513.85	9	9.132421
Feb-14	21120.12	9	7.239819
Mar-14	22386.27	9	6.726458
Apr-14	22417.8	9	6.696429
May-14	24217.34	9	7.079646
Jun-14	25413.78	9	7.017544
Jul-14	25894.97	9	6.493506
Aug-14	26638.11	9	7.234043
Sep-14	26630.51	9	6.751055
Oct-14	27865.83	9	6.302521
Nov-14	28693.99	9	4.979253
Dec-14	27499.42	9	4.115226
Jan-15	29182.95	8.75	5.85774
Feb-15	29361.5	8.75	7.172996
Mar-15	27957.49	8.5	6.302521
Apr-15	27011.31	8.5	6.276151
May-15	27828.44	8.5	5.785124
Jun-15	27780.83	8.25	5.737705
Jul-15	28114.56	8.25	6.097561
Aug-15	26283.09	8.25	4.365079
Sep-15	26154.83	8.25	4.347826
Oct-15	26656.83	7.75	5.13834
Nov-15	26145.67	7.75	6.324111
Dec-15	26117.54	7.75	6.719368

Data Analysis

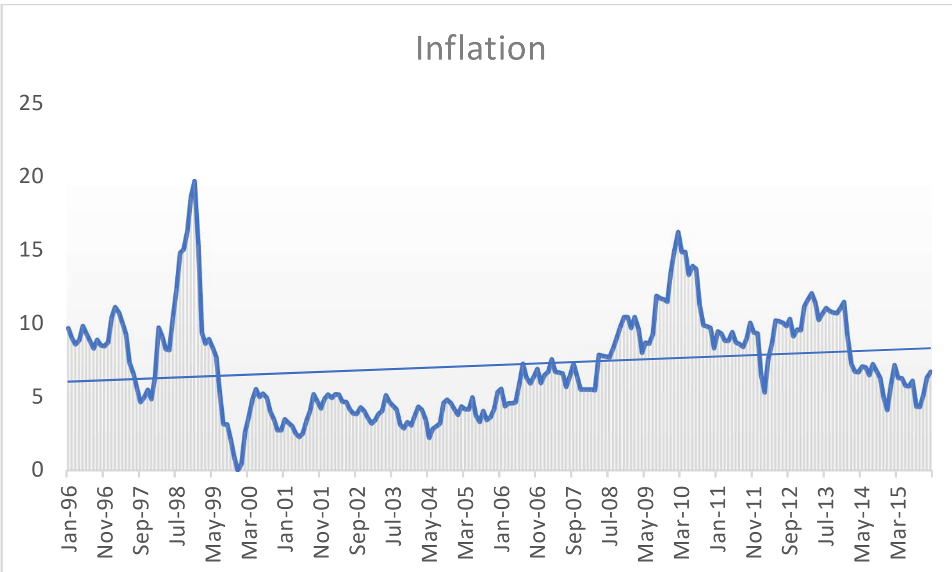
Checking Stationarity of the time series data



The graph of SENSEX is obviously in increasing trend thus, the mean of the same time width at two different point of time is not same, thus making the series non-stationary, which we shall test Augmented Dickey Fuller test.



The graph of interest rate with date seems stationary because of randomness, of the data also there is no observed data doesn't vary much from the trendline. So, nothing clear can be said about the data thus Augmented Dickey Fuller test is essential to test the stationarity of the data.



The graph show above is the Inflation rate graph with time, this graph too seems pretty random thus giving a hint that the data is infact stationary. Augmented Dickey Fuller test shall confirm the stationarity of the data.

Augmented Dickey Fuller Test

Augmented Dickey Fuller test is done to check the presence of unit root or non-stationarity in the time series of the data. The null hypothesis of the ADF test says that there is a unit root in the data set. In statistics and econometric, these hypothesis testing is used to test the non-stationarity of the data set, which is essential to remove from the sample to remove the possibility of biasedness in the given sample data set.

The alternate hypotheses depend on the type of non-stationarity and the presence of unit test being tested in the sample.

In R programming, the codes are given to check just unit root, unit root with trend and unit root with drift. Thus, 3 null and alternate hypotheses are checked in the ADF test. Following is the code of ADF testing and the result and interpretation is followed by the code.

//R codes for ADF in stock quotes//

```
➢ library("SDSFoundations", lib.loc="~/R/win-library/3.2")
➢ > library("ssd", lib.loc="~/R/win-library/3.2")
➢ > library("readxl", lib.loc="~/R/win-library/3.2")
➢ > library("urca", lib.loc="~/R/win-library/3.2")
➢ > ?acf
➢ > data <- read.csv("D:/Notes and ppts/Dissertation/Disseration Data/Dat
  a to be analysed.csv")
➢ View(data)
➢ data <- data$Sensex
➢ int <- data$Interest
➢ inf <- data$Inflation
➢ acf(stk, lag.max = 10, type = c("correlation"))
➢ pacf(stk, lag.max = 10)
➢ adf <- ur.df(stk, type = c("trend"), lags = 10, selectlags = c("BIC"))
➢ summary(adf)
```

//Output//

```
###############################################
# Augmented Dickey-Fuller Test Unit Root Test #
###############################################

Test regression trend


Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
    Min      1Q  Median      3Q     Max
-3226.6  -350.1     3.1   396.2  2880.8

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -87.05279  122.21094  -0.712   0.4770
z.lag.1      -0.04537    0.01905  -2.382   0.0180 *
tt            5.65715    2.24181   2.523   0.0123 *
z.diff.lag    0.02390    0.06640   0.360   0.7192
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Residual standard error: 808.1 on 225 degrees of freedom
Multiple R-squared:  0.02759,	Adjusted R-squared:  0.01463
F-statistic: 2.128 on 3 and 225 DF,  p-value: 0.09749


Value of test-statistic is: -2.3821 3.2939 3.1871

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -3.99 -3.43 -3.13
phi2  6.22  4.75  4.07
phi3  8.43  6.49  5.47
```

Interpretation

The test is done for 10 lags of the data of stock quote of Sensex and trend ADF testing is done on the object. The critical test statistic value of the data is -2.3821 which is less than all the three values i.e. -3.99, -3.43, -3.13 thus, we **fail to reject the null hypotheses**, thus concluding that **there is in fact a unit root in the time series**.

Following are some more interpretation from the tests:

- All the t statistic obtained is less than the critical value thus inferring that at all tested level of significance, we fail to reject the hypotheses thus stating that
    - There is a unit root at 1%, 5% and 10% confidence interval. (ζ_3)
    - There is a unit root but no trend (φ_2)
    - There is a unit root with no trend along with the drift (φ_3)
    - The first column of critical value is the representation of presence of unit root in the set.
    - The second column tests the presence of trend in the data set
    - The third column tests the presence of the drift along with the trend.

Augmented Dickey-Fuller Test for interest rate

//R codes for ADF tests in interest rate//

```
adf1 <- ur.df(int, type = c("trend"), lags = 10, selectlags = c("BIC"))
> summary(adf1)
```

- adf1 <- ur.df(int, type = c("trend"), lags = 10, selectlags = c("BIC"))
- summary(adf1)

//Output//

```
###############################################
# Augmented Dickey-Fuller Test Unit Root Test #
###############################################

Test regression trend


Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.9070 -0.0522 -0.0264  0.0314  3.4302 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)   
(Intercept)  0.1953151  0.1288451   1.516  0.13096   
z.lag.1     -0.0397701  0.0150140  -2.649  0.00865 **
tt           0.0005859  0.0003653   1.604  0.11015   
z.diff.lag1  0.0309976  0.0648085   0.478  0.63291   
z.diff.lag2 -0.0999028  0.0644193  -1.551  0.12236   
z.diff.lag3 -0.1849660  0.0650976  -2.841  0.00491 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3532 on 223 degrees of freedom
Multiple R-squared:  0.09127,	Adjusted R-squared:  0.07089 
F-statistic: 4.479 on 5 and 223 DF,  p-value: 0.000656


Value of test-statistic is: -2.6489 4.13 5.7305 

Critical values for test statistics: 
      1pct  5pct 10pct
tau3 -3.99 -3.43 -3.13
phi2  6.22  4.75  4.07
phi3  8.43  6.49  5.47
```

Interpretation

- The practical value of the test statistic is for interest rate shows that at 10% confidence interval we can reject the null hypothesis saying that, there is in fact stationarity in the time series.
- This result is consistent with all the three hypotheses thus rejecting all of them at 10% confidence interval thus saying that, the series is stationary but has a drift and trend in the time series at given confidence interval.
- At 1% and 5%, the result is same as the previous ADF test for unit test thus saying that, the series has in fact a unit root but is devoid of any presence of drift or trend in the series.
- The interest rate time series too has unit root at 95% confidence interval but lacks in drift and trend of any kind.

Augmented Dickey-Fuller Test for Inflation rate

//R codes for ADF test for inflation rate//

```
> adf2 <- ur.df(inf, type = c("trend"), lags = 10, selectlags = c("BIC"))
> summary(adf2)
```

- adf2 <- ur.df(inf, type = c("trend"), lags = 10, selectlags = c("BIC"))
- summary(adf2)

//Output//

```
###############################################
# Augmented Dickey-Fuller Test Unit Root Test #
###############################################

Test regression trend


Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
    Min      1Q  Median      3Q     Max
-3.7545 -0.5525 -0.0273  0.5287  2.9828

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.363332   0.176888   2.054 0.041129 *
z.lag.1     -0.069798   0.019951  -3.498 0.000564 ***
tt           0.001014   0.001022   0.992 0.322225
z.diff.lag   0.350496   0.062397   5.617  5.7e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9883 on 225 degrees of freedom
Multiple R-squared:  0.1463,   Adjusted R-squared:  0.1349
```

```
F-statistic: 12.86 on 3 and 225 DF,  p-value: 8.777e-08


Value of test-statistic is: -3.4984 4.0843 6.124

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -3.99 -3.43 -3.13
phi2  6.22  4.75  4.07
phi3  8.43  6.49  5.47
```

Interpretation

- The Augmented Dickey fuller test of inflation rate shows that at 95% confidence interval, the critical value of test statistic is outside the range of ζ_3, thus rejecting the null hypotheses suggesting that, the series is stationary.
- The 2nd and 3rd critical value of test statistic are within the limits of critical value at 95% level of significance thus suggesting that we **fail to reject the null hypotheses,** thus concluding that there is no trend or drift in the series.
- The 1st test statistic is rejected at both 5% and 90% confidence interval thus stating that the data is non-stationary at 99% confidence interval.
- The 2nd and 3rd test statistic was beyond critical limit only at 90% confidence interval, thus saying that the series lacs drift and trend at 99% and 95% level of significance.

As seen in the output of the R Studio console that, the lag difference of stock quote of SENSEX is only up to 1 as the p value is less than 0.05, i.e. 0.018, thus in case of stock quote of SENSEX, the non-stationarity exists only up to 1st lag. In the case of interest rate, the output in the R console suggests that the p value is significant from lag 3, thus there is a non-stationarity in the series in the 3rd lag of the series.

//Confirmation of degree of non-stationarity in the series//

Differencing of the time series

Using the function of ndiffs in R programming model

//R Codes for finding differencing factor for making the data stationary//

- ndiffs(stk, alpha = 0.05, test = c("adf","kpss"), max.d = 2)
- ndiffs(int, alpha = 0.05, test = c("adf"), max.d = 2)
- ndiffs(inf, alpha = 0.05, test = c("adf"), max.d = 2)
- ndiffs(inf, alpha = 0.05, test = c("kpss"),max.d = 2)

The output for the above code turns out to be 1, which means the data need to be differenced by 1 degree in order to make the data stationary.

//R Codes for differencing the time series for making data stationary//

```
diff_int <- rep(NA, 239)

for(i in 1:239){

  diff_int[i] = int[i+1]-int[i]

}
```

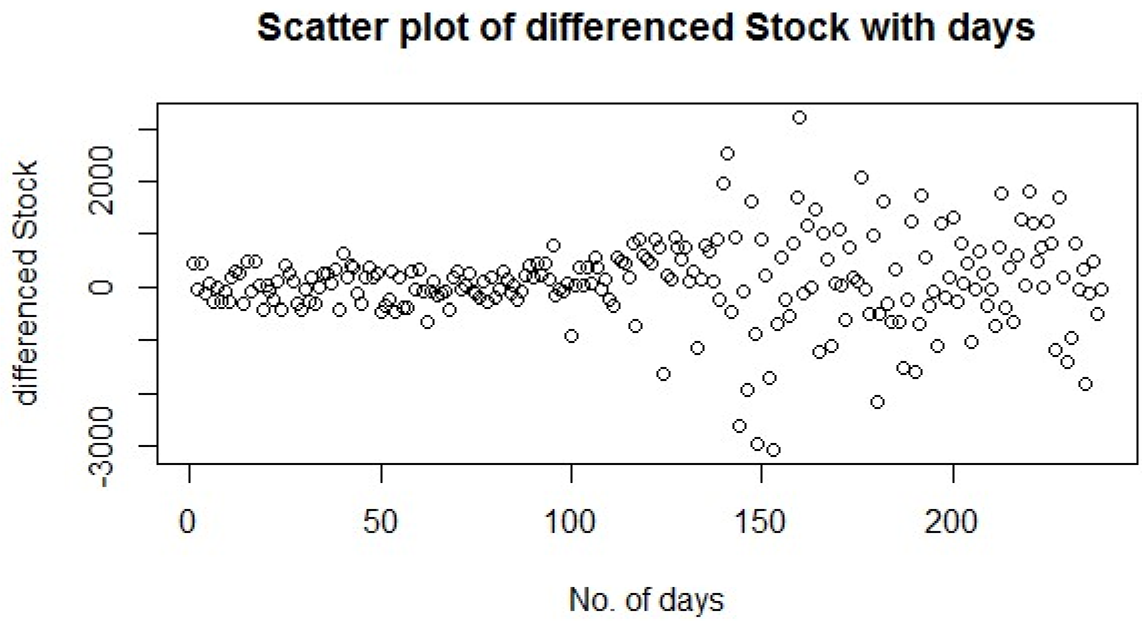
Since, the differencing created is of degree 1, therefore

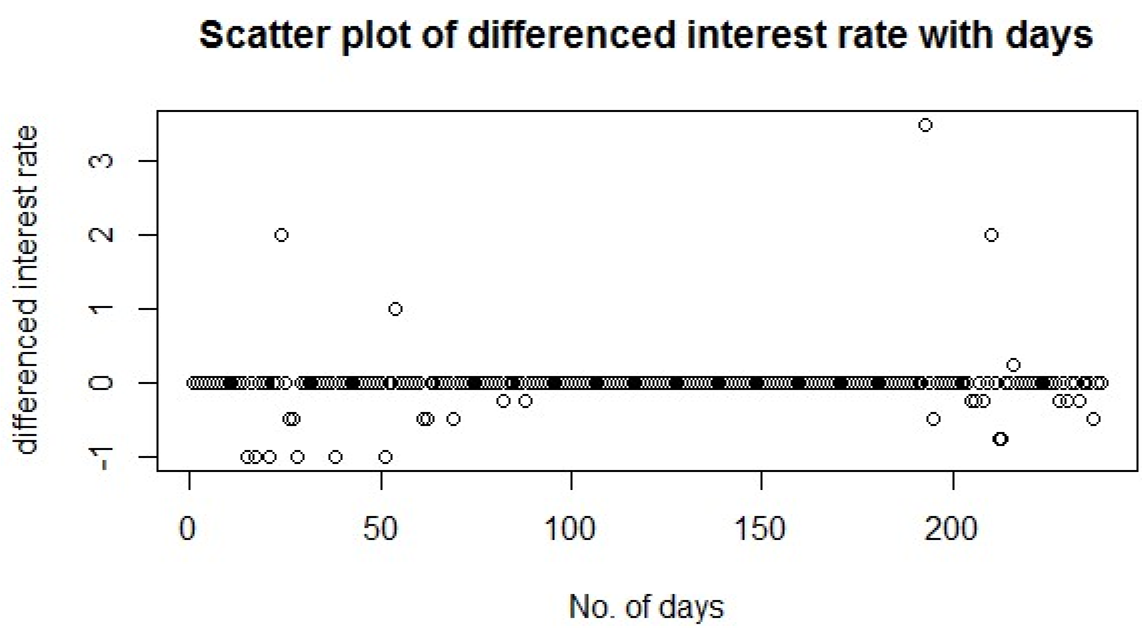
$Int^1 = int(t) - int(t\text{-}1)$

```
diff_stk <- rep(NA, 239)

for(j in 1:239){

  diff_stk[j] = stk[j+1]-stk[j]

}
```

This differencing the data involved in SENSEX stock market thus making data stationary

Differenced Plots





If we compare the new plot with the old one we can see the difference especially in stock price one, the increasing pattern has been eliminated and the curve is more of a randomly distributed with stationarity in the plot. Also, the same can be said about interest rates because most of it is stationary thus, the statistic would be time in variant hence making it stationary as per required in time series modelling.

Computing Auto Correlation and Partial Autocorrelation function for the variables

If there is a variable X with n components, and if there exist a correlation between X_t and X_{t-s} where s is the lag of the time series, then the data is said to have an autocorrelation with lag s. This usually exist with every data which is time variant, such as stock price, exchange rate, inflation rate etc. This means that past data of the random variable affects the present and even future data. The ACF determines up to which degree it affects and till which past data it affects.

According to **Wikipedia,**

Autocorrelation, also known as serial correlation, is the correlation of a signal with a delayed copy of itself as a function of delay. Informally, it is the similarity between observations as a function of the time lag between them. The analysis of autocorrelation is a mathematical tool for finding repeating patterns, such as the presence of a periodic signal obscured by noise, or identifying the missing fundamental frequency in a signal implied by its harmonic frequencies. It is often used in signal processing for analyzing functions or series of values, such as time domain signals.

Unit root processes, trend stationary processes, autoregressive processes, and moving average processes are specific forms of processes with autocorrelation.

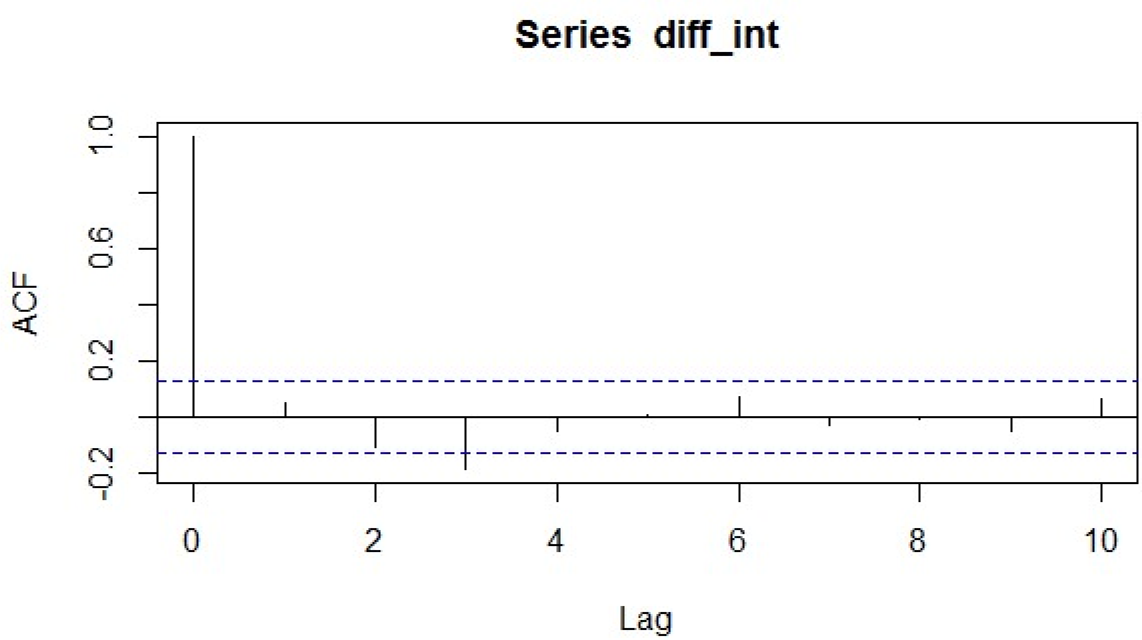
Partial Auto-Correlation function is a function in which correlation of data is calculated with itself with a time lag t such that all other factor between the lag stands null and void.

Auto Correlation and Partial Auto Correlation tests

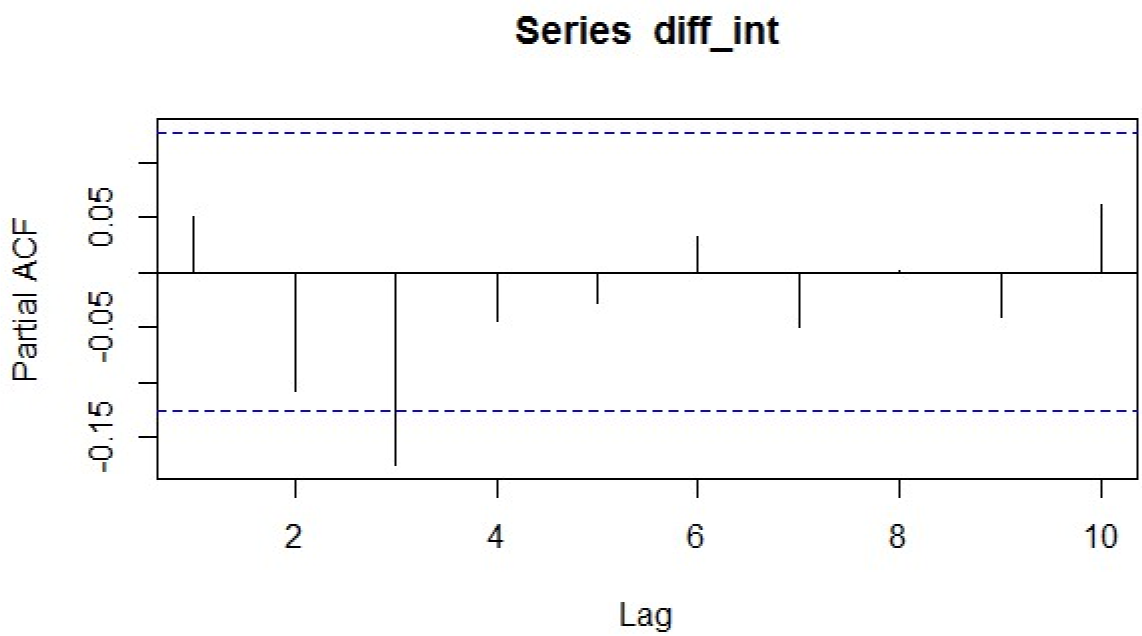
Plotting ACF for differenced interest rate, differenced inflation rate and stock rate

//R codes for ACF and PACF//

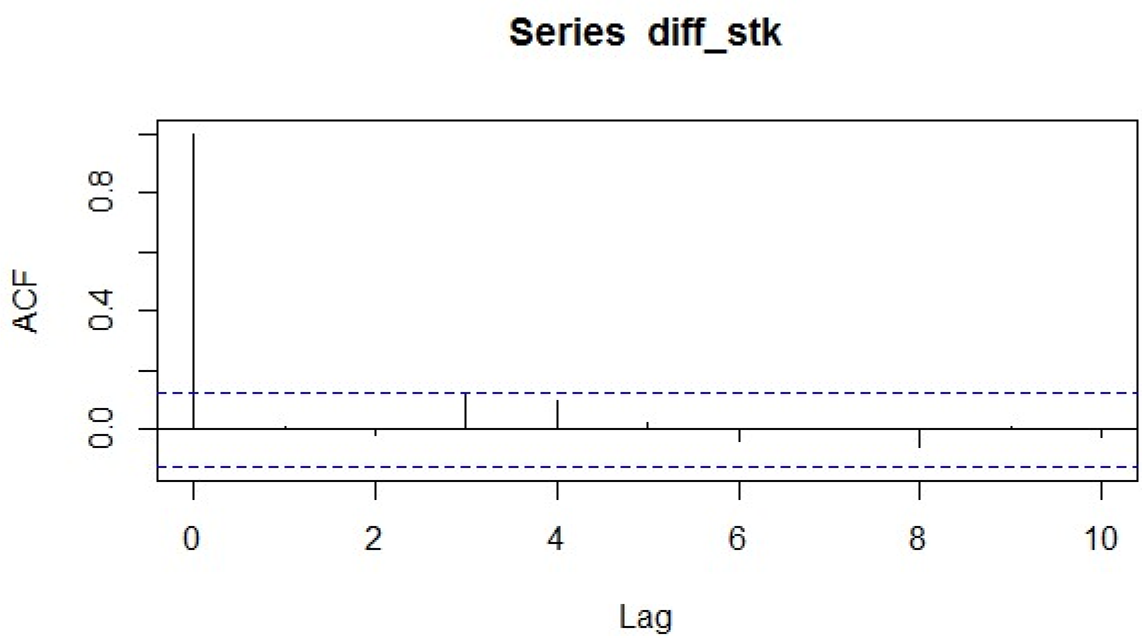
- acf(diff_int, lag.max = 10, type = ("correlation"))
- pacf(diff_int, lag.max = 10)
- acf(diff_stk, lag.max = 10, type = ("correlation"))
- pacf(diff_stk, lag.max = 10)
- acf(inf, lag.max = 10, type = ("correlation"))
- pacf(inf, lag.max = 10)



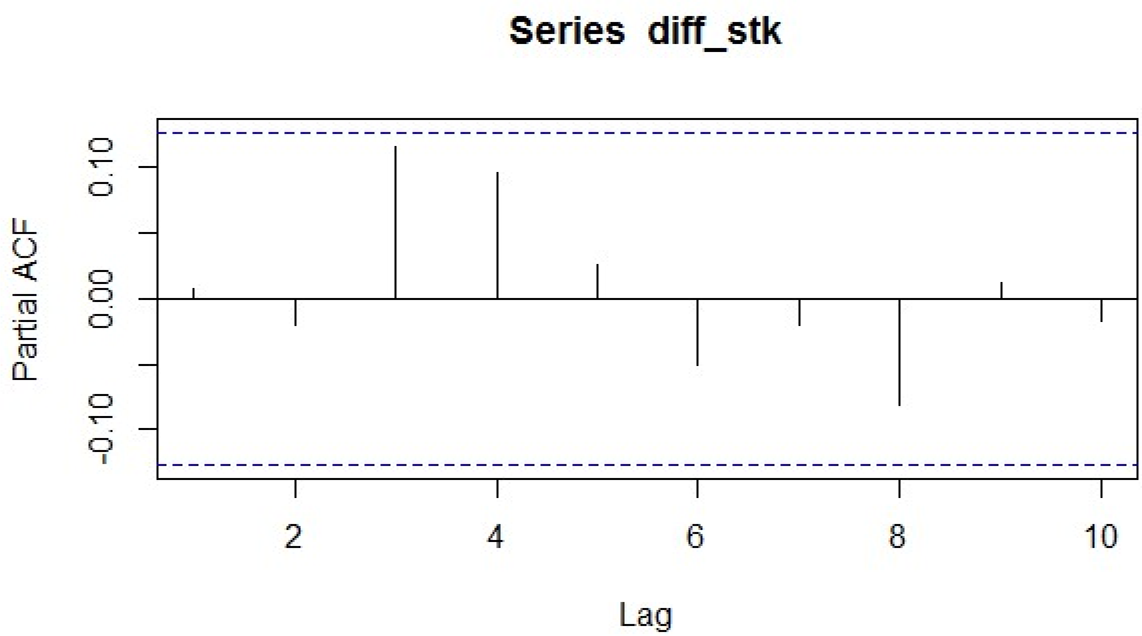
In this ACF series we see that the ACF of the differenced series of interest rate spikes to zero after lag 0.



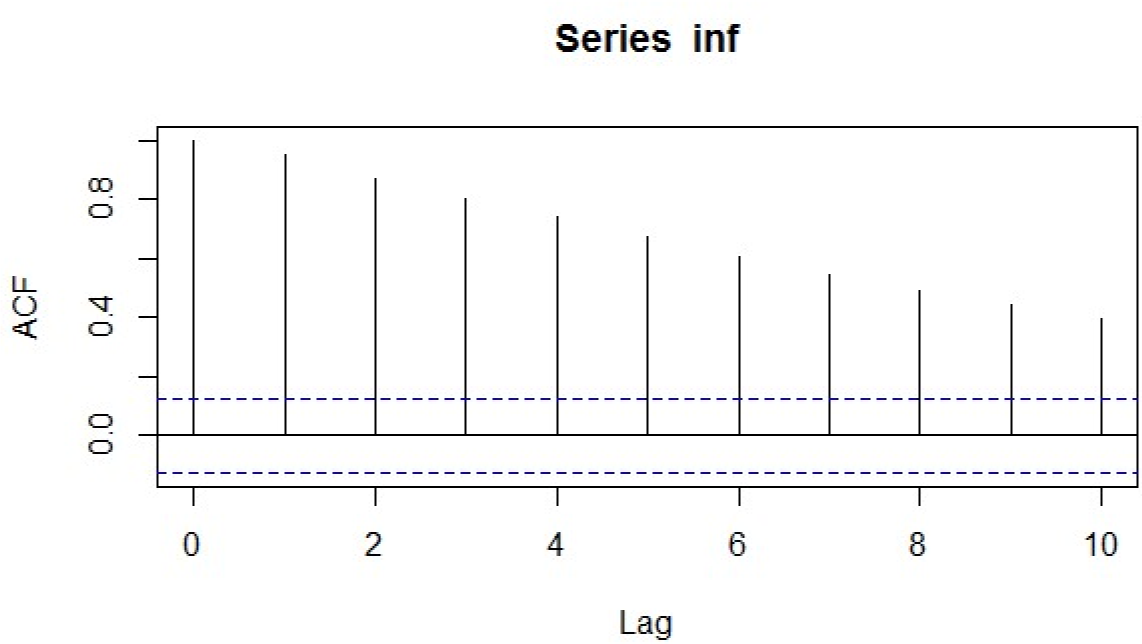
PACF modelling of the differenced interest rate shows that although the spike decays to zero



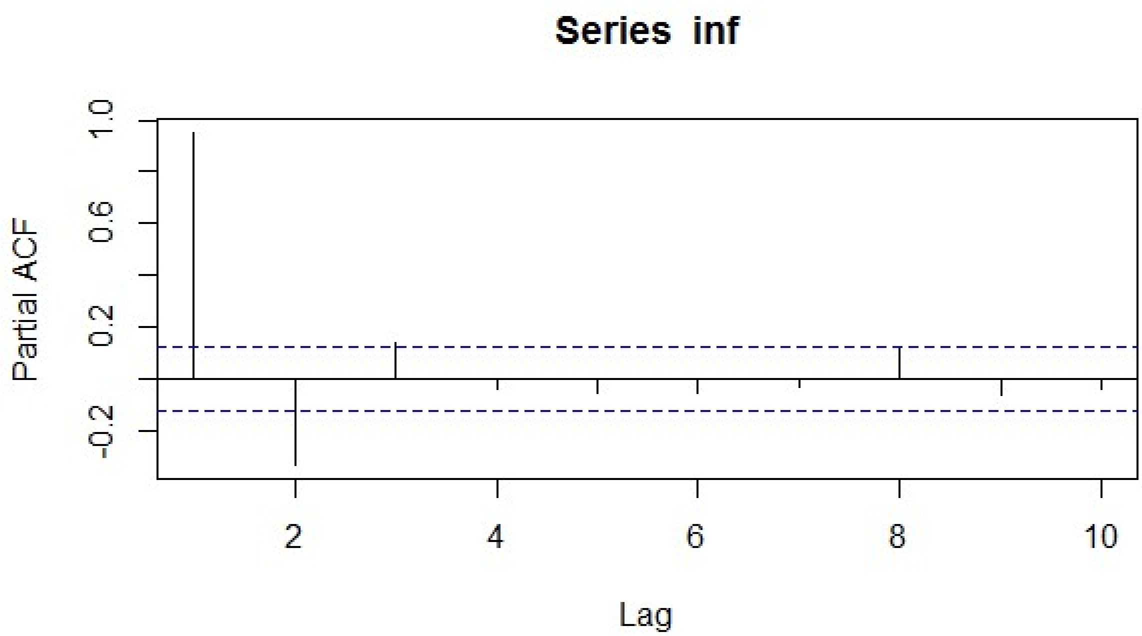
In ACF modelling of differenced stock quote of SENSEX we see that, the graph spikes to zero after lag 0 or no lag thus signaling the removal of non-stationarity of the function.



The PACF modelling in differenced stock value shows that the value gradually decays to zero but spikes to zero like in ACF modelling.



In the ACF, modelling the inflation rate gradually decays to zero, unlike the other variables which spiked to zero, thus signaling the Autoregressive modelling to the time series.



In the inflation rate time series, which was already stationary to begin with, it is seen that PACF modelling in inflation rate spikes after zero just after lag 2.

Following information, we have obtained for our three variables

	ACF	PACF
Interest Rate (differenced)	Spikes to zero lag (0)	Decays to zero
Inflation Rate (differenced)	Decays to zero	Spikes to zero lag (2)
Stock Quote	Spikes to zero lag (0)	Decays to zero

Thus, according to Time series theory,

Model	ACF	PACF
AR(p)	Spikes decays toward zero	Spikes cutoff toward zero
MA(q)	Spikes cutoff to zero	Spikes decays toward zero
ARMA(p,q)	Spikes Decays to zero	Spikes Decays to zero

It is evident that, from the result obtained from above no one model is suitable for all but ARIMA best fit must be used to fit the time series data.

Fitting of ARIMA model to data

//R codes for fitting of model//

- arima_fit <- arima(x = diff_int, order = c(2L,1L,2L))
- summary(arima_fit)
- coef(arima_fit)

- arima_fit <- auto.arima(int,max.p = 3,max.q = 3,max.P = 3,max.Q = 3,start.p = 1, start.q = 1,start.P = 1,start.Q = 1, stationary = FALSE, ic = c("bic"))
- summary(arima_fit)
- coef(arima_fit)
- arima_fit <- auto.arima(int,max.p = 3,max.q = 3)
- summary(arima_fit)
- coef(arima_fit)
- arima_fit1 <- auto.arima(stk,max.p = 3,max.q = 3)
- summary(arima_fit)
- coef(arima_fit)

//output//

```
> arima_fit <- arima(x = diff_int, order = c(0L,1L,3L))
> summary(arima_fit)

Call:
arima(x = diff_int, order = c(0L, 1L, 3L))

Coefficients:
          ma1      ma2     ma3
      -0.9800  -0.1224  0.1153
s.e.   0.0714   0.0771  0.0740

sigma^2 estimated as 0.1277:  log likelihood = -94.7,  aic = 197.4

Training set error measures:
                     ME      RMSE       MAE MPE MAPE      MASE       ACF1
Training set 0.01995646 0.3566026 0.1259113 NaN  Inf 0.7783606 0.01579915
> coef(arima_fit)
       ma1        ma2        ma3
-0.9800398 -0.1224287  0.1152993
> arima_fit <- arima(x = diff_int, order = c(3L,1L,3L))
> summary(arima_fit)

Call:
arima(x = diff_int, order = c(3L, 1L, 3L))

Coefficients:
         ar1     ar2      ar3      ma1      ma2     ma3
      0.0168  0.3141  -0.2039  -0.9844  -0.4391  0.4402
s.e.  0.2867  0.2579   0.0717   0.2894   0.4617  0.2555

sigma^2 estimated as 0.1222:  log likelihood = -89.53,  aic = 193.06

Training set error measures:
                     ME      RMSE       MAE MPE MAPE      MASE         ACF1
Training set 0.01201841 0.3488808 0.1293188 NaN  Inf 0.7994255 -0.004988881
> coef(arima_fit)
        ar1         ar2         ar3         ma1         ma2         ma3
 0.01682728  0.31414827 -0.20391056 -0.98442359 -0.43911534  0.44019591
> arima_fit <- arima(x = diff_int, order = c(2L,1L,2L))
> summary(arima_fit)
```

```
Call:
arima(x = diff_int, order = c(2L, 1L, 2L))

Coefficients:
         ar1      ar2      ma1     ma2
      0.7636  -0.1842  -1.7282  0.7368
s.e.  0.1389   0.0675   0.1303  0.1294

sigma^2 estimated as 0.1234:  log likelihood = -90.62,  aic = 191.24

Training set error measures:
                    ME      RMSE       MAE MPE MAPE      MASE        ACF1
Training set 0.0104086 0.3505201 0.1286599 NaN  Inf 0.7953519 -0.01375744
> acf_summ <- acf(diff_int, lag.max = 10, type = ("correlation"))
> coef(acf_summ)
NULL
> summary(acf_summ)
       Length Class  Mode
acf    11     -none- numeric
type    1     -none- character
n.used  1     -none- numeric
lag    11     -none- numeric
series  1     -none- character
snames  0     -none- NULL
> pacf_summ <- pacf(diff_int, lag.max = 10)
> coef(pacf_summ)
NULL
> summary(pacf_summ)
       Length Class  Mode
acf    10     -none- numeric
type    1     -none- character
n.used  1     -none- numeric
lag    10     -none- numeric
series  1     -none- character
snames  0     -none- NULL
> arima_fit <- auto.arima(int,max.p = 3,max.q = 3,max.P = 3,max.Q = 3,start.p
= 1, start.q = 1,start.P = 1,start.Q = 1, stationary = FALSE, ic = c("bic"))
> summary(arima_fit)
Series: int
ARIMA(0,1,0) with drift

Coefficients:
        drift
      -0.0178
s.e.   0.0231

sigma^2 estimated as 0.1286:  log likelihood=-93.54
AIC=191.09   AICc=191.14   BIC=198.04

Training set error measures:
                       ME      RMSE       MAE         MPE     MAPE    MASE
Training set 5.007407e-05 0.3571418 0.1049751 -0.01787181 1.221151 1.15352
                   ACF1
Training set 0.05061151
> coef(arima_fit)
      drift
-0.01778243
```

```
> arima_fit1 <- auto.arima(inf,max.p = 3,max.q = 3,max.P = 3,max.Q = 3,start.
p = 1, start.q = 1,start.P = 1,start.Q = 1, stationary = FALSE, ic = c("aic")
)
> summary(arima_fit)
Series: int
ARIMA(0,1,0) with drift

Coefficients:
        drift
      -0.0178
s.e.   0.0231

sigma^2 estimated as 0.1286:  log likelihood=-93.54
AIC=191.09   AICc=191.14   BIC=198.04

Training set error measures:
                       ME      RMSE       MAE         MPE     MAPE    MASE
Training set 5.007407e-05 0.3571418 0.1049751 -0.01787181 1.221151 1.15352
                   ACF1
Training set 0.05061151
> coef(arima_fit)
      drift
-0.01778243
> arima_fit1 <- auto.arima(stk,max.p = 3,max.q = 3,max.P = 3,max.Q = 3,start.
p = 1, start.q = 1,start.P = 1,start.Q = 1, stationary = FALSE, ic = c("aic")
)
> summary(arima_fit)
Series: int
ARIMA(0,1,0) with drift

Coefficients:
        drift
      -0.0178
s.e.   0.0231

sigma^2 estimated as 0.1286:  log likelihood=-93.54
AIC=191.09   AICc=191.14   BIC=198.04

Training set error measures:
                       ME      RMSE       MAE         MPE     MAPE    MASE
Training set 5.007407e-05 0.3571418 0.1049751 -0.01787181 1.221151 1.15352
                   ACF1
Training set 0.05061151
> coef(arima_fit)
      drift
-0.01778243
```

//Multi regression modelling//

//R codes//

- bdi_mult <- lm(stk~int+inf)
- summary(bdi_mult)
- coef(bdi_mult)

//output//

```
Call:
lm(formula = stk ~ int + inf)

Residuals:
   Min     1Q Median     3Q    Max 
-15956  -5550  -1930   4857  20086 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  11531.1     2147.6   5.369 1.88e-07 ***
int           -716.4      278.1  -2.576   0.0106 *  
inf            708.0      148.9   4.754 3.47e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7523 on 237 degrees of freedom
Multiple R-squared:  0.09398,	Adjusted R-squared:  0.08633 
F-statistic: 12.29 on 2 and 237 DF,  p-value: 8.336e-06

> coef(bdi_mult)
(Intercept)         int         inf 
 11531.1439   -716.4444    708.0147 
Call:
lm(formula = inf ~ int)

Residuals:
    Min      1Q  Median      3Q     Max 
-7.3878 -2.2830 -0.7233  2.1867 11.8077 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   3.5748     0.9054   3.948 0.000104 ***
int           0.4766     0.1170   4.073 6.32e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.274 on 238 degrees of freedom
Multiple R-squared:  0.06516,	Adjusted R-squared:  0.06124 
F-statistic: 16.59 on 1 and 238 DF,  p-value: 6.321e-05
```

Conclusion

Equation Obtained

Time Series ARIMA modelling equation

- stk(t) = -0.0178stk(t-1)
- int(t) = -0.0178int(t-1)
- inf(t) = -0.0178inf(t-1)
- stk = 11531.143 – 716.44 int + 708.014 inf

substituting the values of time series models in the multiple regression models we get,

$$\boldsymbol{stk(t) = 11531.143 + 12.752int(t-1) + 12.602\,\mathrm{inf}(t-1) - 0.0178stk(t-1) + \varepsilon}$$

The above multiple regression model says that ***only 9.4% of the change in stock price is explained by the change in interest and inflation rate.***

Although a drift is seen in all the three variables within itself of time series modelling, and an auto correlation was found between them but it was found that there is very nominal impact of inflation rate on interest rate directly.

Only 6.5% of change in interest rate is explained by inflation rate!

References

Bibliography

Alam, M. M. (March, 2009). Relationship between Interest rate and stock price. *International Journal of business and management*, 9.

Ali, H. (Feb, 2014). Impact of interest rate on Stock Market A study from Pakistan. 6.

ARIMA modelling in R. (n.d.). Retrieved from otexts: https://www.otexts.org/fpp/8/7

Bobasu, A. (January, 2016). Quantifying the impact of monetary policy on economic growth. *journal of economics, business and management*, 4.

Campbell, J. Y. (June, 1985). Stock return and term structure. *National Bureau of economic research*, 53.

Feildsten, M. (1983). Inflation, Tax Rules, Capital Formation. In M. Feildsten. Chicago: University of Chicago press.

Forming ARIMA equation. (n.d.). Retrieved from Stats Stackexchange: http://stats.stackexchange.com/questions/78458/how-can-i-form-arima-equation-given-ma-and-ar-terms

Haian Chen, D. H. (2014). The interaction between stock price and interest rate. *Lund University*, 42.

India Inflation rate. (2017). Retrieved from Trading Economics: http://www.tradingeconomics.com/india/inflation-cpi

Interest Rate, Government Securities. (2017, Feb 1). Retrieved from FRED@Economic Data: https://fred.stlouisfed.org/series/INTGSBINM193N

interpreting Dickey Fuller Test. (n.d.). Retrieved from Stats Stack Exchange: http://stats.stackexchange.com/questions/251397/interpretation-dickey-fuller-test

Ioannis Chatziantounniou, D. D. (March 2014). Stock market response to change in monetary and fiscal policy. 35.

Muthukumaran, D. T. (Oct, 2014). An analytical study of interest rate of stock returns of india. *International journal of research and management*, 8.

ndiffs. (n.d.). Retrieved from rdocumentation: https://www.rdocumentation.org/packages/forecast/versions/7.3/topics/ndiffs

Nissan, D. (March, 2001). An Empirical study of the effect of change of interest rate on ARR and ROE equity. 51.

Prices- Inflation CPI. (n.d.). Retrieved from OECD Data: https://data.oecd.org/price/inflation-cpi.htm

R: ARIMA modelling for time series. (n.d.). Retrieved from Stat:ethz: https://stat.ethz.ch/R-manual/R-devel/library/stats/html/arima.html

Stationarity. (n.d.). Retrieved from Stats Stackexchange: http://stats.stackexchange.com/questions/104215/difference-between-series-with-drift-and-series-with-trend

Stationarity and differencing time series. (n.d.). Retrieved from People Duke: https://people.duke.edu/~rnau/411diff.htm

Verma, J. R. (January-March, 1997). The stochastic dynamics of Short term interest rate in india. 16.

Wikipedia. (n.d.). Retrieved from Augmented Dickey Fuller Test: https://en.wikipedia.org/wiki/Augmented_Dickey%E2%80%93Fuller_test