International Journal of Research in Engineering, Science and Management
Volume 4, Issue 8, August 2021
https://www.ijresm.com | ISSN (Online): 2581-5792

The Impact of Precipitation on Stock Market Returns in India

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***Abstract*: This study investigates the impact of precipitation on Indian equity returns. This study empirically examines the effect of monsoon change on the numerous sectors such as automobile and metal amidst others and strikes a comparison with the returns of NIFTY 50 index which is considered as the optimum indicator for the Indian equity market. This study objectively questions the myth that monsoon is highly positively reflective of the returns of the equity market assuming the country to be an agrarian economy. This has been tested using the statistical tool of correlation. AR-GARCH model has been applied to investigate the market's response to precipitation dynamics. All rainfall-related variables have been statistically adjusted to the scope of the study.**

***Keywords*: AR-GARCH, Capital market, Correlation, NIFTY 50, Precipitation change.**

1. Introduction

Precipitation plays a major role in Indian economy; it is a common perception everyone believes in. It is said emphatically that India is the only country that has all the climate variations of the world, but the climate in most part of India is mostly affected by rainfall regime and is actually tropical. The intensity and lasting of monsoon is more or less dependent on the area, however the dampest period lies between months of July and October.

This research aims to find if the equity market is dependent on precipitation or not as it is a major part of the economy as a whole. Equity market is also known as stock market where shares are issued and traded, either through standardised stock exchanges or OTC (over the counter) markets. Stock market is one of the most essential area of market economy as through this, companies get access to capital and on the other hand investors get a slice of ownership in a company along with the potential to realize further gains which are based on a company's future performance.

An exchange is basically a meeting point for buyers and sellers of stocks of listed companies, whereas private stocks are traded through dealers, which is known as OTC markets. For this we have chosen NIFTY 50 as an indicator of Indian stock market and applied different statistical tools to find if it is true or not. The reason for choosing NIFTY 50 is that it represents the weighted average of 50 large cap Indian company stocks in 13 sectors and is one of the main stock indices used in India.

The weighted average is computed using "Free Float Market Capitalisation" weighted method, where the level of index shows free float market capital of every stock present in the index. We have also taken different sectors under NIFTY 50 to find if any particular sector is more heavily correlated with monsoon.

Tools that have been used for this research include Correlation and AR-GARCH. Correlation is a statistical measure that shows dependence or association of two or more variables with each other and whether they fluctuate together or not. Correlation can be either positive or negative, where a positive value of correlation indicates that the selected variables move in the same direction and a negative value of correlation indicates that the variables move in opposite direction. The value of correlation indicates the extent of this movement which can be in the same or opposite direction. AR-GARCH, on the other hand is a statistical model which is used to analyse a range of different types of financial data. The purpose to use this model in our research was to test the relationship between the volatility of returns of NIFTY 50 and volatility of precipitation in the entire country.

2. Background

Indian subcontinent experiences a drastic variation in its climate which ranges from extreme cold weather experienced in the northern Himalayas to extreme hot weather experienced in the western region of the Thar Desert. Even the amount of precipitation received varies drastically throughout the geography of the subcontinent. According to a national survey 66.46 % of the Indian population lives in rural area and 42% of the total workforce in engaged in the agrarian allied activities. Around 55% of whole arable land depend directly or indirectly on the rainfall for its harvest. A low precipitation has an immense impact over the earnings of agrarian society resulting in the lowering of rural consumption demand and credit creation thus creating a negative domino effect in various industries like automobile, infrastructure FMCG etc. Beside this sector like energy sectors which comprises of hydroelectric plants observe a varying volatility in output due to changes in

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precipitation pattern.

Thus, in the modern times where a stock market returns defines the productivity of the economy, it becomes imperative for one to analyse whether this prominent factor which draws the trend for the economy also draws trend the for returns that he gets from his investment in the stock market. This paper attempts to answer this dilemma by analysing stock returns of Nifty50 as dependent variable and precipitation as independent variable. Thus, trying to lay a foundation for interlinkage between the two and helping the investor to know whether he should consider this factor while investing or an analyst while predicting the future course of stock market returns.

3. Objectives and Scope

A. *Objectives*

1. Finding correlation between nifty 50 companies returns and monthly precipitation percentage over the years.
2. To estimate volatility in Stock returns, specifically Nifty 50, and the dependence of volatility on change in precipitation.

B. *Scope*

The study is confined to equity market only. This paper focuses largely on the variables and factors related to the precipitation and not on the climate and related changes which have been decided based on the extensive review of literature.

Hypothesis Statements for Correlation & Volatility respectively

Null Hypothesis: Indian Equity market is independent of precipitation percentage.

Alternative Hypothesis: Indian Equity market is dependent on precipitation percentage.

Null Hypothesis: Nifty 50 Index Volatility is independent of Change in Precipitation.

Alternate Hypothesis: Nifty 50 Index Volatility is dependent on Change in Precipitation.

4. Literature Review

Title: Reassessment of the Weather Effect: Stock Prices and Wall Street Weather, Authors: Mitra Akhtari.

This research was done with an aim to find if an investor's decision is changed in a significant manner based on the hours of sunshine such that mispricing of investment follows. Tools like simple regression are used to find relationship between daily cloudiness of New York City and return on the Dow Jones Industrial Average Index (1948-2010). As the result, Negative relationship was found between the two stating that investors are more optimistic and less risk averse during sunny days when compared to rainy days. The possible reason that they have given for this relationship is that the weather effect is stronger when there exist retail investors in the market who are not professional and presumably less rational than investment professionals. Another reason mentioned is that market trends and cyclical weather pattern simply match up in certain periods. (AKHTARI, 2011).

Title: Impact of Monsoon on Indian Equity Market, Authors: Hardik Vachhrajani, Jay Desai, Kinjal Desai, Methodology: Kruskall-Wallis Test, OLS Regression.

This paper aims to examine equity market returns based on monsoon season as earlier studies concentrated only on Holiday Effect, Monthly Effect and other anomalies. The research is done using monthly data of S&P BSE Sensex for the period of 1st January 1991 to 31st December 2013. The objective of this paper is to find whether there is significant impact of monsoon on Indian stock market returns and to identify the specific months that have the same. The research highlighted that average return for all the months of a year are not same and post monsoon period returns (June to December) are more than pre monsoon period, specially the four months of monsoon (June to September) have higher monthly returns compared to other months. (Hardik Vachhrajani 2014).

Title: Does it pay to be environmentally conscious: A study of NIFTY companies, Authors: Aarti Kan, Adyan Priyanka Aggarwal.

This paper aims to determine significance of the existence of a relationship between environmental performance and its impact on economic performance using quantitative measures like EPS, P/E Ratio and Return on Assets into account over a period of 3years.

Sample taken up for the purpose of this research comprised Top 50 companies listed on NSE i.e. NIFTY 50. Inferences were derived based on the outputs of Multiple regression analysis.

Companies are given environmental rating which in turn influences the returns of the NIFTY index. However, the study fails to establish strong support of evidence with respect to the limitations, hence, all the three hypotheses are rejected. (Aarti Kadyan, March 2014).

Title: The Effect of Climate Change on Australian Stock Equity Returns, Author: Sveltana Vlady (2015)

This examination looks at the impact of environmental change on the Australian oil and gas industry and compares it to the indexes S&P ASX 200 and All Ordinaries, which are considered as the prime indicators for the Australian equity market.

After greenhouse gas emission reduction policies have been introduced, there are no empirical multiyear studies that examine the relationship between climate change and market value on company and industry levels in comparison with the whole Australian market. Thus, this study tries to fill in this gap in the literature.

Samples used in the study are The Oil and Gas index and Australian refining company Caltex Limited, as well as S&P/ASX 200 index, All Ordinaries index with the methodology of AR–GARCH model and Descriptive statistics.

Results specify that that climate change is value applicable only for the refining weather-sensitive company Caltex. The capital market has responded on past stuns and news and is influenced by difference from the last time frame. In any case, this difference does not come from environmental change. (VLADY, 2015)

Title: Weather-Induced Mood Effects on Stock Returns, Authors: Anya Khanthavit.

This paper studies how weather influences investors' mood which compels them to raise or lower asset prices. The study found that the effects are indirect, as weather affects returns by affecting the mood of the investor –not directly affecting returns. The author says that weather effects are, in fact, weather-induced mood effects. In this study, she estimated a model of weather-induced mood effects in its full form. The model in its reduced form had exactly the same form as did the direct weather-effect model. Using the daily returns on Thailand's stock index portfolios, this study found that all weather variables – cloud cover, air pressure, rainfall, ground visibility, relative humidity, temperature, and wind speed – significantly affected mood. The mood effects on the yields were variable with respect to time. They were substantially reliable in the early sample period up to 2009 but wavering in the later period from 2010 onwards. The results have helped to explain why prior studies on the subject reported insignificant effects on returns from certain weather variables even though the psychological literature suggested that these variables were important. (Khanthavit. 2017).

Title: Effect of weather on stock market: Evidence from a panel of emerging countries' stock markets, Authors: Massimo Marini, Fabio Pizzutilo.

This study targets previous research work done on the weather effect. They have taken into consideration studies that postulated that good or bad weather induces a positive or negative mood respectively as well as other studies that have concluded that mood can influence humankind decision making process under risk and uncertainty. They have also taken into consideration the studies that have challenged this, questioning whether sunshine, temperature or other weather variables exert an impact on stock prices by affecting the behaviour of market operators, thus challenging the efficient market hypothesis. This study mainly concentrates on the stock markets of emerging countries.

They fill this gap by conducting a comprehensive analysis of the effect of four weather variables (temperature, cloud cover, humidity and wind) on the stock markets of nine emerging countries namely, Chile, Colombia, the Czech Republic, Hungary, Malaysia, Mexico, the Philippines, Poland & Thailand which are located in three climatic and economically different areas of the world. They extend the analysis by analysing stock prices' behaviour along with that of stock indices and by examining the opening market activity along with the whole-day activity. Based on their results, they strongly rejected the weather effect hypothesis. (Massimo MARIANI, 2018)

Title: An Empirical Investigation of the Interlinkages of Stock Returns and the Weather at the Indian Stock Exchange, Authors: Chinnadurai Kathiravan, Murugesan Selvam, Sankaran.

This paper studies correlation between weather and Indian Stock Market Returns. The research is done to find relation between 2 Indices – BSE SENSEX, CNX NIFTY and 3 weather factors (Humidity, Wind Speed, Temperature) for the period of 2001 to 2016 in 5 metro cities. Results of the Granger causality show that correlation between one city and a factor is not same as correlation between another city and the same factor. The research revealed that wind speed does not play any role in SENSEX, NIFTY returns but Temperature and Humidity have substantial influence on Indian stock market. (Chinadurai Kathiravan M. S., 2018).

Title: Calendar Anomalies in the Indian Stock Markets: Monsoon Effect, Authors: Aman Bajaj, Nathimuthu N and Lavanya Mary, Christ University, India.

This research was done to analyse the existence of monsoon effect in the Indian stock market and impact of their volatility during monsoon months. They have talked about calendar anomaly which can be used to identify seasonal trends in past prices thereby contradicting the weak form of Efficient Market Hypothesis (EMH). They chose four stock indices of NSE for their study to cover various combinations of stocks that are present in the market. The result drawn was that in India the stock volatility is highly clustered which will lead to persistence of volatility. The results from the various tests conducted like

EGARCH Model and ARCH LM Test also supports the hypothesis that the returns and volatility both were higher during the month of September in India which confirms that monsoon effect is present in Indian Stock Market. (Aman Bajaj, 2019).

Title: Impact of Weather on Return and Volatility: Evidence from Indian Stock Market, Authors: Vijayakumar N., Dharani M., MURUGANANADAN S, Methodology: autoregressive conditional heteroskedastic (ARCH), conditional heteroskedastic (GARCH).

The paper focuses on the volatility caused in the Indian stock market due to variation in the weather pattern observed in India. The study examines the data points from S&P CNX Nifty index and daily weather data from January 2008 to December 2013.

It uses data like dew point, visibility and temperature of the 4 metropolitan cities of India: Kolkata, Chennai, Mumbai and Delhi as the sample population. The daily values of the index are converted into returns (Rt) by taking the first differences in the natural logarithms.

Models like autoregressive conditional heteroskedastic (ARCH), and generalised autoregressive conditional heteroskedastic (GARCH) are employed to check the volatility and returns expected from the stock market during that particular time frame. After applying the models mean variation was found out between the various variable like temperature, dew point and visibility which was correlated to the return from the market for the 4 mentioned cities. It was analysed that both in Mumbai and Kolkata temperature was the only significant factor whereas in Delhi visibility and temperature had an effect but in Chennai all three factors were insignificant. Altogether it was concluded that only temperature can be considered to be a significant factor for analysing the variation in the volatility of the stock market. The paper also suggested that a study regarding the investment behaviour of the investor should be correlated to the weather pattern in order to establish a significant relationship between the stock market and the weather of a country. (N., 2015).

Title: The Indian Monson, GDP and Agriculture, Authors: Sulochana Gadgil and Siddhartha Gadgil, Methodology: Fitted

exponential growth curves.

This paper analyses the impact of the variation in the magnitude of monsoon over the GDP and food grain production present in the Indian economy by analysing the data points from the year 1951 to 2003 of all the three variables. Since the magnitude of monsoon in India is represented through ISMR (Indian Summer Monsoon Rainfall), it has been taken as the basic data variable for correlating monsoon with GDP and Food grain production. The anomaly of ISMR for each year is calculated by analysing the difference between the ISMR for that year and the long- term average. Greater ISMR suggests that the whole country was facing severe droughts or floods whereas, for years for which the ISMR is near its average value, there was a large spatial variation in the rainfall anomalies over the country, with deficit rainfall over some parts of the country and normal or excess over other which lead to small dips in GDP. The paper tries to established the fact that since the contribution of agriculture to GDP had fallen from 50% to 22% over five decades the impact of monsoon over GPD should also decline over time. In order to prove this an estimated GDP was calculated in the absence of the fluctuation of monsoon pattern. Trends were chalked out using exponential growth curves. These curves also took into account the various events like liberalisation and war in order to establish a greater significant relationship between the various variables. It was observed that impact of severe droughts on GDP is large in the earlier era as well as the modern era, despite the substantial reduction in the contribution of agriculture to GDP over the last five decades. But the study also suggested that heavy flooding like in the year 2006 can be more impactful than droughts over the years. (GADGIL, 2006).

5. Research Methodology

A. Data Collection

For this paper we used secondary data,

- Precipitation yearly data (2002 to 2017)
- Composition of Nifty 50 companies (2002 to 2017)
- Share prices of the Nifty 50 companies (2002 to 2008)
- No. of equity shares of the Nifty 50 companies (2002 to 2008)
- Market Capitalisation of the Nifty 50 companies (2002 to 2008)
- Weights of the Nifty 50 companies (2009 to 2017)
- 9 Nifty Indices data (2002 to 2017)
    1. Nifty Infrastructure Index
    2. Nifty Financial Services Index
    3. Nifty Automobile Index
    4. Nifty Energy Index
    5. Nifty FMCG Index
    6. Nifty Pharmaceuticals Index
    7. Nifty IT Index
    8. Nifty Metal Index
    9. BSE Telecom Index

B. Data Analysis Tools

1. Excel functions to sort, format the precipitation data and stock market data and to calculate weights of the Nifty 50 companies.
2. E-views & SAS for ARCH GARCH Model.

6. Data Analysis

A. Correlation

The data available for precipitation details was on a daily basis hence it has been converted into monthly data by taking average. We have then found out the correlation between returns of NIFTY 50 and the precipitation percentage to establish a trend between the two.

Data for the monthly composition of NIFTY 50 was taken with the prices and the number of shares for each company for the period of 2002 to 2017. The product of the number of shares and the daily prices gives us the market capitalisation. In order to calculate the company weightages in the NIFTY 50 index "free float market capitalisation" method is used where-in the number of outstanding shares in the market is multiplied by the market price of the shares. In our case, the number of outstanding shares was not explicitly available hence the number of equity shares have been used to calculate the market capitalisation.

Correlation between the various sectoral NIFTY 50 indices and the precipitation percentage have been calculated so as to compare the correlation of various sectors with precipitation.

The composition of companies of NIFTY 50 have been segregated based on their sectors and the average weightages of each year have been found out via simulation of the monthly data.

Through the process of correlation between the daily precipitation values all over the country and NIFTY 50 returns over the same time period, it is observed that a substantial trend is not a part of the picture. The range of correlation values is negative 0.6 to positive 0.4 which does not lie in the range of high correlation on both sides of the number line. At the outset, due to absence of a pure trend in the observations, we can say that the values obtained from the analysis will have to be simulated in the respective years so as to check the allocation of weights to various companies and their respective sector wise trends in place. For the years 2002, 2003, 2004, 2005, 2007, 2011, 2012 and 2013 we have obtained negative values of correlation which depicts that the two variables in our review are negatively correlated but not of a higher magnitude which would have established high negative correlation. For the years 2009, 2010, 2015 and 2017 the correlation values lie very close to zero correlation which implies a neutral effect between both the variables. However, in the years 2014 and 2016 we see the values are higher than the neutral scenario but not worth making an inference of high positive correlation. Furthermore, the respective companies that comprises NIFTY 50 in these years will have to be evaluated sector wise to demarcate market internal correlation.

In 2004, the correlation between Nifty 50 returns and precipitation is negative 0.648 which is the highest negative correlation in the analysed period. This is justified because all the sectoral indices also have negative correlation values.

Table 1

Index	2004	Weightage
Nifty 50	-0.64846	
Auto	-0.36551	17.19
FMCG	-0.48774	24.42
Infra	-0.37276	1.32
IT	-0.23165	2.45
Energy	-0.29679	6.61
Financial S	-0.33439	9.99
Metal		13.25
Pharma	-0.08622	14.62
Telecom		2.77

Table 2

Index	2005	Weightage
Nifty 50	-0.18969	
Auto	-0.10721	9.33
FMCG	0.12644	25.89
Infra	0.044771	1.84
IT	0.113333	4.16
Energy	0.044561	6.09
Financial S	0.389138	12.11
Metal		19.31
Pharma	0.113315	11.84
Telecom	-0.9399	6.28

In 2005, it is observed that telecom sector has the highest value of negative correlation and substantial level of weightage though it is not one of the highest weights given to a sector in the year, it impacts NIFTY 50 returns by a huge margin due to high negative correlation.

Table 3

Index	2007	Weightage
Nifty 50	-0.03517	
Auto	-0.14627	5.43
FMCG	-0.60386	20.02
Infra	-0.57158	2.36
IT	0.230179	3.61
Energy	-0.55084	19.59
Financial S	-0.58422	11.34
Metal		17.02
Pharma	-0.58856	11.17
Telecom	-0.35498	6.41

In the year 2007, there exists negative correlation between financial services, energy, pharma and Telecom with precipitation which is then balanced out by the high positive correlation of the IT sector. Hence, the overall negative correlation of the NIFTY 50 index is low.

In 2009, the precipitation level is higher than average hence, there is positive correlation between precipitation and nifty 50 returns with the justification of positive correlation with all the sectoral indices as well.

In 2012, there is negative correlation overall which is backed by negative correlation of high magnitude with the indices of telecom, automobile and IT sector.

In 2014, there exists positive correlation between precipitation and each sector except a few specifically the IT industry, which does not create a substantial impact due to a very low weight in the NIFTY 50 index about 1.88 only.

Table 4

Index	2009	Weightage
Nifty 50	0.173726	
Auto	0.476148	4.52
FMCG	0.514363	26.01
Infra	0.582907	25.33
IT	0.359935	2.20
Energy	0.506664	14.58
Financial S	0.562537	11.54
Metal		6.40
Pharma	0.195894	2.46
Telecom	0.465333	5.97

Table 5

Index	2012	Weightage
Nifty 50	-0.56458	
Auto	-0.28429	8.15
FMCG	0.465262	15.17
Infra	-0.04274	36.04
IT	-0.41473	2.81
Energy	0.161195	9.14
Financial S	0.061741	14.15
Metal	-0.02461	5.95
Pharma	0.270992	4.41
Telecom	-0.25801	2.34

Table 6

Index	2014	Weightage
Nifty 50	0.258685	
Auto	0.096227	8.69
FMCG	0.15789	13.10
Infra	0.575159	37.35
IT	-0.17848	1.88
Energy	0.564411	7.92
Financial S	0.317531	17.34
Metal	0.687623	3.71
Pharma	-0.1793	5.78
Telecom	0.40006	1.76

Table 7

Index	2017	Weightage
Nifty 50	0.092824	
Auto	0.044669	10.14
FMCG	0.359582	13.47
Infra	0.018911	42.56
IT	0.06065	2.16
Energy	-0.20292	6.54
Financial S	0.272336	11.76
Metal	-0.1846	3.97
Pharma	0.019644	4.51
Telecom	-0.23183	2.13

In the year 2017, infrastructure industry plays the key role in determining correlation. The weight given to the sector is at the highest at 42.56% which brings about an impact on the correlation value which overall stands at 0.09 which is not a very conclusive figure.

B. Volatility

Null Hypothesis: Nifty 50 Index Volatility is independent of Change in Precipitation

Alternate Hypothesis: Nifty 50 Index Volatility is dependent on Change in Precipitation

This section discusses the impact of precipitation on the volatility of Nifty 50 with reference to average precipitation in all states of India. In order to gauge the impact of precipitation on stock returns in variance conditions GARCH (1,1) model is employed.

The results of GARCH (1,1) are presented below.

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: NIFTY_50_RETURNS
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 10/08/19 Time: 15:16
Sample: 2002M01 2017M12
Included observations: 192
Failure to improve likelihood (non-zero gradients) after 83 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1) + C(5)
*CHANGE_IN_PRECIPITATION

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.020025	0.005926	3.379408	0.0007
Variance Equation				
C	0.002810	0.002315	1.213795	0.2248
RESID(-1)^2	-0.040736	0.051580	-0.789763	0.4297
GARCH(-1)	0.573883	0.390012	1.471447	0.1412
CHANGE_IN_PRECIPITATION	-0.000491	6.73E-05	-7.298697	0.0000

R-squared	-0.007209	Mean dependent var	0.014392
Adjusted R-squared	-0.007209	S.D. dependent var	0.066519
S.E. of regression	0.066759	Akaike info criterion	-2.537185
Sum squared resid	0.851233	Schwarz criterion	-2.452354
Log likelihood	248.5697	Hannan-Quinn criter.	-2.502828
Durbin-Watson stat	1.887713		

Fig. 1. Results of GARCH (1,1)

The figure shows the result of the variance equation testing the impact of change in precipitation with stock market return in India by employing GARCH (1,1). The variance equation result with probability value of 0.0000 reveals that the precipitation is influencing the stock returns for the study period in India. On the other hand, in the variance equation, the coefficient of precipitation is negative which indicates that the there is an inverse relationship between the two i.e. an increase in the change in precipitation results in lesser volatility for stock returns, the result rejects the null hypothesis, and it accepts that precipitation is influencing the stock return volatility.

7. Limitations

1. Availability of data has been the most prominent limitation to this study because of which data mining and compilation was a mammoth task.
2. The weightages needed for the NIFTY 50 companies for all years had to be calculated and was not available on any reliable data source including NSE prior to 2009.
3. Sectoral indices for each sector do not exist; hence, some of them had to be clubbed under correlated indices for the purpose of inclusion in analysis.
4. The impact on returns has only been taken into account from the precipitation perspective and the overall weather conditions have not been analysed.
5. The trend so obtained has been formulated based on past data which may or may not continue in the long term due to climatic changes.

8. Conclusion

1) As seen from the graphs, a trend in correlation has not been found that implies a direct or inverse relationship between the two variables.
2) Hence, for correlation, we accept the Null Hypothesis, i.e., the returns of NIFTY 50 are independent of precipitation level of the country.
3) The variance equation result with probability value of 0.0000 reveals that the precipitation is influencing the stock returns for the study period in India.
4) The coefficient of precipitation is negative which indicates that the there is an inverse relationship between the two i.e. an increase in the change in precipitation results in lesser volatility for stock returns.

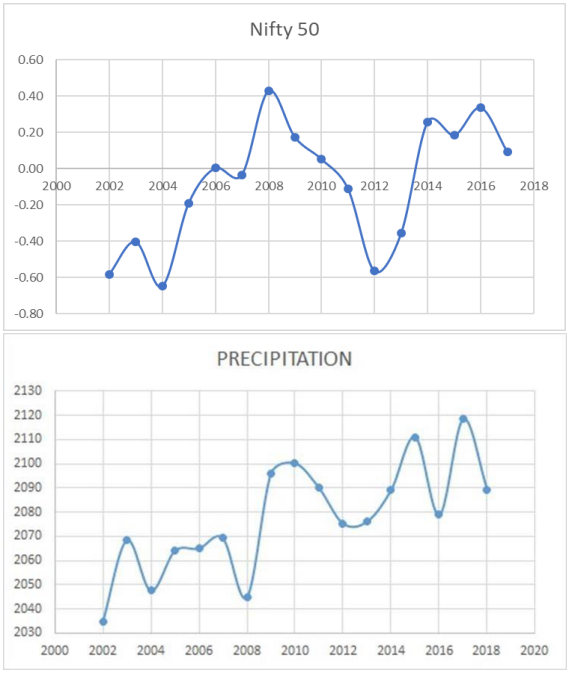

Fig. 2. Correlation between Nifty 50 Returns and Precipitation Percentage

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