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Interrelationship between Rainfall Index and Nifty Index: An Empirical Study

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Abstract: The proposed study is an attempt to determine whether a relationship exists between rainfall index and NSE Nifty index. The study used the monthly mean rainfall data and monthly closing price of Nifty index. The study applied Augmented Dickey-Fuller (ADF) test, correlation analysis, the GARCH (1,1) model, and the Granger Causality test to analyse the interrelationship. The results of correlation matrix show that there is no interrelationship between the two variables. The GARCH (1,1) model found that the NSE Nifty index is not affected by the rainfall index and Granger Causality test displays that rainfall index does not Granger Cause the Nifty index. According to the authors' knowledge, this is the first empirical study to determine the interrelationship between the rainfall index and the Nifty Index over a longer period of time.

Keywords: Rainfall index, NSE Nifty index, GARCH (1,1) model, Granger Causality test and Distinct asset.

1. Introduction

The Indian Nifty is one of the major financial indicators showing daily economic changes. The Nifty is affected by many factors, including rainfall. Rainfall variability is one of the systemic risks for the Indian economy. India is the only country that experiences all of the world's weather variations, and rainfall has a significant impact on the economy. India is still a developing country and it depends on the monsoon for economic development Narual et al. (2021). The equity market is one of the leading economic indicators and it should be influenced by the monsoon in India. The Efficient Market Hypothesis is one of the modern investment theories,

and it states that prices of stocks quickly adjust to all the available information. Rainfall is one of the weather factors that shows revenue direction for the rainfall dependent industries. Normal rainfall increases farmers' purchasing power and improves trade balances by increasing exports and decreasing imports. The deficit rainfall results in higher prices of goods and it leads to higher inflation. Higher inflation adversely affects the economic development of a country. According to the Indian Meteorological Department (IMD), total quantum rainfall of less than 90% of the Long Period Average (LPA) indicates drought; 90% to 96% of the LPA indicates normal rainfall; 104% to 110% of the LPA indicates above normal rainfall; and more than 110% of the LPA indicates excess rainfall. There are some rainfall dependent industries like fertilizer, FMCG, automobiles, banking, agro-chemicals, power generation, and tractor manufacturers whose prospects are directly or indirectly dependent on normal rainfall. According to behavioural finance theory, there exists a relationship between weather factors like rainfall, snow, humidity, temperature, etc. and stock market activity. Because these weather factors affect investors' moods and contribute to the risk-taking ability of investors. Investors' investment decisions were influenced by the weather conditions in India, but this is not yet strongly proven empirically Vijayakumar et al. (2015). Therefore, they suggest further empirical analysis. Various studies have been conducted to examine the interrelationship between rainfall index and Nifty activity. But there is no conclusive proof of interrelationship between these two variables. This empirical study has been undertaken to shed more light on this issue.

2. Literature Review

Despite the fact that there is a wealth of literature on the subject of the interrelationship between weather and the stock market, only a few studies have been published on the interrelationship between rainfall index and stock market index in India. An attempt has been made to review previous research on interrelationship between the rainfall index and stock market index to identify the research gap based on results of previous studies.

Chang et al. (2006) dealt with how Taiwan's weather was related to the stock market returns of the Taiwan Stock Exchange. The GJR-GARCH model examined the three weather variables: temperature, humidity, and cloud cover and concluded that only temperature and cloud cover had an impact on stock market return. Keef and Roush (2007) investigated the effect of Sydney weather variables

like wind speed, cloud cover and temperature on daily stock index returns on the Australian Stock Exchange. The regression model reported that wind speed and cloud cover did not influence stock index return and temperature negatively influenced stock index return. Yoon and Kang (2008) attempted to demonstrate the relationship between the Korea Composite Stock Price Index 200 stock market returns and Korean weather factors such as temperature, humidity, and cloud cover. The GJR-GARCH model revealed that temperature has a significant negative influence on stock market return, whereas humidity and cloud cover have no effect. Symeonidis et al. (2010) investigated the empirical relationship between stock market volatility and weather variables like cloudiness, temperature, and precipitation. The study showed that investors' moods were influenced by the weather variables and by stock market returns. Barkar and Sapuan (2012) check whether a relationship exists between stock market return and weather factors like temperature, humidity, and rainfall in Malaysia. According to the empirical results, only temperature has a significant negative effect on stock market returns. Humidity and rainfall, on the other hand, had little or no effect on stock market returns. Shah (2018) investigated the impact of the temperature of Shanghai and Karachi on people's behaviour towards the stock market. The GARCH model revealed that temperature had a positive relationship with the Karachi Stock Exchange and a negative relationship with the Shanghai Stock Exchange. This demonstrates that the Karachi Stock Exchange provides a higher return when temperatures are high and a lower return when temperatures are low. The Shanghai Stock Exchange yields more when the temperature is low and less when the temperature is high. Shahzad (2019) evaluated the relationship between weather variables like humidity, temperature, air pressure, wind speed, clouds, rain, haze, and snowfall with stock return and volatility in the Greater China region's stock market. The study found that temperature, wind speed, rain, and cloud cover produced more significant results than the other variables chosen for this study. The empirical results show that Shanghai and Hong Kong stock market returns were not impacted by weather. Whereas, Shenzhen and Taiwan stock index returns were significantly impacted by the weather variables. This result shows that there was a mixed effect of weather on the stock market

Vijayakumar et al. (2015) tried to figure out how weather factors in Chennai, Mumbai, Delhi, and Kolkata impacted on stock market returns and volatility of NSE S & P CNX NIFTY. The study concluded that Mumbai's temperature had

an influence on stock market return as per the mean equation. The temperature of Mumbai, Delhi, and Chennai affected stock returns as per the variance equation. So, this study revealed that the investor's decisions were influenced by the temperature in India. The effect of weather variables such as temperature, humidity, cloud cover, air pressure, visibility, wind speed, thunder storms, rain, Seasonal Affective Disorder (SAD), and lunar phases on the return and volatility of six South Asian markets was studied by Shah et al. (2017). They found that Seasonal Affective Disorder (SAD) and rain had significantly positive influences on returns and reduced the volatility in the Indian markets. Whereas the temperature or size of the moon increased the volatility in the Indian stock markets. Other than SAD, there are other weather variables that are more related to stock markets than Indian stock markets. So, weather variables influenced the stock market return of the South Asian markets. Kathiravan and Sigo (2017) investigated the effects of Chennai, Mumbai, Delhi, Kolkata, and Hyderabad temperature on the return and volatility of the Indian BSE SENSEX and NSE NIFTY indices. The study showed that the temperature in all cities significantly affected the returns and volatility of the SENSEX and Nifty indices, except for the Delhi city temperature. Kathiravan et al. (2019) investigated the relationship between Delhi weather factors like humidity, temperature, and wind speed with the stock market indices like BSE SENSEX and NSE NIFTY. The correlation matrix showed that there was no relationship between the returns of weather variables and stock market indices. But Granger Causality showed that humidity causes the BSE SENSEX, whereas temperature and wind speed did not cause the BSE SENSEX. For NSE Nifty, there was no causality relationship between the selected weather variables. Eventually, the author concluded that these findings were useful for investors, speculators, and officials of stock exchanges to diversify their portfolio. Narula et al. (2021) investigated the relationship between the precipitation changes and the Indian equity returns of the Nifty 50 sectorial indices. The statistical tool correlation showed that there was an insignificant and negative correlation between the precipitation and the selected stock index return. But, the GARCH model depicted precipitation changes influencing stock index return inversely, i.e., an increase in precipitation changes resulted in less volatility of stock return and vice versa. Bajaj et al. (2019) identified the effect of the monsoon on Indian stock market volatility in returns. The study considered the Nifty 50, Nifty Smallcap 100, Nifty Midcap 100, and Nifty 500 and employed the GARCH model for analysis. The study found that there was volatility in returns

for the September month for the Nifty 50 and Nifty 500 indices, but there was no volatility in the returns of the Nifty Smallcap 100 and Nifty Midcap 100 in the month of September. The author concluded that the monsoon had an effect on the Indian stock market. Nagarajan et al. (2021) examined the impact of Indian Summer Monsoon Rainfall (ISMR) forecast announcements on Cumulative Average Abnormal Returns (CAARs) of NSE CNX 500 stocks. The study revealed that CAARs were positive for a normal forecast of ISMR and negative for a below normal ISMR forecast. Therefore, the author concluded that ISMR had a significant impact on the Indian economy and corporate performance.

The majority of the existing literature examined the impact of weather variables such as temperature, snowfall, humidity, wind speed, and cloud cover on stock market indices' returns and volatility. However, only a few studies have been conducted to examine the interrelationship between rainfall and the stock market index. In India, only a few studies on the relationship between the rainfall index and the stock market index were available. For a long time, no study has been undertaken to study the interrelationship between the rainfall index and the Nifty index. Previous research on the relationship between rainfall and the stock market index produced inconclusive results. This study envisages further investigation in order to provide conclusive proof and fill the obvious research gap.

3. Research Methodology

The objective of this paper is to examine the interrelationship between the rainfall index and the stock market index of the NSE Nifty by applying advanced statistical tools including Granger Causality and the effect of rainfall index on Nifty index volatility. The study considered the following hypotheses.

1. Ho: "There is no interrelationship between rainfall index and stock market Nifty index."
2. Ho: "The rainfall index does not Granger cause stock market Nifty index volatility."
3. Ho: "There is no effect of rainfall index on stock market volatility."

The present study used various statistical and econometrics tests like the ADF test, correlation, Granger Causality test and GARCH (1,1). The present study presumes that one rainfall index point is equal to one millimetre of rainfall.

For the purpose of analysis, the rainfall index and the closing price of the NSE Nifty index were converted into log values. The study used the Granger Causality test to know whether the rainfall index causes the Nifty index over a period of time. The number of lags used in this paper is 8 and it is based on the Vector Autoregressive (VAR) lag selection criteria. So, the study employed the following equations:

Rainfall Index with the NSE Nifty:

$$NNt=C1*RIt\text{-}i + C2*NN\ t\text{-}j + u1t$$

Where:

RI: Rainfall Index, C1: Coefficient of NSE Nifty, t-i: lag period for NSE Nifty, t-j: lag period for rainfall index, u1t: Residual for equations.

The GARCH (1,1) model is employed than the OLS regression to know the effect of rainfall index on the Nifty index (Shah et al. 2018). Because the variance of the error terms are asymmetrical or unequal i.e. data had heteroscedasticity effect. The GARCH (1,1) model

$$\sigma_t^2 = \omega + \alpha r_{t-1}^2 + \beta \sigma_{t-1}^2$$

conditional and mean equation used in this study is given below:

$$NI_t = C_0 + C_1\ NI_{t-1} + C_t\ RI_t + \varepsilon_t$$

where the ARCH term is σ^2_{t-1} and the GARCH term is σ^2_{t-1}.

NI is the Nifty index at time t and t-1, RI is the rainfall index at time t, C is the constant, "ω" is an error term and "␣" is constant

For the purpose of analysis, the study covered a period of 30 years from January 1991 to December 2020. The monthly average rainfall data covered all 36 meteorological subdivisions and these were collected from the Indian Metrological Department website http: //www.imd.gov.in. The study collected Nifty stock index data from the NSE from http://www.nseindia.com/website.

4. Empirical Results and Discussion

This section provides the results of the interrelationship between the rainfall index with the Nifty index in India for the period from 1991 to 2020. In order to know the interrelationship, study used the Descriptive Statistics, Correlation, ADF test, Granger Causality test and GARCH (1,1) model. The results of each test are presented below.

4.1. Descriptive Statistics

Table 1: Result of the Descriptive Statistics

Variables	*Rainfall Index*	*Nifty Index*
Mean	114.7198	4080.497
Median	59.43472	2787.442
Maximum	404.7500	13550.44
Minimum	1.744444	317.4500
Standard Deviation	112.1083	3511.933
Skewness	0.886427	0.821266
Kurtosis	2.383607	2.421857
Jarque-Bera	52.84431 (0.0000)	45.48244 0.0000)
Total Observations	360	360

Source: E-views output of the data sourced from IMD and NSE for 1991 to 2020

Table 1 shows the results of the descriptive statistics for the rainfall index and the Nifty index for the period from 1991 to 2020. The mean indicates the monthly average of the rainfall index and the Nifty 50 index. The above table clearly shows that the rainfall index has the lowest mean value of 114.7198 and Nifty has the highest mean value of 4080.497. The monthly minimum rainfall is 1.744444 and monthly maximum rainfall is 404.7500, whereas the monthly minimum Nifty value is 317.4500 and the maximum 13550.44 for the study period. In terms of dispersion and volatility, the rainfall index has the lowest volatility with a value of 112.1083 and Nifty index is more volatile with a value of 3511.933. It can be concluded that the higher the volatility, the higher the risk, and higher the risk, the more returns on the Nifty 50 index. The analysis of skewness clearly indicated that the Rainfall index and the Nifty index are positively skewed and fallen under the right tail with values of 0.886427 and 0.821266 respectively. The kurtosis of rainfall index and Nifty 50 index is positive with the values of 2.383607 and 2.421857. The selected variables are not normally distributed as per the computed p-values of Jarque-Bera, less than 0.05. Therefore, the results of the above descriptive statistics indicate that all the selected series are not normally distributed.

4.2. Results of ADF and PP Tests

Table 2: Result of Augmented Dickey-fuller and Phillips-Perron Test

At level							
	Augmented Dickey-Fuller Test (ADF)				*Phillips-Perron Test (PP)*		
	Critical Values	*ADF Test Statistics*	*Test Critical Values*	*Probability*	*PP test Statistics*	*Test Critical Values*	*Probability*
Rainfall index	1%	-3.165823	-3.448998	0.0229	-4.436232	-3.448363	0.0003
	5%	-3.165823	-2.869653	0.0229	-4.436232	-2.869374	0.0003
	10%	-3.165823	-2.571161	0.0229	-4.436232	-2.571011	0.0003
Nifty index	1%	0.827354	-3.448414	0.9944	1.283452	-3.448363	0.9986
	5%	0.827354	-2.869396	0.9944	1.283452	-2.869374	0.9986
	10%	0.827354	-2.571023	0.9944	1.283452	-2.571011	0.9986
At 1st Difference							
	Augmented Dickey-Fuller Test				*Phillips-Perron Test*		
	Critical Values	*ADF Test Statistics*	*Test Critical Values*	*Probability*	*PP test Statistics*	*Test Critical Values*	*Probability*
NSE Nifty	1%	-13.66306	-3.448414	0.0000	-12.94476	-3.448414	0.0000
	5%	-13.66306	-2.869396	0.0000	-12.94476	-2.869396	0.0000
	10%	-13.66306	-2.571023	0.0000	-12.94476	-2.571023	0.0000

Source: E-views output of the data sourced from IMD and NSE for 1991 to 2020

The ADF and PP tests were used to test the stationary among the selected series. Table 2 provides the results of the Unit Root Test through the ADF and PP tests for this study for the period 1991 to 2020. The null hypothesis is that the rainfall index and the NSE index have a unit root or non-stationary.

Table 2 presents the results of the ADF Unit Root Test at 1%, 5% and 10% significance levels with the respective P values. The ADF and PP test statistics values of rainfall index is greater than the test critical values at 1%, 5%, and 10% significance levels, with respect to P values less than 0.05. Therefore, rainfall index is stationary at level. The Nifty index is non-stationary at level because ADF and PP test statistics values are less than the critical values at 1%, 5% and 10% significance levels, and with respect to P values, are more than 0.05. Therefore, the null hypothesis existence unit root is rejected for the rainfall index but accepted for the Nifty index. Hence, the result shows that the Nifty index is non-stationary at its current level, i.e., the Nifty index mean and variance values are not constant over a period of time.

The results of the ADF and PP tests show that the first difference test statistics value of the Nifty index is 13.66306 and the PP test statistics value is -12.94476,

which are more than the test critical values at 1%, 5% and 10% significant level. The P values of both the tests are less than the significance level of 0.05. Therefore, the null hypothesis of the existence of a unit root is rejected. Therefore, the results show that the Nifty index is stationary at its first difference. It means the mean and variance of Nifty index are constant over a period of time at the first difference.

4.3. Results of Correlations

Correlation measures the relationship between two or more selected variables. It helps to know how one variable is related to another variable. Its value lies between +1 to -1. Table 3 displays the correlation matrix between the Rainfall index and the Nifty index for monthly data from 1991 to 2020. The correlation value for the rainfall index with the Nifty index is 0.005 at significance value of 0.925. This shows that there is no relationship between the rainfall index and Nifty index during the study period. Therefore, the null hypothesis "There is no relationship between rainfall index and NSE index" is accepted and the alternative hypothesis "There is a relationship between rainfall index and NSE index" is rejected. It means rainfall index and NSE are not correlated with each other.

Table 3: Results of Correlation between Rainfall index and Nifty index

		NSE Nifty Index
Rainfall Index	Pearson Correlation	0.005
	Sig (2-tailed)	0.925

Source: SPSS output of the data sourced from IMD and NSE for 1991 to 2020

4.4. Results of Granger Causality test

The Granger Causality test is used to determine whether past values of rainfall index time series can be used to forecast the Nifty index time series data. The results of the Granger Causality test are presented in Table 5.

Table 5: Results of Granger Causality test

Null Hypotheses	*F Statistics*	*Prob.*	*Decision*
Rainfall index does not Granger Cause Nifty Index	0.13880	0.8705	Accept

Source: E-views output of the data sourced from IMD and NSE for 1991 to 2020

The results of the Granger Causality test show that the P-value of all results is greater than the level of significance (alpha=0.05). So, we can accept the null hypotheses, namely "The rainfall index does not Granger Cause NSE Nifty Index."

We can reject the alternative hypotheses, namely "The rainfall index does Granger Cause NSE Nifty Index". It implies that the rainfall index past values can't be used to predict or forecast the NSE Nifty Index values. Therefore, finally, it can be concluded that there is no causality relationship between the Rainfall index and Nifty Indices.

4.5. Results of GARCH (1,1) Model

Table 4: Results of GARCH (1, 1) Model

Dependent Variable: Nifty Index				
GARCH (1 1)	*Co-efficient value*	*Standard Error*	***Z-Statistics***	***P-Value***
ARCH (1) α	0.130404	0.038513	3.386001	0.0007
GARCH (1) β	0.814126	0.060061	13.55503	0.0000
Rainfall Index	-0.000134	7.95E-05	-1.688634	0.0913
Total (α + β)	0.94453			

Source: E-views output of the data sourced from IMD and NSE for 1991 to 2020

Table 4 demonstrates the results of the variance equation that impacts the Nifty index volatility by employing the GARCH (1,1) model for the sample period. The results of variance equation with a probability value of 0.0913 show that the rainfall index has no influence on the NSE Nifty index volatility for the study period at a 5% significance level. Therefore, the null hypothesis "There is no effect of rainfall index on NSE Nifty index" is accepted and the alternative hypothesis "There is an effect of rainfall index on NSE Nifty index volatility" is rejected.

The total coefficient of both ARCH and GARCH terms is 0.94453 (0.130404+0.814126) and is statistically significant. It implies that a high degree of volatility exists in the Nifty index series. This explains that once new information has occurred in the market, volatility tends to be there for a long period of time in the Nifty index. It means today's volatility fully or partially depends on the volatility of the previous day and the Nifty index coefficient value does not exceed one, therefore the series is not exploding. Therefore, the Nifty index reacts to the new information and rainfall is not a factor that influences the Nifty index volatility.

5. Conclusion

In this study the interrelationship between the rainfall index and the stock market's NSE Nifty index was analysed. The results of this paper strongly support the

hypothesis that there is no interrelationship between the rainfall index and Nifty index. The rainfall index is not correlated with the Nifty index. The results of the Granger Causality test showed that there was no causality between the rainfall index and the Nifty index. This result implies that rainfall index past values can't be used to predict or forecast the Nifty index value. The study applied the GARCH (1,1) model and tested the variance equation to capture the influence of the rainfall index on Nifty index volatility. The study found that the rainfall index had no influence on the volatility of the Nifty index. This implies that both these variables are independent of each other. As a result, this rainfall index is potentially a distinct and unique asset worth considering portfolio investment strategy. Diversifying the risk of assets with uncorrelated assets helps the investor to offset the returns of one asset with the loss of other assets. The rainfall index can be considered as a new kind of asset that can be used to construct an efficient portfolio of assets.

One major limitation of the present study is that it investigated the interrelationship between the rainfall index and only Nifty. Further studies can be conducted to know the interrelationship between the rainfall index and the other stock indices or any other financial indices.

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