Impact of Weather on Return and Volatility: Evidence From Indian Stock Market

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Abstract

This study examines the impact of Weather factors on return and volatility of the Indian stock market. The study uses the daily data of top four metros and tests its impact on the return and volatility of S&P CNX Nifty index from January 2008 to December 2013. This study applies GARCH (1, 1) model and find that the stock returns are influenced by temperature in Chennai and the stock return volatility influenced by the temperature in Mumbai, Delhi and Kolkata.

Keywords: Weather Effect, Volatility, ARCH, GARCH and Stock Market

Introduction

India, the country has a tropical climate relatively marked by high temperature and dry winters. Generally, it has three seasons: hot season, wet (monsoon season) and dry (winter) season. Where, the hot season is from March to May, 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, which lies between mid-July and September, is erratic where some areas experience heavy rains the others experience drought and still others get flooded

Due to its geographical position and the climatic conditions, India witnesses different climatic seasons in a year commonly known as – winter, summer and Monsoon.

Winter: During this period, the days will be cold. In some higher ranges of northern India, temperature can drop down to below 0°C. Normally winters are dry in northern India. In Southern part, the temperature difference is not so marked due to moderating effect of Indian Ocean, Bay of Bengal and Arabian Sea. This season may be observed in almost all parts of India during November to February.

Summer: this period falls between March to May in India. The average temperature varies region-wise but in northern & western region the maximum temperature can be far above the average. Hot wind, known as 'Loo' is the marked feature of summers in northern India.

Monsoon (Rainy): During the months of June, July, August and September India gets major part of its share of rain. Rain starts from Andaman-Nicobar then Kerala and advances to almost all parts of the country. In the month of September this monsoon after drenching all of India, begins to retreat, called as Retreating Monsoon. Rainfall begins to decrease and upto November, the monsoon completely goes from major part of India, except for Tamil Nadu and some other southern states.

Indian Meteorological department (IMD) divides a year into four seasons for India, namely winter, pre-monsoon, and southwest & post monsoon season. Division of these four seasons depends upon Monsoon pattern. The psychology study of Isen and Shalker (1978), observed that the people in a good mood make optimistic judgments and choices and that people in a bad mood make pessimistic judgements and choices. Howarth and Haffman (1984) identified sunshine both positively and negatively influencing the human psychology. Moreover, the human psychology and mood affected by numerous factors one among the factors is the climate (whether condition). Saunders (1993) advocated that the weather

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influence the mood of the brokers and traders prominently at a particular locality, which ultimately may have impact on the security prices. Weather affects humans daily live and mood by four-fifths of global economic activity (Schwarz 2005). While investing, a human may behave rationally and sometimes randomly. When we investigate on the stock markets, the investment Psychology and mood of an individual definitely influence the stock return (Neal and Wheatley 1998; Shleifer 2000).

The economic models assume that rational individuals who inferences and make rational choices based on available information mostly drive the stock markets. Thus, an investor's mood in their actions and behaviour influences the stock markets.

A body of researches exhibits the existence of relationship between weather patterns in major financial centres and stock returns by indirectly establishing the influence of investor mood on assessing the price of financial assets and specifically security prices (see: Saunders,1993; Trombley, 1997; Kramer and Runde, 1997; Hirshleifer, 2001; Cao and Wei, 2002; Keef and Roush, 2002; Goetzmann and Zhu, 2003; Hirshleifer and Shumway, 2003; Loughran and Schultz, 2003; Pardo and Valor, 2003; Dowling and Lucey, 2005; Garrett et al., 2005; Chang et al., 2006; Floros, 2008b; Jacobsen et al., 2008; Yoon and Kang, 2009; Kang, Jiang, Lee and Yoon, 2010; Hammami and Abaoub, 2010; Symeonidis, Daskalakis and Markellos, 2010; Suleyman, et al, 2014). However, how mood of an investor changes due to weather condition and how that influences their investment decision is unrevealed certainly. Therefore, this study makes an attempt to investigate how whether factors in major cities of India influences the return and volatility of the stock market.

This study is presented in five sections; the First section is the introduction dealing the weather conditions that prevail in India and compilation of the previous studies on the subject. Next section explains the earlier studies regarding weather effect and stock return. Section three and four portrays the methodology and empirical results respectively. The last section presents summary and conclusion.

LITERATURE REVIEW

This section discusses the previous researches related to weather effect on stock return and volatility.

Saunders (1993) investigated the influence of weather-induced moods on the equity returns by employing daily data of the Dow-Jones Industrial Average from 1927 to 1989 from New York Stock Exchange and in American Stock Exchange from 1962 to 1989. The study applied GARCH model under various distributional assumptions and found the temperature negatively affecting the stock returns in New York. The results indicated that when cloud cover was 100 percent, returns were below average, but when cloud cover was below 20 percent, returns were above average.

Kramer and Runde (1997) analysed the cloud cover in the context of the German stock index (DAX) and additionally with three weather indicators observed at Frankfurt – humidity, atmospheric pressure and rainfall. The study adopted the saunders method and indicated the non existence of systematic relationship between the selected variables on the stock returns by using GARCH model.

Trombley (1997) re-examined the relationship between mood of investor's and equity returns by replicating the Saunders (1993) results and shows that returns on 100% cloudy days are not significantly different from returns on days with 0% cloud cover or 0 to 10% cloud cover. Trombley claims that Saunders comparison of 100% cloudy days with 0 to 20% cloudy days is the only comparison during this period that would produce a statistically significant. He concluded that the relationship between security returns and Wall Street weather is neither as clear nor as strong as Saunders suggests. There is no significant difference between returns on clear sunny days and on cloudy or rainy days.

Kamstra, Kramer, and Levi (2000) determined the relationship between weather and stock market returns over relevant periods of United States, United Kingdom, Canada and Germany. The study observed that the Friday to Monday return seems significantly lower on daylight savings time- changes in weekends and such changes would affect sleep patterns, not just waking hours of sunlight. Further, examining weather data allowed the study to exploit the full sample of daily returns instead of a sample restricted to the dates of daylight savings changes. The results found that fall weekends are associated with higher returns.

Goetzmann and Zhu (2002) investigated the weather effect for a particular group of agents in the market. The study used a database of trading accounts of approximately 80,000 investors from 1991 to 1996 to understand whether investor's trade differently based on the weather. The study examined the five major cities of United States and found that the buying or selling of stocks in cloudy days by individual investors' behaviour seems indifferent. Further, the study observed the widening of spreads (measure of liquidity) on cloudy days and controlled the same, then advocated that the stock market liquidity and return driven by weather -induced mood of the investors.

Keef and Roush (2002) studied the relationship between wind speed, direction and stock market returns and found that both wind speed and wind direction from the south in Wellington, the capital city of New Zealand, had significantly negative effect on stock returns. Thus, the bone-chilling cold wind, results in lower investor sentiment.

Hirshleifer and Shumway (2003) examined the relationship between weather and stock market returns using daily data of Lisbon Stock Exchange (PSI 20 index) period from 1995-2007 in Portugal. The study employed AR (1)-TGARCH(1,1) model under various distributional assumptions and found that temperature affects negatively the PSI20 stock returns in Portugal. Moreover, returns found to be positive in January and higher over the first fortnight of the month, and then lower temperature in January leads to higher stock returns due to investor's aggressive risk taking.

Pardo and Valor (2003) investigated the weather induced mood influence on the stock market returns of Spain. This study specifically tested the influence of weather variables (sunshine hours and humidity levels) on index returns in an open outcry trading system and compared the same with screen based trading system. The result shows that on the independency of the trading system, weather do not influence the stock market returns.

Loughran and Schultz (2004) found that if storm occurs in the morning, investors have to shovel snow to dig cars out and spend greater periods of time commuting. These investors would therefore have insufficient time to engage in trading which results decreasing of local listed companies trading volume and thereby illustrating the immediate impacts of weather on the stock market.

Garrett, Kamstra and Kramer (2005) tried to gauge the SAD effect in the context of a conditional CAPM framework. Using the daily and monthly stock market returns of six countries viz US, Japan, the UK, and Sweden in the Northern Hemisphere, and New Zealand and Australia, the study captured the SAD effect by allowing for time variation in market risk and a time-varying price of risk. The study finally confirms the existence of SAD effect in the six selected stock markets.

Chang, Nieh, Yang, and Yang (2006) investigated the relationships between weather factors and stock market returns in Taiwan using daily data for the period of 1997 to 2003. The study employed GJR-GARCH and evidenced that temperature and cloud cover influencing stock returns in Taiwan.

Jacobsen and Marquering (2008) tried to explain stock returns by weather induced mood shifts of investors. They confirm the earlier results in the literature that there is indeed a strong seasonal effect in stock returns in many countries: stock market returns tend to be significantly lower during summer and fall months than during winter and spring months.

Yoon and Kang (2009) attempted to test the relationship that exists between stock returns and the weather variables of temperature, humidity, and cloud cover in the Korean stock market from 1990 to 2006. The study found the non existence of weather effects on the stock returns after the crisis period and indicates that the weather effect was weakened because of heightening of market efficiency.

Kang, Jiang, Lee, and Yoon (2010) investigated the weather effect on returns and volatility in the Shanghai stock markets using daily weather data for temperature, humidity, and sunshine duration in Shanghai from 1996 to 2007. The study employed dummies In order to gauge extreme weather condition using the 21-day and 31-day moving average and moving standard deviation. The dummies were included in the linear model and GARCH (1, 1) model for sample return series and their volatility, respectively. The analysis found the existence of weather effect in the A-share returns but not in B-share returns and it strongly effects both A and B shares volatility.

Symeonidis, Daskalakis, and Markellos (2010) examined the relation between stock market volatility and investor mood influenced by weather (captured by

cloudiness, temperature and precipitation). The study employed historical, implied and realized measures of volatility and observed that SAD and cloudiness are negatively associated with various measures of stock market volatility.

Suleyman., Kahyaoglu, and Odabas (2014) studied weather effect on the investment behaviors of individual investors trading in BIST (Borsa Istanbul) from the years 2009 to 2011 period. They found the level of cloudiness and temperature having influence on the on investor behaviors, and the number of sunny days, the number of overcast days, and sunshine duration have no effect on investor behaviors.

Most of the studies are carried out in developed countries like UK, USA. The research regarding weather and stock return movement in India is limited. Thus, we assume that the weather induced mood of the investors to influence the stock returns and volatility in the selected metros of study.

DATA AND METHODOLOGY

The study uses the daily closing values of S&P CNX Nifty index and daily Weather data from January 2008 to December 2013. The required index value and weather data are respectively obtained from National stock exchange of India (http://www.nseindia.com) and India Meteorological Department (www.imd.gov.in). The study considered the sample of four metros Chennai, Kolkata, Mumbai and Delhi weather data measured interms of temperature, dew point and visibility. The Temperature ranges from 10 to 35 degree Celsius, dew point ranges from zero (clear skies) to 30°C and visibility is the distance away at which a target can be seen regardless of weather conditions which range from 0° to 7°. The daily values of the index are converted into returns (R_t) by taking the first differences in the natural logarithms.

$$R_t = \ln[(P_t) /(P_{t-1}] \times 100$$

Where P_t is the value of an index at time t and P_{t-1} is the value of the index at time t-1. There are different types of modelling for conditional variances suggested in the literature. The present study employs autoregressive conditional heteroskedastic (ARCH), and generalised autoregressive conditional heteroskedastic (GARCH) models to investigate the impact of weather on stock market return and volatility in Indian stock market. A model, developed by Engle (1982), allows the forecasted variances of return to change with the squared lagged values of the error terms from the previous periods. This is known as the autoregressive conditional heteroskedastic model (1) [ARCH (1,1)].

$$\varepsilon_t \sim (0,\sigma_t^2)$$

The generalized version of ARCH (1) is suggested by Bollerslev (1986) and makes the conditional variance a function of lagged values of both lagged conditional volatility (h_t^2) and the error term (ε_t^2).

$$\varepsilon_t \sim (0,\sigma_t^2)$$

Where R_t is the current return, R_{t-1} is the lagged return, and is the error term, h_t is the current conditional volatility, and h_{t-1} is the lagged conditional volatility. The coefficient $\alpha_0 > 0$, $\alpha_1 \geq 0$, $\beta_1 \geq 0$, and $\alpha_1 + \beta_1 < 1$. The sum of slope coefficients ($\alpha_1 + \beta_1$) measures the persistence of the volatility. If the sum of slope coefficients is less than one, GARCH process is stationary. In GARCH (1,1) model, the effect of a return shock on current volatility declines geometrically over time. Bollerslev et al., 1992 investigated that GARCH (1,1) model is the excellent model for a wide range of financial data. Karmaker (2005) noted in his research work that GARCH (1,1) model is found to be excellent model for a wide range of financial data in India.

Further, Karmaker (2005) mentioned that the sizes of the parameters α_1 and β_1 determine the short-run dynamics of the volatility of the stock return. Large β_1 indicates that shocks to conditional variance take a long time to die out, so volatility persistence. Large α_1 means that volatility reacts quit intensely to market movement. In financial market, normally, α_1 is less than 0.2 and β_1 is more than 0.8.

To investigate the weather effect on return and volatility of the Nifty index, the following model is framed.

$$\varepsilon_t \sim (0,\sigma_t^2)$$

The Model above represents the conditional mean and conditional variance equations, which is modelled as an autoregressive process. The h_t, conditional variance depends on lagged squared errors and lagged conditional variances. The well-defined GARCH model necessitates that coefficient of the lagged squared errors, lagged

Table 1: Impact of Mumbai Weather on stock Return and volatility in India

Mean equation						
Weather/ Parameters	Temperature		Dew Point		Visibility	
	Co efficient	p-value	Co efficient	p-value	Co efficient	p-value
Constant	0.058601	0.0571	0.058918	0.0564	0.059257	0.0555
Weather	0.041780	0.2951	-0.010603	0.7935	-0.023077	0.6164
Variance equation						
Constant	0.020802	0.0013	0.019694	0.0012	0.019886	0.0012
ARCH	0.104014	0.0000	0.102294	0.0000	0.104503	0.0000
GARCH	0.894858	0.0000	0.896237	0.0000	0.894474	0.0000
Weather	-0.079250	0.0345	0.015102	0.7012	0.019638	0.7277

conditional variances must be non-negative, and their sum must be less than unity.

EMPIRICAL RESULTS

This section discusses the results of weather impact on the stock returns and volatility in India specifically with reference to weather conditions of four major metros in India respectively includes Mumbai, Kolkata, Delhi and Chennai. In order to gauge the weather impact on stock returns in mean conditions and variance conditions GARCH (1,1) model is employed. The results of GARCH (1,1) are presented below for each metros for both mean and variance equation.

Table 1 shows the results of mean and variance equations testing the impact of temperature, dew point and visibility with stock market return in Mumbai by employing GARCH (1,1). The mean equation result with probability value of temperature, dew point and visibility (0.2951, 0.7935, and 0.6164) reveals that the weather variables are not influencing the stock returns for the study period in Mumbai. On the other hand, the variance equation the coefficient of temperature seems significant, the result rejects the null hypothesis, and it accepts that temperature is influencing the stock return volatility. While in the case of dew point and visibility, they are not significant and hence they are not influencing the stock return volatility.

Table 2 represents the result of the impact of Kolkata temperature, dew point and visibility on the stock market return and volatility in India. The mean equation with probability value of temperature, dew point and visibility (0.8263, 0.9545, and 0.6568) reveals that all the weather variables are not significant and the result accept the null hypothesis that temperature, dew point and visibility does not impact the stock returns. In case of the variance equation, the coefficient of temperature is significant at 10 percent level and the result rejects the null hypothesis, and it accepts that temperature is influencing the stock return volatility. While in the case of dew point and visibility, they are not significant and hence they are not influencing the stock return volatility.

Table 3 shows the results of mean and variance equation for Delhi. The mean equation result with probability value of temperature, dew point and visibility (0.3494, 0.9785,

Table 2: Impact of Kolkata Weather on stock Return and volatility in India

Mean equation						
Weather/ Parameters	Temperature		Dew Point		Visibility	
	Co efficient	p-value	Co efficient	p-value	Co efficient	p-value
Constant	0.061242	0.0499	0.058577	0.0578	0.058416	0.0590
Weather	0.007450	0.8263	0.002211	0.9545	-0.023239	0.6568
Variance equation						
Constant	0.015586	0.0079	0.020995	0.0010	0.020410	0.0009
ARCH	0.099422	0.0000	0.103742	0.0000	0.105863	0.0000
GARCH	0.900096	0.0000	0.894789	0.0000	0.893023	0.0000
Weather	0.053196	0.0850	-0.012877	0.6502	-0.041315	0.5345

and 0.5078) reveals that not all the weather variables are influencing the stock returns for the study period. On the other hand, the variance equation coefficient of temperature and visibility seems significant, it accepts that temperature, and visibility is influencing the stock return volatility.

Table 4 shows the results for mean and variance equation. The mean equation result shows that the coefficient of temperature seems significant and the influence the stock returns. On the other hand, the variance equation the coefficients of temperature, dew point and visibility are not significant and the result accepts the null hypothesis that temperature does not affect the stock returns. In case of variance equation, all weather variables are insignificant. The results reveal that weather condition in Chennai does not affect the stock return volatility in the Indian stock market.

Thus, the study observed the weather measuring variable temperature seems to influence stock return in Chennai. The temperature variables of Mumbai and Delhi seem to influence stock return in variance equation.

SUMMARY AND CONCLUSION

Psychological evidence suggests close relationships between weather and Weather affects all human either, directly or indirectly. The effect of natural light stimulates human physiology and psychology. For instance, numerous people during winter the relative lack of daylight make people listless, and in serious cases can even cause depression. Meanwhile, shorter daylight hours make people doubtful and pessimistic mood**.** Individuals feel in a more positive frame of mind on sunny than cloud days in west countries. In India during summer, season people fell scorching them; however, the investors are assumed comfortable in their own means. This study applies GARCH(1,1) to examine relationship among weather and stock returns. The daily weather data's are collected for four metros in India, which includes Mumbai, Kolkata, Delhi, and Chennai and stock returns are taken for five years from 2008 to 2013.

The study employed GARCH (1,1) to capture the relationship between weather variables and Stock returns.

Table 3: Impact of Delhi Weather on stock Return and volatility in India

Mean equation						
Weather/ Parameters	*Temperature*		*Dew Point*		*Visibility*	
	Co efficient	*p-value*	*Co efficient*	*p-value*	*Co efficient*	*p-value*
Constant	0.054826	0.0799	0.057087	0.0629	0.056379	0.0632
Weather	0.031662	0.3494	-0.000950	0.9785	-0.028771	0.5078
Variance equation						
Constant	0.014772	0.0133	0.017431	0.0035	0.016408	0.0045
ARCH	0.098871	0.0000	0.100826	0.0000	0.098665	0.0000
GARCH	0.899001	0.0000	0.897305	0.0000	0.901435	0.0000
Weather	0.056648	0.0458	0.056186	0.1138	0.079726	0.0466

Table 4: Impact of Chennai Weather on stock Return and volatility in India

Mean equation						
Weather/ Parameters	*Temperature*		*Dew Point*		*Visibility*	
	Co efficient	*p-value*	*Co efficient*	*p-value*	*Co efficient*	*p-value*
Constant	0.055182	0.0796	0.059679	0.0531	0.058681	0.0571
Weather	0.096705	0.0176	-0.011285	0.7802	0.016175	0.7319
Variance equation						
Constant	0.018774	0.0027	0.018513	0.0023	0.019915	0.0011
ARCH	0.103705	0.0000	0.102511	0.0000	0.103628	0.0000
GARCH	0.895524	0.0000	0.896371	0.0000	0.895189	0.0000
Weather	0.015165	0.7099	0.053316	0.1008	0.002502	0.9649

The study tested both Mean equation and Variance equation to capture the influence of weather variables on the stock returns in absolute form and in variance form representing the stock return volatility. The study observed that the weather variable temperature in Mumbai alone influencing the stock returns as per mean equation. Whereas, in the Variance equation the weather variable temperature in Mumbai, Delhi and Chennai is influencing stock returns. This result reveals that the temperature is influencing the stock return volatility in India.

Thus, the study evident that the inventors' decisions are influenced by the weather conditions in India. However the reflection of weather on the investors' investment decision in stock market is not strongly proven, therefore further research must be carried out in this subject by investigating with corporate finance managers, equity analysis, treasury managers, fund managers and individual investors who are actively participating in the stock market operations.

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