

AN EMPIRICAL INVESTIGATION OF THE INTER-LINKAGES OF STOCK RETURNS AND THE WEATHER AT THE INDIAN STOCK EXCHANGE

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ABSTRACT

This paper investigated the effect of three weather factors (temperature, humidity and wind speed), on the returns of the Indian stock indices (BSE Sensex and S&P CNX Nifty). This study examined how weather affected the Movement and relationship 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. Statistical tools like Descriptive Statistics, Correlation Matrix and Granger Causality Test were used for the analysis. This study found that the temperature influenced the investors' mood in Bangalore, in respect of BSE Sensex and Kolkata & Mumbai, in respect of CNX Nifty and Humidity influenced Mumbai, in respect of CNX Nifty.

Keywords: Weather Factor, BSE Sensex, S&P CNX Nifty, Descriptive Statistics, Correlation Matrix, Granger Causality Test.

INTRODUCTION

The traditional finance studies suggest that financial markets move rationally and they are based on economic fundamentals. But psychological factors also influence the investment decisions and the mood of people significantly affects the decisions they make (Saunders, 1993; Hirshleifer & Shumway, 2003). It is well-known that weather effect is closely related to investors' mood and sentiments. Weather conditions affect an individual's emotional state or mood, which obstructs the people from making optimal or rational decisions. If the existence of weather effect affects the investors' decision making, various weather conditions might influence the movement of stock returns. The weather was extensively understood to influence people's mood. Good or bad weather, in the regions in which investors' trade, could be affected by their moods. Howarth & Hoffman (1984); Lucey & Dowling (2005) viewed that the returns may increase or decrease, according to the weather conditions. Many psychological studies confirmed the fact that depending on the mood, the individuals were more predisposed to either pessimistic or optimistic expectations (Arkes & Isen, 1988; Etzioni, 1988; Romer, 2000). Some economists (Lucey & Dowling, 2005) argued that the investors may not always act rationally when they make decisions in the economic market. Investors' psychological movements may affect their decisions (Bell & Baron, 1976; Allen & Fischer, 1978). Over the recent years, many researchers in behavioral finance have put their efforts to investigate the psychological factors that influence

the investors' evaluation of securities. These psychological factors are related to mood fluctuations, induced by weather. (Kamstra, Kramer & Levi, 2003) investigated the relations between stock market returns and current weather conditions and the study found the 'sunshine effect', which is a negative correlation between cloudiness and stock market return. Predictability of stock returns was important for practitioners and academicians in finance since it has important implications for market efficiency, which, in turn, helps to produce more realistic asset pricing models (Rapach & Zhou, 2013; Neely, Tu, Rapach & Zhou, 2014). The market openness and globalization increased the proportion of foreign investors in local stock markets, which could weaken the weather effects in markets. With the development of electronic-trading system, the communication technology, arbitrageurs could make international portfolio strategies, using program trading. This development could also weaken the weather effects and make stock market more efficient.

REVIEW OF LITERATURE

An attempt has been made, to review the earlier research works, undertaken in the area of stock markets and weather factors, to understand research gaps, tools used and findings of earlier studies.

Table 1 CORRELATION BETWEEN STOCK RETURNS AND THE WEATHER AT THE INDIAN STOCK EXCHANGE					
Sl. No	Authors and year	Period of the Study	Tools used for Analysis	Samples and Inputs	Findings of the study
	David & Tyler (2003)	1982 to 1997	Descriptive Statistics, Correlation Coefficient and OLS Regression Analysis.	Tokyo, Hong Kong, Seoul, Lisbon, Mexico City, Toronto, Jakarta, Frankfurt and Wellington and daily weather data (temperature humidity, cloud cover and sunshine).	This paper studied the relationship between morning sunshine in the city of a country's leading stock exchange.
	Stephen & Melvin (2005)	1980 to 2002	Regression Analysis and Diagnostic tests.	Weather data (temperature, humidity and cloud cover) and Bank bills, Government bonds, Stock indices.	The influence of weather on the interest rates of bank bills and Government bonds and the returns of stock indices was studied. It is found that bank bills were positively influenced by sunshine while stock indices were negatively influenced by wind factor.
	Melanie & Jason (2005)	1962 to 2001	Descriptive Statistics. Bin-test, Regression Analysis.	Eight financial markets (US, Canada, Britain, Germany, Sweden, Australia, Japan and Taiwan) and temperature data of eight countries.	There was negative correlation between temperature and stock market returns.
	Michael &	1988	Descriptive statistics,	Irish Stock Exchange Official	This study examined

	Brian (2005)	to 2001	Regression analysis.	Price Index and Weather data (cloud cover, precipitation and humidity).	relationship between investor mood (based on the weather,) and Irish stock returns.
	Tsangyao et al. (2006)	1997 to 2003	Descriptive Statistics, Unit Root Tests, GJR-GARCH and Threshold Model.	Weather data (temperature, humidity and cloud cover) in Taipei city and daily closing index of the Taiwan stock market.	This study examined the relationships between weather factors and stock market returns. It is found that temperature and cloud cover were two important weather factors that affected the stock returns in Taiwan.
	Michael & Brian (2008)	1994 to 2004	GARCH Model and Regression Analysis.	Weather data (precipitation, temperature, wind, geomagnetic storms) and biorhythm data (seasonal affective disorder, daylight savings time changes, lunar phases).	This study investigated the relationship between seven variables and a global equity dataset. It is found that seasonal affective disorder and low temperatures showed the greatest relationship with equity pricing.
	Ori & Itai (2008)	1998 to 2002	Descriptive Statistics, Regressions Analysis.	3282 individual accounts from Israel's largest commercial banks (New Israeli Shekel (NIS)).	The relationship between Stock purchase and the weather was examined. It is found that lack of sunlight influenced people's moods.
	Shao-Chi (2008)	1994 to 2004	Descriptive Statistics, Regressions Analysis.	New York Stock Exchange (NYSE), The weather data of New York City.	This work studied the relation between weather and intraday returns and trading patterns of NYSE stocks. The weather significantly influenced the investors' intraday trading behavior.
	Seong-Min & Sang (2009)	1990 to 2006	Descriptive Statistics, Unit root tests and ARCH GJR-GARCH.	Korea Composite Stock Price Index 200 (KOSPI 200) and daily weather data (temperature, humidity and cloud cover).	This study examined the relationship between stock returns and the weather variables of temperature, humidity and cloud cover in the Korean stock market.
	Sang et al. (2009)	1999 to 2008	Descriptive Statistics, Linear Regression models, GARCH (1, 1) model.	Hong Kong Exchange (HSI), Shenzhen Exchange (SSE), SSE A-Share Index (SZZA) and daily weather data (temperature humidity, cloud cover and sunshine).	This study examined the weather effects on returns of the Hong Kong Exchange and the Shenzhen Exchange, There was no weather effect in the post opening period.
	Manfred & Leopold (2015)	2002 to 2006	Descriptive Statistics, Correlations and Regressions analysis.	Daily data from the US market-New York Stock Exchange and daily weather data (temperature, humidity and cloud cover).	This paper studied the relationship between weather affective disorder and the financial market.
	Nikolaos et al. (2016)	2009 to	Descriptive Statistics,	Dow Jones Sustainability Europe Index and wind and	It is found that not only do changes in humidity and

		2014	Autocorrelation, GARCH model, TGARCH (1, 1), GJR-GARCH (1, 1).	humidity.	wind levels seem to affect positively the European stock market but changes in returns oil and gold prices as well.
	Nicholas & Rangan (2017)	1973 to 2015	Descriptive statistics, Pearson Correlation Coefficients, Regressions, GARCH.	New York Stock returns, South African Stock Returns and Weather data (temperatures, humidity, wind speed, rainfall/precipitation and cloud cover).	This study identified the impact of weather conditions observed in New York on stock market returns.
	Chinnadurai & Sigo (2017)	2000 to 2015	Descriptive Statistics, ADF Test and GARCH (1, 1) Model.	BSE SENSEX, S&P CNX NIFTY and weather (Temperature) in five metro cities of India (Chennai, Bombay, Calcutta, Delhi and Hyderabad).	This study examined the Temperature effects on returns of the Indian stock indices. It is found that Chennai, Mumbai, Kolkata and Hyderabad temperature influenced the investor's mood.

The review of earlier studies clearly reveals the fact that there was no comprehensive study, exclusively covering the correlation between stock returns and the weather, at the Indian Stock Exchange (Table 1). This research, on this subject, could help the policy makers and the investors, to easily identify the riskless weather condition and their diversification strategy for investments. It is an attempt to fill the gap of research on the Stock Returns and the Weather Conditions.

NEED AND IMPORTANCE OF THE STUDY

This research study is important because Indian Subcontinent attracts more number of portfolio investments compared to other Asian markets. The present study examined the interlinkages of three weather factors (temperature, humidity and wind speed), on the returns of the Indian stock indices (namely BSE Sensex and S&P CNX Nifty). Research in this area of weather factor and stock market has been mainly undertaken in the US, Europe and UK, where data are more available. A limited number of researches have been conducted examining the weather effect on the Indian capital market; moreover, none of the studies address causation. Which motivated to take a deeper look into seasonality in Indian stock markets? This study would help the investors make their investment decision strategy in Indian stock indices. The present study would be useful to the investors could formulate profitable trading strategies if they were able to predict the share price behavior with full information on these weather factors.

OBJECTIVES OF THE STUDY

The main objective of this study was to examine, the linkages and relationship among the sample indices (BSE Sensex and CNX Nifty) and weather factors (Temperature, Humidity and Wind speed), over the sample period.

HYPOTHESES OF THE STUDY

- NH₁: There is no normal distribution among the sample indices and weather factors in five sample cities.*
- NH₂: There is no co-relation between the sample indices and weather factors in five sample cities.*
- NH₃: There is no causal relationship among the sample indices and weather factors in five sample cities.*

METHODOLOGY OF THE STUDY

Period of Study

For the purpose of examining the linkages and relationship among the sample indices (BSE Sensex and CNX Nifty) and weather factors (Temperature, Humidity and Wind speed)), the study covered a period of 16 years, from January 1, 2001 through December 31, 2016 (Chinnadurai, Sankaran, Kasilingam & Sigo, 2017).

Sample Design

In order to examine the linkages and relationship among the sample indices and weather factors, the study identified two Stock Market Indices, namely, BSE Sensex and CNX Nifty and three weather variables, namely, Temperature, Humidity and Wind Speed.

Sources of Data

For the purpose of analysis, the study used daily 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 factors, in five metro cities of India (Bangalore, Chennai, Delhi, Mumbai and Kolkata), were collected from Indian Metrological Department-www.imd.gov.in

TOOLS USED FOR ANALYSIS

The following tools were used for the analysis.

1. Descriptive Statistics (to find out the normal distribution of returns of sample indices and weather factors in five sample cities).
2. Correlation Matrix (to find the correlation between sample indices and weather factors in five sample cities)
3. Granger Causality Test (to examine the linkage among the sample indices and weather factors in five sample cities).

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 three weather factors (temperature, humidity and wind speed) and only in five metro cities (Bangalore, Chennai, Delhi, Kolkata and Mumbai) of India.
3. The study was based only on secondary data.
4. The limitations, associated with various statistical tools, may also apply to this study.

ANALYSIS OF EFFECT OF WEATHER ON SAMPLE STOCK MARKET INDICES

For the purpose of the study, the analysis of Normality, Pearson Correlation and Granger Causality, for the returns of Sample Indices and returns of Weather factors, is presented as follows:

1. Analysis of Normality for the returns of Sample Indices and weather factors in Sample Cities in India,
2. Analysis of Pearson Correlation for the returns of Sample Indices and weather factors in Sample Cities in India
3. Analysis of Granger Causality for the returns of Sample Indices and weather factors in Sample Cities in India.

Analysis of Normality for the returns of Sample Indices and Weather Factor in Sample Cities in India

The results of descriptive statistics, for the returns of sample indices and weather factors (temperature, humidity and wind speed), in top cities of India (Bangalore, Chennai, Delhi, Kolkata and Mumbai), during the study period from 1st January 2001 to 31st December 2016, are presented in Table 2. For the purpose of the analysis, the daily data, relating to sample two indices (BSE Sensex and NSE S&P CNX NIFTY) and daily data of weather factors, in five major cities of India, were compared. The Table clearly shows that there were positive mean returns, earned by two sample indices, against three weather factors, in five metro cities of India. The mean value of temperature, at Delhi Metro City was found to be the highest (0.005925), among all five sample cities, considered for this study. Similarly, the mean value of humidity, at Delhi Metro City, was found to be the highest (0.019858), among all five sample cities. But the mean value of Wind Speed, at Kolkata City, was found to be the highest (0.184436), among all five sample cities, during the study period. It is to be noted that the mean value, in respect of two sample indices, showed positive sign and it indicated the fact that both the indices (BSE Sensex and NSE S&P CNX Nifty) and weather factors (temperature, humidity and wind speed), in five major cities of India (Bangalore, Chennai, Delhi, Kolkata and Mumbai), earned high return, during the study period. The analysis of standard deviation clearly indicated that the Capital City of India, namely Delhi, earned the highest standard deviation value of 0.120873, for temperature while the South Indian business city, namely, Chennai, earned the lowest standard deviation value of 0.037435, during the study period. It is interesting to note that the Indian Capital City namely, Delhi also earned the highest standard deviation of 0.217686, for humidity while the highest value of 1.159937, for wind speed, was earned by Kolkata. According to the analysis of skewness, five sample cities, namely, Bangalore, Chennai, Delhi, Kolkata and Mumbai and the two sample indices, namely, SENSEX and NIFTY, were skewed significantly. It is to be noted that the values of skewness, for all sample cities, were found between -1 to +1. But the level of kurtosis was positive for all sample cities and stock market indices during the study period. The overall analysis confirmed the fact that there was a normal distribution of daily return data of sample indices against the weather factors (temperature, humidity and wind speed), in five cities, during the study period. Hence the null hypothesis (NH₁), "There is no normality in the daily

return data of sample indices and weather factors (temperature) in five cities over the sample period from 1st January, 2001 to 31st December, 2016”, is rejected.

Table 2
RESULTS OF DESCRIPTIVE STATISTICS OF STOCK MARKET INDICES AND WEATHER FACTORS FOR METRO CITIES IN INDIA FROM 1st JANUARY 2001 TO 31st DECEMBER 2016

		NIFTY	SENSEX	TEMPERATURE	HUMIDITY	WIND_SPEED
Bangalore	Mean	0.000583	0.000587	0.000885	0.008673	0.120123
	Std. Dev.	0.014787	0.01471	0.04271	0.133574	0.718762
	Skewness	-0.024474	0.099713	0.021995	0.992702	6.521538
	Kurtosis	13.08238	12.12199	4.438427	7.618707	82.91203
	Jarque-Bera	16875.01	13819.59	342.5789	4180.787	1084481
	Probability	0	0	0	0	0
	Observations	3984	3984	3984	3984	3984
Chennai	Mean	0.000583	0.000587	0.000696	0.003758	0.08018
	Std. Dev.	0.014787	0.01471	0.037435	0.088684	0.651228
	Skewness	-0.024474	0.099713	0.022353	0.696058	14.40649
	Kurtosis	13.08238	12.12199	6.080793	5.704478	353.9133
	Jarque-Bera	16875.01	13819.59	1575.885	1535.863	20579074
	Probability	0	0	0	0	0
	Observations	3984	3984	3984	3984	3984
Delhi	Mean	0.000583	0.000587	0.005925	0.019858	0.108496
	Std. Dev.	0.014787	0.01471	0.120873	0.217686	0.588785
	Skewness	-0.024474	0.099713	9.320177	2.394425	3.724069
	Kurtosis	13.08238	12.12199	293.2552	19.23257	36.43255
	Jarque-Bera	16875.01	13819.59	14042861	47547.26	194752.9
	Probability	0	0	0	0	0
	Observations	3984	3984	3984	3984	3984
Kolkata	Mean	0.000583	0.000587	0.00144	0.005624	0.184436
	Std. Dev.	0.014787	0.01471	0.056889	0.105934	1.159937
	Skewness	-0.024474	0.099713	0.053305	1.017094	18.8108
	Kurtosis	13.08238	12.12199	5.188328	8.616909	683.9603
	Jarque-Bera	16875.01	13819.59	793.0239	5895.887	76842090
	Probability	0	0	0	0	0
	Observations	3984	3984	3984	3984	3984
Mumbai	Mean	0.000583	0.000587	0.000872	0.009326	0.035966
	Std. Dev.	0.014787	0.01471	0.040293	0.146634	0.295511
	Skewness	-0.024474	0.099713	0.436087	1.691739	2.378554
	Kurtosis	13.08238	12.12199	6.947021	14.42829	17.94156
	Jarque-Bera	16875.01	13819.59	2711.023	23569.09	40795.64
	Probability	0	0	0	0	0
	Observations	3984	3984	3984	3984	3984

Source: Compiled from NSE, BSE and IMD/Computed using E-Views 6 Version

Analysis of Pearson Correlation for the Returns of Sample Indices and Weather Factors in Sample Cities in India during the Study Period

Table 3 shows the results of correlation among the returns of sample indices, in respect of weather factors in sample cities in India, during the study period, from 1st January, 2001 to 31st December, 2016. According to the results of the Table 3, the values of correlation, for weather

factors, ranged from -0.021 (Chennai Temperature) to 0.0200 (Kolkata Temperature), in respect of BSE SENSEX. Similarly, the value of correlation, ranged from -0.030 (Mumbai Temperature) to 0.032 (Mumbai humidity), in respect of NSE S&P CNX NIFTY. The Table brings out the fact that the values of correlation, for all sample variables, were lesser than one, during the study period. The analysis of temperature factors, in five sample cities, in respect of BSE SENSEX and NSE S&P CNX NIFTY revealed that there was no correlation between the returns of temperature, in five sample cities and the returns of BSE SENSEX and NSE S&P CNX NIFTY, during the study period, as the values of correlation were less than one. Similarly, the analysis of humidity factors, in five sample cities, in respect of BSE SENSEX and NSE S&P CNX NIFTY, revealed that there was no correlation between the returns of humidity in five cities, in respect of returns of BSE SENSEX and NSE S&P CNX NIFTY, during the study period, as the values of correlation were less than one. Furthermore, the analysis of wind speed factor, in five cities, in respect of BSE SENSEX and NSE S&P CNX NIFTY showed that there was no correlation between the returns of temperature, in five cities, with respect of returns for BSE SENSEX and NSE S&P CNX NIFTY, during the study period, as the values of correlation were less than one. Hence the Null Hypothesis (H_0), "There is no co-relation in the daily return data of sample indices and weather (temperature) in five cities over the sample period", is accepted. According to the results of Pearson correlation, the weather factors did not influence significantly, the returns of sample indices, during the study period. Hence the returns of sample indices were further analyzed, by using the Granger Causality Test and each weather factor was analyzed, separately, against each sample city.

Table 3				
RESULTS OF PEARSON CORRELATION STATISTICS FOR THE RETURNS OF STOCK MARKET INDICES AND WEATHER FACTORS IN METRO CITIES IN INDIA FROM 1st JANUARY 2001 TO 31st DECEMBER 2016				
Correlations				
			SENSEX	NIFTY
Bangalore	TEMPERATURE (Bangalore)	Pearson Correlation	-0.004	-0.016
		Sig. (2-tailed)	0.778	0.319
	HUMIDITY (Bangalore)	Pearson Correlation	-0.002	0.005
		Sig. (2-tailed)	0.907	0.768
	WIND SPEED (Bangalore)	Pearson Correlation	0.014	0.016
		Sig. (2-tailed)	0.361	0.327
Chennai	TEMPERATURE (Chennai)	Pearson Correlation	-0.021	-0.025
		Sig. (2-tailed)	0.179	0.111
	HUMIDITY (Chennai)	Pearson Correlation	0.018	0.025
		Sig. (2-tailed)	0.258	0.111
	WIND SPEED (Chennai)	Pearson Correlation	-0.018	-0.019
		Sig. (2-tailed)	0.253	0.229
Delhi	TEMPERATURE (Delhi)	Pearson Correlation	-0.0130	-0.0110
		Sig. (2-tailed)	0.4030	0.4870
	HUMIDITY (Delhi)	Pearson Correlation	0.0120	0.0150
		Sig. (2-tailed)	0.4660	0.3490
	WIND SPEED (Delhi)	Pearson Correlation	0.0010	0.0030

		Sig. (2-tailed)	0.9500	0.8730
Kolkata	TEMPERATURE (Kolkata)	Pearson Correlation	0.0200	-0.0020
		Sig. (2-tailed)	0.2000	0.9190
	HUMIDITY (Kolkata)	Pearson Correlation	-0.0140	-0.0120
		Sig. (2-tailed)	0.3920	0.4580
	WIND SPEED (Kolkata)	Pearson Correlation	-0.0190	-0.0200
		Sig. (2-tailed)	0.2330	0.1990
Mumbai	TEMPERATURE (Mumbai)	Pearson Correlation	0.013	-0.030
		Sig. (2-tailed)	0.412	0.055
	HUMIDITY (Mumbai)	Pearson Correlation	0.002	0.032
		Sig. (2-tailed)	0.920	0.045
	WIND SPEED (Mumbai)	Pearson Correlation	0.001	-0.004
		Sig. (2-tailed)	0.970	0.786
**Significant at the 0.01 level (2-tailed).				
* Significant at the 0.05 level (2-tailed).				

Source: Compiled from NSE, BSE and IMD/Computed, using E-Views 6 Version

Granger Causality between the Returns of Sample Stock Indices and Weather Factors in Bangalore City

As stated earlier (Section 8 last sentence), an attempt has been made to study and compare the causal relationship between two sample indices (BSE Sensex and NSE S&P CNX Nifty) and three weather factors (temperature, humidity and wind speed), in five major cities of India (Bangalore, Chennai, Delhi, Kolkata and Mumbai) separately. Table 4 shows the results of Granger Causality, for testing the inter linkages of weather factors (temperature, humidity and wind speed), in Bangalore City, with two sample stock indices in India (BSE Sensex and NSE S&P CNX Nifty), during the study period, from 1st January 2001 to 31st December 2016. It is clear that among the sample weather variables in Bangalore City, only one weather variable, namely, Temperature, was perfectly fit in respect of BSE SENSEX and recorded one way-bidirectional causality relation (as per F-Statistics with the value of 4.60740 and P-Value, with the value of 0.01000). Further, the remaining two weather factors namely, humidity and wind speed in Bangalore City, had no causal relation with BSE SENSEX and NSE NIFTY. Hence the null hypothesis (NH₃), there is no causal relationship of sample indices with weather factors in Bangalore city is partially accepted.

Table 4
RESULTS OF GRANGER CAUSALITY BETWEEN SAMPLE STOCK MARKETS AND WEATHER FACTORS OF BANGALORE CITY FROM 1st JANUARY 2001 TO 31st DECEMBER 2016

Null Hypothesis	Obs.	F-Statistic	Prob.	Result
NIFTY does not granger cause TEMPERATURE	3982	2.34609	0.09590	Accepted
TEMPERATURE does not granger cause NIFTY	3982	0.99450	0.37000	Accepted
NIFTY does not granger cause HUMIDITY	3982	0.15114	0.85970	Accepted
HUMIDITY does not granger cause NIFTY	3982	0.27754	0.75770	Accepted
NIFTY does not granger cause WIND_SPEED	3982	0.30810	0.73490	Accepted
WIND_SPEED does not granger cause NIFTY	3982	1.61202	0.19960	Accepted
SENSEX does not granger cause TEMPERATURE	3982	4.60740	0.01000	Rejected
TEMPERATURE does not granger cause SENSEX	3982	0.55781	0.57250	Accepted

SENSEX does not granger cause HUMIDITY	3982	1.78455	0.16800	Accepted
HUMIDITY does not granger cause SENSEX	3982	1.21658	0.29640	Accepted
SENSEX does not granger cause WIND_SPEED	3982	1.74187	0.17530	Accepted
WIND_SPEED does not granger cause SENSEX	3982	0.25312	0.77640	Accepted

Sources: Compiled from NSE, BSE and IMD/using E-views, *Rejection of null hypothesis when the probability value is less than or equal to 0.05

Granger Causality between the Returns of Sample Stock Indices and Weather Factors in Chennai City

Table 5 shows the results of Granger Causality, for testing the inter linkages between weather factors (temperature, humidity and wind speed), in Chennai City and two sample indices (BSE Sensex and NSE S&P CNX Nifty), during the study period, from 1st January 2001 to 31st December 2016. It is understood that among the three sample weather variables in Chennai City, no one weather variable was perfectly fit with the BSE SENSEX and NSE S&P CNX NIFTY. Hence, the Null Hypothesis (NH₃), there is no causal relationship among the stock market indices with weather variable in Chennai City, is accepted.

Table 5 RESULTS OF GRANGER CAUSALITY BETWEEN SAMPLE STOCK MARKETS AND WEATHER FACTORS OF CHENNAI CITY FROM 1st JANUARY 2001 TO 31st DECEMBER 2016				
Null Hypothesis	Obs.	F-Statistic	Prob.	Result
NIFTY does not granger cause TEMPERATURE	3982	0.9627	0.3820	Accepted
TEMPERATURE does not granger cause NIFTY	3982	0.0239	0.9764	Accepted
NIFTY does not granger cause HUMIDITY	3982	0.8990	0.4071	Accepted
HUMIDITY does not granger cause NIFTY	3982	1.7999	0.1655	Accepted
NIFTY does not granger cause WIND_SPEED	3982	0.4620	0.6300	Accepted
WIND_SPEED does not granger cause NIFTY	3982	0.1238	0.8836	Accepted
SENSEX does not granger cause TEMPERATURE	3982	1.0783	0.3403	Accepted
TEMPERATURE does not granger cause SENSEX	3982	0.8289	0.4366	Accepted
SENSEX does not granger cause HUMIDITY	3982	0.8854	0.4126	Accepted
HUMIDITY does not granger cause SENSEX	3982	0.2071	0.8130	Accepted
SENSEX does not granger cause WIND_SPEED	3982	0.5337	0.5865	Accepted
WIND_SPEED does not granger cause SENSEX	3982	0.5169	0.5964	Accepted

Sources: Compiled from NSE, BSE and IMD/using E-views, Rejection of null hypothesis when the probability value is less than or equal to 0.05

Granger Causality between the Returns of Sample Stock Indices and Weather Factors in Delhi City

The results of Granger Causality, for testing the inter linkages between weather factor (temperature, humidity and wind speed) in Delhi City and two sample stock market indices (BSE Sensex and NSE S&P CNX Nifty), during the study period, from 1st January 2001 to 31st December 2016, are given Table 6. It is to be noted that among the sample weather factors in Delhi City, no one weather factor was perfectly fit with the BSE SENSEX and NSE S&P CNX NIFTY. Hence the Null Hypothesis (NH₃), there is no causal relationship among the stock market indices with weather variable in Delhi city, is accepted.

Table 6
RESULTS OF GRANGER CAUSALITY BETWEEN SAMPLE STOCK MARKETS AND WEATHER FACTORS OF DELHI CITY FROM 1st JANUARY 2001 TO 31st DECEMBER 2016

Null Hypothesis	Obs.	F-Statistic	Prob.	Result
NIFTY does not granger cause TEMPERATURE	3982	0.3719	0.6895	Accepted
TEMPERATURE does not granger cause NIFTY	3982	0.0424	0.9585	Accepted
NIFTY does not granger cause HUMIDITY	3982	0.2597	0.7713	Accepted
HUMIDITY does not granger cause NIFTY	3982	0.5486	0.5778	Accepted
NIFTY does not granger cause WIND_SPEED	3982	1.2347	0.2910	Accepted
WIND_SPEED does not granger cause NIFTY	3982	0.6036	0.5469	Accepted
SENSEX does not granger cause TEMPERATURE	3982	0.5240	0.5922	Accepted
TEMPERATURE does not granger cause SENSEX	3982	0.0025	0.9975	Accepted
SENSEX does not granger cause HUMIDITY	3982	0.8597	0.4234	Accepted
HUMIDITY does not granger cause SENSEX	3982	0.6498	0.5222	Accepted
SENSEX does not granger cause WIND_SPEED	3982	1.1378	0.3206	Accepted
WIND_SPEED does not granger cause SENSEX	3982	0.0634	0.9385	Accepted

Sources: Compiled from NSE, BSE and IMD/using E-views, Rejection of Null Hypothesis when the Probability value is less than or equal to 0.05

Granger Causality between the Returns of Sample Stock Indices and Weather Factors in Kolkata City

Table 7 shows the results of Granger Causality, for testing the inter linkages between weather factors (temperature, humidity and wind speed) in Kolkata City and two sample stock market indices in India (BSE Sensex and NSE S&P CNX Nifty), during the study period, from 1st January 2001 to 31st December 2016. It is understood that only one weather variable (Temperature), out of three sample weather variables in Kolkata City, was perfectly fit with the NSE S&P CNX NIFTY and recorded one way-bidirectional causality relation (as per F-Statistics with the value of 3.3931 and P-Value with the value of 0.0337). Further, the remaining two weather factors (humidity and wind speed) in Kolkata City had no causality relation with BSE SENSEX and NSE NIFTY. Hence the Null Hypothesis (NH₃), there is no causal relationship sample indices and weather factors in Kolkata City, is partially accepted.

Table 7
RESULTS OF GRANGER CAUSALITY BETWEEN SAMPLE STOCK MARKETS AND WEATHER FACTORS OF KOLKATA CITY FROM 1st JANUARY 2001 TO 31st DECEMBER 2016

Null Hypothesis:	Obs.	F-Statistic	Prob.	Result
NIFTY does not granger cause TEMPERATURE	3982	3.3931	0.0337	Rejected
TEMPERATURE does not granger cause NIFTY	3982	0.1726	0.8415	Accepted
NIFTY does not granger cause HUMIDITY	3982	1.1051	0.3313	Accepted
HUMIDITY does not granger cause NIFTY	3982	0.8549	0.4254	Accepted
NIFTY does not granger cause WIND_SPEED	3982	1.7011	0.1826	Accepted
WIND_SPEED does not granger cause NIFTY	3982	1.1600	0.3136	Accepted
SENSEX does not granger cause TEMPERATURE	3982	1.7974	0.1659	Accepted
TEMPERATURE does not granger cause SENSEX	3982	0.1529	0.8582	Accepted
SENSEX does not granger cause HUMIDITY	3982	1.5532	0.2117	Accepted
HUMIDITY does not granger cause SENSEX	3982	1.8812	0.1525	Accepted
SENSEX does not granger cause WIND_SPEED	3982	0.5352	0.5856	Accepted

WIND_SPEED does not granger cause SENSEX	3982	0.5156	0.5972	Accepted
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Sources: Compiled from NSE, BSE and IMD/using E-views, Rejection of null hypothesis when the probability value is less than or equal to 0.05

Granger Causality between the Returns of Sample Stock Indices and Weather Factors in Mumbai City

The results of Granger Causality, for testing the inter linkages between weather factors (temperature, humidity and wind speed) in Mumbai City and two sample stock market indices in India (BSE Sensex and NSE S&P CNX Nifty), during the study period, are given in Table 8. It is clear that among three sample weather variables in Mumbai City, two weather variables (Temperature and Humidity) were perfectly fit for the NSE S&P CNX NIFTY and recorded the basis of one way-bidirectional causality relation (as per F-Statistics of Temperature, with the value of 4.5027 and Humidity, with the value of 3.0945 and the P-Value of Temperature, with the value of 0.0111 and Humidity, with the value of 0.0454). Further, the remaining weather factor of wind speed in Mumbai City had no causality relation with BSE SENSEX and NSE NIFTY. Hence the Null Hypothesis (NH₃), there is no causal relationship sample indices and a weather factor in Mumbai City is partially accepted.

Table 8				
RESULTS OF GRANGER CAUSALITY BETWEEN SAMPLE STOCK MARKETS AND WEATHER FACTORS OF MUMBAI CITY FROM 1st JANUARY 2001 TO 31st DECEMBER 2016				
Null Hypothesis	Obs.	F-Statistic	Prob.	Result
NIFTY does not granger cause TEMPERATURE	3982	4.5027	0.0111	Rejected
TEMPERATURE does not granger cause NIFTY	3982	0.8043	0.4475	Accepted
NIFTY does not granger cause HUMIDITY	3982	3.0945	0.0454	Rejected
HUMIDITY does not granger cause NIFTY	3982	1.2287	0.2928	Accepted
NIFTY does not granger cause WIND_SPEED	3982	1.5600	0.2103	Accepted
WIND_SPEED does not granger cause NIFTY	3982	0.3677	0.6923	Accepted
SENSEX does not granger cause TEMPERATURE	3982	2.2882	0.1016	Accepted
TEMPERATURE does not granger cause SENSEX	3982	1.1972	0.3021	Accepted
SENSEX does not granger cause HUMIDITY	3982	1.2588	0.2841	Accepted
HUMIDITY does not granger cause SENSEX	3982	0.8995	0.4068	Accepted
SENSEX does not granger cause WIND_SPEED	3982	0.4035	0.6680	Accepted
WIND_SPEED does not granger cause SENSEX	3982	0.6210	0.5375	Accepted

Sources: Compiled from NSE, BSE and IMD/using E-views, Rejection of null hypothesis when the probability value is less than or equal to 0.05

DISCUSSION AND CONCLUSION

It is a well-known fact that weather could affect an individual's mood and behavior, which would, in turn, influence the people, making decisions in their life. This study identified sample indices in India (BSE Sensex and CNX Nifty) and weather conditions (Temperature, Humidity and Wind speed), in sample cities (Bangalore, Chennai, Delhi, Mumbai and Kolkata) in India. According to the result of Granger Causality, it is found that the Bangalore temperature affected the BSE Sensex returns (as per the F-Statistics with the value of 4.60740 and P-Value, with the value of 0.01000), Kolkata and Mumbai Temperature affected the CNX Nifty (as per the F-Statistics with the value of 3.3931 & 4.5027 and P-Value, with the value of 0.0337 &

0.0111) negatively. Increased temperature played a crucial role in disturbing investors. The results of the study showed that weather variables induced changes in mood and behavior of people in selected cities. The analysis of this study clearly revealed that the temperature in Bangalore influenced investors' mood in respect of BSE Sensex while Kolkata and Mumbai recorded behavioral changes in respect of CNX Nifty. Other weather variables did not have interrelated linkages with sample indices (BSE Sensex and CNX Nifty). This study also found that Mumbai humidity affected the CNX Nifty returns (as per result of Granger Causality the F-Statistics with the value of 3.0945 and P-Value, with the value of 0.0454), in line with Dowling & Lucey (2005). In other words, humidity affected the human mood negatively, leading to aggressive behavior and increased the stock returns consistently (Cao & Wei, 2005). Humidity influenced the people of Mumbai, in respect of CNX Nifty during whole study period. The study found one way-bidirectional causality relation between Bangalore temperature and BSE SENSEX, Kolkata temperature and NSE S&P CNX NIFTY and Mumbai temperature and humidity and NSE S&P CNX NIFTY. Overall, this study found that weather variables (temperature and humidity) did have some substantial influence in Indian stock market (namely BSE Sensex and CNX Nifty).

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