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Effect of Temperature on Stock Market Indices: A Study on BSE and NSE in India

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ABSTRACT

This paper investigated the effect of weather (temperature) factor, on the returns and volatility of the Indian stock indices (BSE Sensex and S&P CNX Nifty). This study examined how weather (temperature) affected the volatility of top stock market indices in India. The study used the monthly data of weather in five sample cities (Chennai, Mumbai, Delhi, Kolkata and Hyderabad) in India. This study applied statistical tools like Descriptive Statistics, ADF Test and GARCH (1, 1) model and found that the returns of sample stock market indices were influenced by weather (temperature) factor in Chennai, Mumbai, Kolkata and Hyderabad in India. But the returns of stock indices were not influenced by the temperature in Delhi City.

JEL Classifications: F65; G02; C1; C58; N2.

Keywords: Weather (Temperature) Factor, BSE Sensex, S&P CNX Nifty, Descriptive Statistics, ADF Test, GARCH (1, 1) Model and Stock Market Volatility.

1. INTRODUCTION

The temperature factor could influence the returns of the stock index, by influencing the investor mood on asset prices. The literature documents the behavioural finance evidence on the effects of mood on stock prices movement (**Yuan et al., 2011**). The psychological literature also has established that mood, feelings and emotions could affect the decision making of people (**Schwartz, 1990; Loewenstein et al., 2001**). People tend to rate their life satisfactions, much higher on sunny days than on cloudy or raining days (**Schwartz and Clore, 1983**).Psychologists have long recognised that weather conditions influence an individual's emotional state or mood, which can create the predisposition to engage in particular behaviours **(E. Howarth and M.S. Hoffman, 1984).** Mood itself can be influenced by environmental factors such as weather conditions (**Watson, 2000**). Weather affects the attitudes and moods of investors (**Hirshleifer and Shumway, 2003; Symeonidis et al., 2010**). According to behavioural finance approach, there is a relationship between the stock returns and weather. Environmental factors like rain, snow, humidity, sunny or cloudy days are considered to be significant factors, which affect the investors' mood and contribute to the investors' risk perception, to be shaped indirectly. Market anomalies in stock markets could be related to investors' trading strategies, psychological factors and environmental factors. Accordingly, it could be said that on sunny days (when there is no or very little clouds in the air), the investor tends to behave more positively and thus refrains from taking risks. In other words, it could be said that the investor keeps the risk tolerance level high on sunny days. Low temperature tends to cause only aggression, but high temperature tends to cause aggression, hysteria and apathy (**Cao and Wei, 2005**). It could be said that a person is more pessimistic on cloudy and rainy days and thus he/she tends to prefer securities, with low risks.

India has a varied climate conditions, relatively marked by high temperature and dry winters. The hot season is from March to May, the wet season is from June to October and the dry season is from November to February. Northern India remains dry, dusty, and unpleasant during the summer months. The nature of monsoon lies between mid-July and September. According to the Indian Meteorological Department (IMD), India has three different climate conditions, namely, winter, summer and monsoon. The Indian Meteorological Department (IMD) divides a year into four sessions, namely, winter, pre-monsoon, south-west and post monsoon season.

2. REVIEW OF LITERATURE

There are many scientific research studies, identifying the volatility of stock market indices and effect of weather (temperature) on the returns of the stock. The select literature, relating to weather (Temperature) on stock exchange index return, is briefly reviewed below.

Melanie Cao and Jason Wei (2004) studied the impact of temperature on stock returns, covering eight financial markets, located in US, Canada, Britain, Germany, Sweden, Australia, Japan and Taiwan. The study applied Run test and Regression analysis. The results indicated that lower temperature could cause antagonism while higher temperature could cause laziness. According to **Tsangyao Chang, et al (2005),** there were relationships between weather factors and stock market returns in Taiwan, using daily data. It was found that the temperature recorded strong threshold effects on stock market returns and stock returns tended to be lower when the weather was extremely hot or extremely cold. **Michael Dowling and Brian M. Lucey (2005)** found evidence for a relationship between eight proxy variables for investor mood (based on the weather, biorhythms, and beliefs) and daily Irish stock returns. The study found that irrelevant mood states, such as mood states caused by the weather, biorhythms, and belief-based factors,

affected the pricing of Irish equities. **Ori Levy and Itai Galili (2007)** investigated the influence of weather differences affects individuals' humours, and three subgroups of investors (Male, young, and poor) were found to be more likely to be net buyers of equity on cloudy days. **Seong Min Yoona and Sang Hoon Kang (2008)** analysed the relationship between stock returns and the weather variables of temperature like humidity and cloud cover, in the Korean stock market. The study found nonexistence of weather effects on the stock returns, after the crisis period. **Shao-Chi Chang et al (2008)** re-examined the relation between weather in New York City and intraday returns and trading patterns of NYSE stocks. It was found that stock returns were generally lower on cloudier days, and cloud cover has a significant influence on stock returns. **Christiane Goodfellow et al (2010)** examined the weather effects on the liquidity of a screen-based electronic stock in Germany. More clouds in the sky lower were the execution costs and higher the liquidity. **Yuan Ming Lee and Kuan Min Wang (2011)** analysed the linkage between the cloud cover and stock returns in Taiwan, in the whole sample period (1986 to 2007) and in the two sub-sample periods (1986 to 1996 and 1997 to 2007). The study examined the transition of the sunshine effect and found that cloud cover recorded significant negative impact on Taiwan's stock market, especially in the low cloud cover periods. **Lazaros Symeonidis et al (2010)** examined the relationship between the empirical association between stock market volatility and investor mood-proxies related to the weather and the environment (nighttime length). The study found that SAD and cloudiness were negatively associated with various measures of stock market volatility. **Gülfen Tuna (2014)** examined the effect of weather on Istanbul Stock Exchange (ISE). This study found that it was not possible for the investors in ISE, to develop trading strategy, by looking humidity at and cloudiness levels and thus obtaining profits above the normal level.

The literature reviewed revealed that there was no extensive study on the effect of temperature on stock market indices and volatility in India. Hence the present study is a step forward, towards the research dealing with the volatility of weather (temperature) and stock Indices in India.

3. RESEARCH METHODS

3.1. Objectives of the Study

The main objectives of this study were to examine the effect of weather (temperature) factor on the return of the stock index. The sub-objectives of the study are given below.

1. To test the normality of sample indices and weather (temperature) factor over the sample period.
2. To examine the stationarity of sample indices and weather (temperature) factor over the sample period.
3. To investigate the dynamics of the time-varying volatility between sample indices and weather (temperature) factor over the sample period.

3.2. Hypotheses of the Study

The present study tested the following three null hypotheses.

1. **NH01:** There is no normality in the monthly data of sample indices and weather (temperature) in five sample cities.

2. **NH02:** There is no stationarity in the monthly data of sample indices and weather (temperature) in five sample cities.
3. **NH03:** There is no volatility in the monthly data of sample indices and weather (temperature) in five sample cities.

4. DATA SOURCE AND ESTIMATION TECHNIQUES

4.1. Sample Selection

The present study proposes to investigate the effect of temperature factor on the returns and volatility of sample stock indices in India. To represent India, five metro cities, namely, Chennai, Bombay, Kolkata, Delhi, and Hyderabad were selected. Similarly, only one top stock index from the two sample stock exchanges, namely, SENSEX from Bombay Stock Exchange (BSE) and S&P CNX Nifty from National Stock Exchange (NSE), were selected as sample indices.

4.2. Sources of data

For the purpose of analysis, the study used monthly data of two stock indices, namely, BSE SENSEX, collected from **http: www.bseindia.com** and for S&P CNX NIFTY, from **http:www.nseindia.com.** Similarly**,** the data relating to weather (Temperature) in five metro cities of India (Chennai, Bombay, Calcutta, Delhi, and Hyderabad) were collected from Indian Metrological Department**-www.imd.gov.in**.

4.3. Period of Study

This research study covered a period of 15 years *i.e.*, from January 2000 to December 2015, for the purpose of the analysis of this study.

4.4. Tools used for Analysis

The following tools were used for analysis.

1. Descriptive Statistics (to find out the normal distribution of sample indices and weather (temperature) in five sample cities)
2. ADF Test (to experiment the stationarity among the sample indices and weather (temperature) in five sample cities)
3. GARCH (1,1) Model (to investigate the volatility among the sample indices and weather (temperature) in five sample cities)

5. LIMITATIONS OF THE STUDY

This study suffered from following limitations

1. Only two indices, namely, SENSEX from Bombay Stock Exchange and S&P CNX Nifty from National Stock Exchange, were selected as the sample.
2. The study was limited to weather (temperature) factor only in five metro cities of India.
3. The study was only based on secondary data.
4. The limitations, associated with various statistical tools, may also apply to this study.

6. ANALYSIS OF EFFECT OF WEATHER (TEMPERATURE) ON SAMPLE INDICES

For the purpose of the study, the analysis of Normality, Stationarity and Volatility of the Weather (Temperature) on the sample Indices, is presented as follows

1. Normality (Descriptive Statistics) for the sample indices and sample cities in respect of Weather (temperature) Factor in India.
2. Stationarity for sample indices and sample cities in respect of Weather (temperature) in India, and
3. Volatility for sample indices and sample cities in respect of Weather (temperature) in India.

6.1. Analysis of Normality (Descriptive Statistics) for the Sample Indices and Sample Cities in respect of Weather (Temperature) Factor in India

Table 1
Results of Descriptive Statistics for Sample Indices and Weather (Temperature) Factor in major cities in India during the Study Period

Descriptive Statistics / *Samples*	*Chennai TEMP*	*Delhi TEMP*	*Hyderabad TEMP*	*Kolkata TEMP*	*Mumbai TEMP*	*NSE*	*BSE*
Mean	0.00375	0.01614	0.00307	0.00365	0.00547	0.01274	0.01288
Median	0.00313	-0.01749	0.00334	-0.01405	-0.00297	0.01405	0.01095
Maximum	0.20415	0.81000	0.27893	0.25368	1.39286	0.28066	0.28255
Minimum	-0.20109	-0.36813	-0.26298	-0.17572	-0.54984	-0.26410	-0.23890
Std. Dev.	0.06339	0.18200	0.08180	0.08923	0.12379	0.07016	0.06873
Skewness	0.07778	0.99769	0.08515	0.79854	0.7380	-0.25658	-0.15818
Kurtosis	3.1056	4.6426	3.9070	3.2402	9.1000	4.8799	4.6338
Jarque-Bera	5.265	50.098	6.388	19.563	59.110	28.481	20.772
Probability	0.0475	0.0000	0.0410	0.0001	0.0000	0.0000	0.0000
Observations	180	180	180	180	180	180	180

Source: Compiled from NSE, BSE and IMD and Computed using E-Views -7

Note: TEMP- Temperature

The results of descriptive statistics, for sample indices and weather (temperature) factor, in top five metro cities of India, during the study period from January 2001 and December 2015, are presented in **Table – 1.** For the purpose of the analysis, the monthly data, relating to two sample indices (BSE Sensex and S&P CNX Nifty) and monthly data of weather (temperature) in five major cities of India (Chennai, Delhi,

Hyderabad, Kolkata, and Mumbai), were compared**.** The Table clearly shows that there were positive mean returns, earned by all sample stock indices, due to weather (temperature), in five metro cities of India. The mean value of temperature at Delhi metro city was found to be the highest **(0.01614),** among all five sample cities. The lowest mean average value of temperature in Delhi was found to be at 0.00307, during the study period. It is to be noted that out of five sample metro cities, Delhi earned the highest standard deviation of 0.18200 on temperature while Mumbai earned the lowest standard deviation value of 0.12379. It is inferred from the analysis that there was high risk (0.18200) with high return (0.01614), in respect of temperature in Delhi, among the sample cities considered for this study. According to the analysis of skewness, sample cities, namely, Chennai, Delhi, Hyderabad, Kolkata, and Mumbai, and sample indices, namely, SENSEX and NIFTY, were skewed significantly, with values of 0.07778, 0.99769, 0.08515, 0.79854, 0.7380, -0.25658 and -0.15818 respectively. It is to be noted that the values of Skewness were found in between -1 to +1. The level of kurtosis was positive for all sample cities and stock indices, in respect of weather (temperature) and the kurtosis values were 3.1056 for Chennai, 4.6426 for Delhi, 3.9070 for Hyderabad, 3.2402 for Kolkata, 9.1000 for Mumbai, 4.6338, for SENSEX and 4.8799 for NIFTY during the study period. This confirmed the fact that there was a normal distribution of monthly data of sample indices and weather (temperature), in five cities, during the study period. Hence the null hypothesis (**NH01), "There is no normality in the monthly data of sample indices and monthly data of weather (temperature) in five cities over the sample period from January, 2001 to December, 2015",** is rejected.

6.2. Stationarity for sample indices and sample cities in respect of Weather (Temperature)

The results of Augmented Dickey Fuller (ADF) Test, for sample indices and cities in respect of weather (Temperature) factor during the study period, from January 2001 to December 2015, are presented in **Table-2.** The Augmented Dickey Fuller (ADF) Test was used to test the stationarity, for the monthly data of sample indices (SENSEX S&P CNX Nifty) and monthly weather data in sample cities (Chennai, Bombay, Calcutta, Delhi, and Hyderabad), during the study period. It is to be noted that test critical values, for all sample indices and weather (temperature) in five sample cities, were analysed at significant levels of 1%, 5% and 10%. The probability value for all the sample indices and weather (Temperature) factor in five cities, was at 0.000000, during the study period. The analysis of the Table clearly indicates that the statistical values for all sample indices were at -12.0399 for SENSEX and -12.5632 for NIFTY and weather (temperature) values were at -10.6004 for Chennai, -12.1171 for Delhi, -8.92315 for Hyderabad,-18.7754 for Kolkata, and -17.5322 for Mumbai. The statistical values, for all the sample indices and weather (Temperature) data for five sample cities of sample indices, were less than that of test critical values at 1%, 5% and 10% significant levels, during the study period. Besides, the returns data, for all the sample indices and weather (Temperature) data at sample cities, indicated stationarity. The overall analysis of the ADF Test clearly confirmed that there was stationarity, in the returns data of sample indices and weather (temperature) data for five sample cities. Hence the null hypothesis (**NH02)** namely **"There is no stationarity in the data of sample indices and weather (Temperature) data in five sample cities over the sample period from January 2001 to December 2015",** is rejected.

Table 2
Results of Augmented Dickey-Fuller (ADF) Test for Sample Indices and Weather (Temperature) Factor during the study period

Chennai (TEMP)/Level		*t-Statistic*	*Prob.**
ADF Test Statistic		-10.6004	0
Test critical values	1%	-3.46898	0
Test critical values	5%	-2.87841	0
Test critical values	10%	-2.57584	0
Delhi (TEMP)		*t*-Statistic	Prob.*
ADF Test Statistic		-12.1171	0
Test critical values	1%	-3.46898	0
Test critical values	5%	-2.87841	0
Test critical values	10%	-2.57584	0
Hyderabad (TEMP)		*t*-Statistic	Prob.*
ADF Test Statistic		-8.92315	0
Test critical values	1%	-3.46875	0
Test critical values	5%	-2.87831	0
Test critical values	10%	-2.57579	0
Kolkata (TEMP)		*t*-Statistic	Prob.*
ADF Test Statistic		-18.7754	0
Test critical values	1%	-3.46921	0
Test critical values	5%	-2.87852	0
Test critical values	10%	-2.5759	0
Mumbai (TEMP)		*t*-Statistic	Prob.*
ADF Test Statistic		-17.5322	0
Test critical values	1%	-3.46699	0
Test critical values	5%	-2.87754	0
Test critical values	10%	-2.57538	0
S&P CNX Nifty		*t*-Statistic	Prob.*
ADF Test Statistic		-12.5632	0
Test critical values	1%	-3.46699	0
Test critical values	5%	-2.87754	0
Test critical values	10%	-2.57538	0
BSE SENSEX		*t*-Statistic	Prob.*
ADF Test Statistic		-12.0399	0
Test critical values	1%	-3.46699	0
Test critical values	5%	-2.87754	0
Test critical values	10%	-2.57538	0

Source: Compiled from NSE, BSE and IMD Computed using E-Views -7

Note: Critical Value at 1%, 5% and 10% level of significance

6.3. Volatility for sample indices and sample cities in respect of Weather (Temperature) in India

Table-3 shows the results of volatility, using GARCH (1, 1) Model, for sample indices (S&P CNX Nifty and BSE SENSEX), caused by the volatility of monthly weather (temperature) data in Chennai during the study period from January 2001 to December 2015. The probability value of temperature was at 0.012 while the return of Nifty and Sensex were at 0.004 and 0.000, during the study period. As the probability value of 0.012 was not higher than 0.5, it is inferred that the weather (temperature) factor in Chennai did not influence the return volatility of sample indices during the study period. The result of volatility, using GARCH (1, 1) Model, for Delhi weather (temperature) on the movements of two sample indices (CNX Nifty and BSE SENSEX) are given in **Table 4.** The analysis of probability value, with 0.4168 for temperature, 0.004 for CNX Nifty and 0.000 for BSE SENSEX, clearly revealed that weather (temperature) in Delhi city did influence the monthly return volatility of two sample indices, during the study period. **Table-5** brings out the results of volatility, using GARCH (1, 1) Model, for sample indices (S&P CNX Nifty and BSE SENSEX) and monthly weather (temperature) data of Hyderabad, during the study period from January 2001 to December 2015. The analysis value of temperature and two stock indices, with the probability values of 0.001, 0.004 and 0.000 respectively, revealed that the weather (temperature) in Hyderabad city did not influence the volatility of sample indices return, during the study period. The results of volatility, using GARCH (1, 1) Model, for Kolkata weather (temperature) on the volatility returns of sample indices, namely, S&P CNX Nifty and BSE SENSEX, are given in **Table-6.** The analysis with the probability values of 0.003, 0.004 and 0.000 for the temperature of Kolkata and CNX Nifty and BSE SENSEX, clearly established that weather (temperature) in Kolkata city did not influence the volatility returns of indices, during the study period. **Table-7** reveals the results of volatility using GARCH (1, 1) Model, for Mumbai weather (temperature) on the volatility returns of sample index, namely, S&P CNX Nifty and BSE SENSEX during the study period. The analysis of probability value of 0.003 for the temperature at Mumbai, 0.004 for CNX Nifty and 0.000 for BSE SENSEX shows that monthly weather (temperature) in Mumbai city did not influence the returns of sample indices during the study period. **Tables (3 to 7)** clearly displays that out of five cities, the $\alpha+\beta$ values for the four sample metro Cities, namely (Chennai-0.012, Hyderabad-0.001, Kolkata-0.003 and Mumbai-0.003), were very close to the value of one but Delhi did earn only a value of 0.4168. The results of GARCH, a model for all the four individual sample metro cities, taken for this study, were compared with the returns of the volatility of BSE and NSE. According to the analysis of GARCH (1.1) Model, the $\alpha+\beta$ value for Hyderabad city was very close to one (0.96386). This indicated the fact that the volatility in the market indices returns was high during the study period. Hence, the Null Hypothesis (**NH03**): **"There is no volatility of in the market indices and weather (Temperature) in five cities over the sample period from January 2001 to December 2015",** is rejected.

6.4. Result of Volatility using GARCH (1, 1)

This segment deliberates the results of Garch (1, 1) in respect of impact of weather (temperature) on index return in India. The sample indices selected are CNX Nifty and BSE SENSEX while temperature in five metropolitans namely Chennai, Delhi, Hyderabad, Kolkata, and Mumbai were studied.

Table 3
Impact of Chennai Weather (Temperature) on the Return of Sample Indices

Sample city and Index	*Values of GARCH (1, 1) Model*				
	C	*A*	*B*	α + β	*P*
Chennai TEMP	0.000396	-0.05812	0.956109	0.89799	0.012
NIFTY	0.000875	-0.18545	0.880444	0.69499	0.004
SENSEX	-0.000008	0.093352	0.907137	1.00049	0.000

Source: Compiled from NSE, BSE and IMD and Computed using E-Views -7

Note: C – Coefficient; a – Alpha; β – Beta; P – Probability

Table 4
Impact of Delhi Weather (Temperature) on the Return of Sample Indices

Sample city and Index	*Values of GARCH (1, 1) Model*				
	C	*A*	*B*	α + β	*P*
Delhi TEMP	0.017395	-0.05231	0.525295	0.47299	0.4168
NIFTY	0.000875	-0.18545	0.880444	0.69499	0.004
SENSEX	-0.000008	0.093352	0.907137	1.00049	0.000

Source: Compiled from NSE, BSE and IMD and Computed using E-Views -7

Note: C – Coefficient; a – Alpha; β – Beta; P – Probability

Table 5
Impact of Hyderabad Weather (Temperature) on the Return of Sample Indices

Sample city and Index	*Values of GARCH (1, 1) Model*				
	C	*A*	*B*	α + β	*P*
Hyderabad TEMP	0.00027	0.055023	0.908837	0.96386	0.001
NIFTY	0.000875	-0.18545	0.880444	0.69499	0.004
SENSEX	-0.000008	0.093352	0.907137	1.00049	0.000

Source: Compiled from NSE, BSE and IMD and Computed using E-Views -7

Note: C – Coefficient; a – Alpha; β – Beta; P - Probability

Table 6
Impact of Kolkata Weather (Temperature) on the Return of Sample Indices

Sample city and Index	*Values of GARCH (1, 1) Model*				
	C	*A*	*B*	α + β	*P*
Kolkata TEMP	0.001192	-0.08546	0.935276	0.84982	0.003
NIFTY	0.000875	-0.18545	0.880444	0.69499	0.004
SENSEX	-0.000008	0.093352	0.907137	1.00049	0.000

Source: Compiled from NSE, BSE and IMD and Computed using E-Views -7

Note: C – Coefficient; a – Alpha; β – Beta; P – Probability

Table 7
Impact of Mumbai Weather (Temperature) on the Return of Sample Indices

Sample city and Index	*Values of GARCH (1, 1) Model*				
	C	*A*	*B*	α + β	*P*
Mumbai TEMP	0.001192	-0.08546	0.935276	0.84982	0.003
NIFTY	0.000875	-0.18545	0.880444	0.69499	0.004
SENSEX	-0.000008	0.093352	0.907137	1.00049	0.000

Source: Compiled from NSE, BSE and IMD and Computed using E-Views -7

Note: C – Coefficient; a – Alpha; β – Beta; P – Probability

7. CONCLUSION

Temperature is one of the important weather variables, affecting the mood of investors across the Globe (**Kamstra et al., 2003 and Saunders, 1993**). According to **Chang et al. (2006),** weather (temperature) created an impact on investors' behaviour, with regard to the stock market operation. Besides, the stock market returns are associated with temperature effect and bad weather was directly related to market volatility (**Symeonidis et al., 2010**). This study investigated the effect of weather (temperature) factor on the returns and volatility of Indian stock indices (BSE Sensex and S&P CNX Nifty). In five sample cities, two major stock indices (BSE Sensex and S&P CNX Nifty) were normally distributed and also attained stationary. Under the ADF, probability (P- Value) was less than 0.05. In addition, the result of GARCH (1, 1) showed that the temperature in all the sample cities, expect Delhi (Temperature), was significantly volatile. It was found that weather (temperature) factor exercised an effect on the returns and volatility of the stock market, indices in India. In other words, the temperature conditions affected investors' decisions making, which may influence the stock returns and volatility. The overall analysis shows that prediction of market movement, by taking temperature as the basis, was not perfectly possible. In this case, it could be said that Indian stock market experienced mixed effect temperature. At the same time, there was evidence that the stock market in India was efficient in a weak form. As a result, it is not possible for the investor in India, to develop a clear trading strategy, by looking at the results of temperature and obtaining profit above normal level, the process The results of this study affirmed the findings of **Vijayakumar et al., (2015)**, who found that there were effects of temperature on stock market indices. But the finding of this study contradicted the results of **Christors Florous (2008)** who found a negative effect of daily temperature on the stock market returns of Belgium (Brussels).

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