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Effect of weather on stock market: A literature review and research agenda

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Abstract: The paper presents a systematic review of the research work, published on the topic of weather effects and stock market behavior. The objectives of the study were to examine the current status of research, by collecting the literature, in the area of weather effects and stock market behavior. In the process, the study would reveal the current status to the budding researchers. In this study, the authors critically assessed and examined fifty one research studies, published from 1993 and 2019, in different regions across the globe. A systematic literature review for this study has been made using Google Scholar. The present study found that number of research works on the weather effects and stock market behavior had increased marginally during the recent time period, especially from the beginning of Twenty First Century. Among the different weather factors, temperature was wildly used for research. Finally, this paper reveals some significant research gap to advance the research agenda for future research.

Subjects: Environmental Psychology; General Psychology; Consumer Psychology

Keywords: Research Methodology; Literature Review; Systematic Review

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PUBLIC INTEREST STATEMENT
Investors’ sentiment is an important research direction of behavioral finance. Many research studies in different parts of the world have attempted to investigate investors’ sentiment. Normally individual investors make investment decisions based on their risk tolerance level, but some investors often deviate from their original investment decisions due to certain sentiments that influence these decisions. In general, both internal and external factors have an impact on the overall risk tolerance level of investors’. This study summaries the research publications from 1993 to 2019 done in the reputed journals in the area of weather factors and investors sentiments. The present study provides the collection, classification and comprehensive bibliography of the research work on weather effect and stock market, which might be helpful for the academicians, practitioners and future researchers. This would be helpful for studying the existing research work, as well as for considering future researches on the same subject area.
**JEL Codes: G02; G11; G12.**

1. Introduction

The classical finance theory, namely, Portfolio Theory (Markowitz, 1952) and Capital Asset Pricing Model Theory (Sharpe, 1964) clarified that the returns from the stock market were determined by the fluctuations in the share price, due to micro or macroeconomic fundamentals in the rational backgrounds. The investors mainly do make investment decisions by rational methods, but those decisions have been influenced by only publically available information relating to stock pricing (Lu & Chou, 2012; Chang et al., 2008). But, Lucey and Dowling (2005) argued that the investors’ behavior is the main factor for their investment decision-making process also concurred. Behavioral finance argued that the stock prices were determined by investors’ psychology (Daniel et al., 1998). The weather could also affect the investors’ moods and thus, their behavior played critical role in financial markets (Keef & Roush, 2002; M. Cao & Wei, 2005; Floros, 2008; Kathiravan. C. et al., 2018).

Different studies proved the fact that environmental factors did influence the individual decision-making process (Cunningham, 1979; Hirshleifer, 2001; Kamstra et al., 2003). Besides, different weather factors, were the most predominant environmental factors influencing the day to day activities of individuals (Saunders, 1993; Watson, 2000; Denissen et al., 2008). A clear sky created a good mood (Cunningham, 1979; Schwarz & Clore, 1983). People experienced more satisfaction from a bright day. Symeonidis et al. found that cloudy days naturally influenced individual moods. But some academic researchers claim that changes of individual mood were influenced by different weather factors (Leger, 1994; Coren, 1996). Weather factors could create the predisposition towards particular individual behaviors (P.A. Bell & R.A. Baron, 1976; M.A. Allen & G.J. Fischer, 1978; M.R. Cunningham, 1979). Weather factors significantly influenced individual moods, which could be proven by songs, daily routines and other activities (F. Shahzad, 2019).

Many research studies clearly asserted that the people made ideal judgments when they were in a good mood and people’s mood played a vital role in the decision-making process (Johnson & Tversky, 1983; Isen, 1993; Hirshleifer & Shumway, 2003; M. Cao & Wei, 2005; Simonsohn, 2007). Forgas et al., (2009) observed that weather factors induced negative mood. Petersen,(1937) also argued that cloud cover influenced the individuals in their decision-making.

In recent days also, academic researchers have identified that individual emotional state did have strong significant influence, over individual investment decisions, in the financial markets (Roll, 1992; Daniel et al., 1998; Hirshleifer, 2001; Kathiravan. C. et al., 2019). Number of studies have examined the effects of investors’ moods, derived from different sources, such as Ramazan (Bialkowski et al., 2012; Munusamy, 2019), Air pollution international sports tournaments (Edmans et al., 2007; Kaplanski & Levy, 2010; Chang et al., 2012) and seasonal depression (Kamstra et al., 2003). Besides, there are many studies that proved the fact that a statistically significant effect in the stock market was observed, due to weather factors. From the literature, relating to different weather factors, it is evident that some studies used cloud cover (snow falling, raining,) to examine its impact on stock price (Stoll & Whaley, 1990; Fabozzi & Ma, 1995; Loughran & Schultz, 2004; Hirshleifer & Shumway, 2003; Kang et al., 2010; Lu & Chou, 2012). A few other studies were based on temperature and stock market movement (Keef & Roush, 2002; M. Cao & Wei, 2005; Floros, 2008; Kathiravan, Raja et al., 2018). Majority of the literature clearly indicate that there was significant effect of investors’ behavior on the stock market returns and movements.

The main purpose of the present review study was to invite the attention of the researchers, towards the topic on weather factors and the stock market movement, which are not presently considered in the mainstream research discussion. Hence an attempt has been made in this paper to review earlier research works, undertaken in the area of weather factors and stock market. This work has been arranged into six sections as follows. Section two discusses the motivation of the
study, section three describes an objectives of the study, section four provides details about design and data, followed by the present study for attaining the study objectives, section five explains the earlier literature on weather factors and stock market, and section six offers conclusion, important suggestion and scope for the future research study.

2. Motivation of the study
In the global warming era, the weather factors are considered an important element in the day to day activities of human being and our ecosystem as well. The theory of weather factors and stock market movement and their relationship, have become subject of the study recently across the globe, particularly in USA, China, UK, and the European countries. This theory is now applied in developing countries like India also. Therefore, this paper assembled earlier research publications, to overview the status of global trends of research, in the area of weather factors and stock markets movements and this study also displays these studies for easy access. The present work was also conducted with an intention of bringing out the various methodologies, used in various countries, for evaluating the impact of various weather factors on international stock markets to determine the direction of future research in the same area.

3. The objective of the study
The main aim of the paper was to review the earlier research works, published in the area of climate change and investment decisions. In order to achieve the objectives, this study has examined the present research status, by collecting literature in the area of weather effects and stock market behavior, to provide easy access to the budding researchers.

4. Design and data

4.1. Data
Around 51 research articles were reviewed in the area of weather factors and stock market investment across the globe and the study covered a period of more than 45, years from 1993 to 2019. Published research articles were collected from databases like Science direct (https://www.sciencedirect.com/), and google scholar (https://scholar.google.com/). Table 1, provides the detailed distribution of different components of research, like study period, studied country, different variables, weather and stock market and findings relating to weather factors and the stock market. It is to be noted that the sample of 51 papers, written by 147, authors working at different institutions across the globe, was reviewed for the purpose of this study.

4.2. Methodology
This study propose to review the published research work, relating to weather factors and stock market behavior, from different sources, including electronic databases, web sites (science direct, and google scholar), and academic research journals, during the period from 1993 to 2019. It is to be noted that totally 75 research documents (Journal articles, working paper, and thesis) were downloaded from different sources as said above. But, the present study considered only 51 publications, published in refereed journals. It did not consider rest of 24 research papers presented in the national and international conferences, Thesis (doctoral and master’s) and published and unpublished working papers. The present study had adopted the Systematic Literature Review (SLR), developed by Tranfield et al. (2003) and applied different studies (Singh & Kumar, 2014). The process of review of published literature consisted of three stages, as given in Figure 1.

The sample of 51 research articles symbolizes the importance of weather factors and stock market and they were selected from databases, during the study period. The earlier research articles were classified under year wise, country wise etc.
Table 1. Classification of literature on weather factors and stock market

| Details of Author’s | Title of Study | Weather Factors | Name of Stock Market | Study Period | Tools | Findings and conclusions |
|---------------------|----------------|-----------------|----------------------|--------------|-------|--------------------------|
| Saunders (1993), USA | Stock Prices and Wall Street Weather | Cloud Cover | Dow Jones and NYSE | 1927–1989 | Descriptive Statistics and Test statistics (Z statistics) | The results revealed that cloud cover recorded significant influence on stock prices. |
| Mark A. Trombley (1997), USA | Stock Prices and Wall Street Weather: Additional Evidence | Cloud Cover | Dow Jones and NYSE | 1927–1992 | Duncan’s Multiple Range Test | The study found that there was positive relationship between cloud cover and stock returns. |
| Krämer and Runde (1997), German | Stocks and the Weather: An Exercise in Data Mining or Yet Another Capital Market Anomaly? | Cloud Cover | German stock index DAX | 1960–1990 | Descriptive Statistics and F-test | There was no significant difference between returns on cloud cover and stock returns. |
| Keef and Roush (2002), New Zealand | The Weather and Stock Returns in New Zealand | Cloud Cover, Temperature and Wind Speed | New Zealand Stock Exchange | 1986–2002 | Factor Analysis and OLS regression | The study identified that temperature has limited impact on stock returns while wind speed exercised significant impact and cloud cover recorded no impact. |
| Pardo and Valor (2003), Spanish | Spanish Stock Returns: Where is the Weather Effect? | Sunshine | Spanish stock market | 1981–2000 | Descriptive Statistics | The empirical study found that there was no impact of weather factors on Spanish stock prices. |
| Tufan and Hamarat (2004), Turkey | Do Cloudy Days Affect Stock Exchange Returns: Evidence from Istanbul Stock Exchange | Cloud | Istanbul Stock Exchange | 1987–2002 | Descriptive Statistics, ADF Test and Kruskal Wallis Test | Cloudy days have no relationship with the Istanbul Stock Exchange returns. |
| Keef and Roush (2005), New Zealand | Influence of weather on New Zealand financial securities | Temperature, Sunshine and Wind speed | New Zealand stock indices | 1985–2002 | Factor analysis and Regression | The study found that bank bills were positively influenced by the sunshine factor and stock indices were negatively influenced by wind speed. |
| William N. Goetzmann and Ning Zhu (2005), USA | Rain or Shine: Where is the Weather Effect? | Sunny and Cloudy | NYSE | 1991–1996 | Regression and Descriptive Statistics | The study suggested that the investors of New York City were not influenced by New York weather factors. |
| M. Cao and Wei (2005), US, Canada, Britain, Germany, Sweden, Australia | Stock market returns: A note on temperature anomaly | Temperature | Eight Countries Stock Market | 1962–2001 | Bin tests, Auxiliary analyses, and Regression analysis | The study found negative correlation between temperature factors and stock market returns. |
| Details of Author’s | Title of Study | Weather Factors | Name of Stock Market | Study Period | Tools | Findings and conclusions |
|---------------------|----------------|-----------------|----------------------|--------------|-------|--------------------------|
| Dowling and Lucey (2005), Ireland | Weather, biorhythms, beliefs and stock returns—Some preliminary Irish evidence | Humidity and Cloud Cover | Dublin Stock Exchange | 1988–2001 | Descriptive Statistics and Regression | Research study found relationship between stock price and weather factors. |
| Chang et al. (2006), Taiwan | Are stock market returns related to the weather effects? Empirical evidence from Taiwan | Temperature and Cloud cover | Taiwan stock market | 1997–2003 | GJR-GARCH | The study results found that temperature and cloud cover had influenced the stock returns. |
| Christos Floros (2008), Austria, Belgium, France, Greece, and the UK. | Stock market returns and the temperature effect: new evidence from Europe | temperature | Five Countries Stock Market | 1995–2006 | Descriptive Statistics, AR (1)-GARCH | There was no negative correlation between temperature factors and in the stock the market in Austria, Belgium, and France. But Greece and UK showed a positive relationship. |
| Levy and Galil (2008), Israel | Stock purchase and the weather: Individual differences | Sunshine | Israel Stock Market | 1998–2002 | Regression and Logit models | The study found that sunlight influenced investors’ moods. |
| Shu and Hung (2009), Belgium, Czech Republic, Finland, France, Greece, Hungary, Ireland, Italy, Luxemburg, Norway, Poland, Portugal, Russia, Spain, Sweden, Switzerland, Turkey, and the UK. | Effect of wind on stock market returns: evidence from European markets | wind speeds | Stock market | 1994 to 2004 | Descriptive Statistics, GARCH(1,1), 1-Test regression analysis, and Spearman’s rank correlation test | The study found that temperature influenced by European stock markets. |
| Worthington (2009), Australia | An Empirical Note on Weather Effects in the Australian Stock Market | Precipitation, humidity, temperature, and sunshine | Stock Market | 1958–2005 | Descriptive statistics, Regression | The study found that weather factors exercised no impact on market returns. |
| Yoon and Kang (2009), Korea | Weather effects on returns: Evidence from the Korean stock market | Temperature, Humidity, and Cloud cover | Korea Composite Stock Price Index 200 (KOSPI 200) | 1990–2006 | Descriptive statistics, Unit root tests and -GARCH | It is found that weather factors influence the market efficiency. |
| Kong et al. (2010), Shanghai | Weather effects on the returns and volatility of the Shanghai stock market | temperature, humidity, and sunshine | Shanghai stock market | 1996–2007 | Descriptive Statistics and Regression | The weather factors have had strong influence on the stock market volatility. |
| Goodfellow et al. (2010), German | Does screen trade weather the weather? A note on cloudy skies, liquidity, and computerized stock markets | Sky cover | German Stock Exchange | 2002–2005 | Descriptive Statistics and Regression | The study found that sky cover influenced the market maker. |
| Details of Author’s | Title of Study | Weather Factors | Name of Stock Market | Study Period | Tools | Findings and Conclusions |
|--------------------|----------------|------------------|----------------------|--------------|-------|--------------------------|
| Sriboonchitta et al. (2014), Thailand | Stock market returns and the temperature effect: Thailand | Temperature | Taiwan Stock Exchange Capitalization Weighted Stock Index | 1996–2010 | Descriptive Statistics, Correlation, The unit-root test, Regression | There was negative relationship between temperature and stock market returns |
| Y.-M. Lee, K.-M. Wang (2011), Thailand | The effectiveness of the sunshine effect in Taiwan’s stock market before and after the 1997 financial crisis | cloud cover and sunshine | Taiwan Stock Exchange Capitalization Weighted Stock Index | 1986 to 1996 and 1997 to 2007 | Correlation, The unit-root test, | The cloud cover exercised significant but negative impact on Taiwan’s stock market |
| Pedro M. Silva et al. (2011) Portugal | Weather and stock markets: empirical evidence from Portugal | Rain, Temperature, Sunshine and Wind speed | Portuguese stock market index | 2000–2009 | Descriptive statistics, Regression | The study found that low temperatures were associated with higher returns |
| Christos Floros (2011), Portugal | On the relationship between weather and stock market returns | Temperature | Portuguese stock market index | 1995–2007 | Descriptive Statistics and GARCH | Temperature impacted negatively the stock market |
| Lu and Chau (2012), China | Does the weather have an impact on returns and trading activities in order-driven stock markets? Evidence from China | cloud cover, temperature, humidity, pressure, visibility and wind speed | Shanghai Stock Exchange (SSE) | 2003–2008 | Descriptive Statistics and Regression | The weather factors did not determine by the investor’s decision-making process |
| Wang et al. (2012), Taiwan | Does the weather impact the stock market? Empirical evidence in Taiwan | Precipitation, sunshine hours and temperature | Taiwan stock market | 2001–2007 | Descriptive Statistics and ARCH | Precipitation did not impact stock return but sunshine and temperature influenced stock return |
| Suzaida Bakar and Noraina Mazuin Sapuan (2017), Malaysia | Are Stock Market Returns Related to the Weather Effects Factors? Empirical Evidence from Malaysia | temperature, humidity and rainfall | Kuala Lumpur Composite Index | 1983–2008 | Descriptive Statistics, Unit root tests, and GARCH | Temperature exercised strong effects on stock market returns |
| Brahmana et al. (2012), Indonesia | Weather, investor irrationality and day-of-the-week anomaly: the case of Indonesia | Temperature | Indonesia Stock exchange | 1999–2009 | Descriptive Statistics, regression and Robustness check | Temperature did not influence the market returns |
| Brahmana et al. (2014), Malaysia | The Role of Weather on Investors’ Monday Irrationality: Insights from Malaysia | Temperature | Malaysian stock market | 1999–2010 | Descriptive Statistics and regressions | The weather factors influenced investors’ sentiment conditions in the stock market |

(Continued)
| Details of Author’s | Title of Study | Weather Factors | Name of Stock Market | Study Period | Tools | Findings and conclusions |
|---------------------|----------------|-----------------|----------------------|--------------|-------|--------------------------|
| G. Cao & Y. Han (2015), China | Does the weather affect the Chinese stock markets? Evidence from the analysis of the DCCA cross-correlation coefficient | Temperature, Humidity, Wind speed | Shanghai composite index | 1993–2006 | Descriptive Statistics, Pearson’s correlation, and DCCA cross-correlation | The study found a correlation between weather factors and the stock markets |
| R.K. Brahmana et al. (2015), Indonesia | Does tropical weather condition affect investor behavior? Case of Indonesian stock market | cloud cover and temperature | Indonesia Stock Exchange | 1999 – 2012 | Descriptive Statistics, and Regression | Temperature and cloud cover had no influence on stock market returns |
| Cao et al. (2015), China | Effects of climatic events on the Chinese stock market: applying event analysis | climatic disasters | Shenzhen Component Index | 2008–2011 | CAR | Magnitude of the effect, on each industry, depends on the unexpected climatic events |
| Frühwirth and Sögner (2015), Austria | Weather and SAD related mood effects on the financial market | cloud cover, temperature, humidity, pressure, visibility and wind speed | Corporate bond yield | 2002–2006 | Regression | Some weather factors influenced financial segments |
| Shim et al. (2015), Korea | Weather and stock market volatility: the case of a leading emerging market | Temperature, Wind speed, Humidity and Cloud cover | Korean market | 2003–2013 | GARCH | Investors reacted to extremely high weather conditions than low weather conditions. |
| Apergis et al. (2016), New York and London | (Unusual) weather and stock returns—I am not in the mood for mood: further evidence from international markets | temperatures, humidity, wind speed, rainfall/precipitation, and sunshine | Stock Market | 2000–2013 | Pearson correlation and regressions | The unusual weather conditions, both in NY and in London, had a statistically significant effect on global stock market returns |
| Kaustia and Rantapauska (2016), Finland | Does mood affect trading behavior? | sunniness, temperature, and precipitation, | Finland Stock Market | 1995–2002 | Descriptive statistics and regressions | The study found that the stock returns and environmental variables were related. |
| Nikolaos Sariannidis (2016), Europe | The effect of weather on the European stock market The case of Dow Jones Sustainability Europe Index | Temperature, Wind speed, Humidity and Cloud cover | Stock Market | 2009–2014 | Descriptive statistics, Autocorrelation, and GJR-GARCH | Humidity and wind speed did impact positively the European stock market |
| Apergis and Gupta (2017), South Africa | Can (unusual) weather conditions in New York predict South African stock returns? | Temperatures, humidity, Wind speed, rainfall and cloud cover | South African stock market | 1973–2015 | Pearson Correlation, GARCH, Regressions | The weather factors did have significant and negative impact on the stock returns |
| Details of Author's | Title of Study | Weather Factors | Name of Stock Market | Study Period | Tools | Findings and conclusions |
|--------------------|----------------|-----------------|----------------------|--------------|-------|-------------------------|
| Kathiravan, C. et al. (2017), India | Effect of Temperature on Stock Market Indices: A Study on BSE and NSE in India | Temperature | BSE Sensex and S&P CNX Nifty | 2000–2015 | Descriptive Statistics, ADF Test and GARCH | Temperature influenced the stock market |
| Q. Li. et al. (2018), China | Relationship research between meteorological disasters and stock markets based on a multifractal detrending moving average algorithm | Natural disasters | Chinese stock markets | 2005–2015 | Multifractal detrending moving average algorithm | Natural disasters influenced stock price negatively |
| Sheikh et al. (2017), India, Pakistan, Bangladesh, and Sri Lanka | Weather Effects on Stock Returns and Volatility in South Asian Markets | Temperature, humidity, cloud cover, air pressure, visibility, wind speed, thundertorm, and rain | Stock Market | 2000–2012 | ARMA and TARCH | Weather factors exercised convincing influences in South Asian stock markets |
| Kathiravan, Raja et al. (2018), India | An Empirical Investigation of the Interlinkages of Stock Returns and the Weather at the Indian Stock Exchange | temperature, humidity and wind speed | BSE Sensex and S&P CNX Nifty | 2001–2016 | Descriptive Statistics, Correlation, and Granger Causality | Weather factors did influence Indian stock markets |
| Kathiravan, Raja et al. (2018), India | On the relationship between weather and Agricultural Commodity Index in India: a study with reference to Dhaanya of NCDEX | temperature, humidity and wind speed | Agriculture Commodity Index—NCDEX | 2007–2016 | Descriptive Statistics, Unit Root, Correlation Matrix, and Granger Causality | Temperature and wind speed influenced the Commodity Market |
| Yi-Hsien Wang et al. (2018), Taiwan, Japan and Hong Kong | Relationship among Weather Effects, Investors’ Moods and Stock Market Risk: An Analysis of Bull and Bear Markets in Taiwan, Japan, and Hong Kong | Sunshine, temperature, and humidity | Stock Market | 2012–2015 | Regression | Temperature influenced the stock market negatively |
| Kathiravan, Raja et al. (2018), Sri Lanka | Stock market returns and the weather effect in Sri Lanka | Temperature, humidity and wind speed | Colombo Stock Market Index | 2008–2017 | Descriptive Statistics, ADF Test and OLS regression | Wind speed exercised significant impact on the Colombo stock market |
| Chukiat Chaiboonsri et al. (2011), Thailand | Stock market returns and the temperature effect of Thailand: the GEV and GPD estimation | Temperature | SET index | 2012–2015 | Descriptive statistics, Regressions | Temperature of Thailand negatively impacted the SET-Index Return of Thailand |

(Continued)
| Details of Author's | Title of Study                                                                 | Weather Factors                          | Name of Stock Market           | Study Period | Tools                           | Findings and conclusions                                                                                                                                 |
|---------------------|--------------------------------------------------------------------------------|------------------------------------------|--------------------------------|--------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ic, Kahyaoglu and Odabas, (2014), Turkey | The effects of weather on investor behavior: a study on individual Turkish stock market investors | Primary Data                            |                                | 2014         | Descriptive statistics, Regressions | The study found that there was negative relationship between temperature and stock market                                                                      |
| Vlady (2015), Australia | The Effect of Climate Change on Australian Stock Equity Returns               | Weather factors                         | Australian Stock Exchange      | 1992–2006    | Descriptive statistics, Regressions | Climate change information found significant relationship with the stock market                                                                              |
| Khanthavit et al. (2019) China and Pakistan | Does Weather Has the Same Effect on Different Countries Stock Market Return | Temperature, humidity and wind speed    | SSE-180, KSE 100               | 2011–2016    | GARCH                           | Temperature influenced both stock markets, negatively                                                                                                    |
| Shahzad (2019), China | Do weather influence investor behavior, stock returns, and volatility? Evidence from the Greater China region | Humidity, temperature, air pressure, wind speed | Shanghai and Shenzhen Stock Exchanges | 2005–2017    | Descriptive Statistics, Unit root, and ARCH | Weather variables had exercised significant impact on China’s stock market                                                                         |
| Anya Khanthavit (Thailand), 2019 | Weather, investor sentiment, and stock returns in the stock exchange of Thailand | Air pressure, Cloud cover, Visibility, Rainfall, Humidity, Temperature, and Wind speed | Stock Exchange of Thailand index | 1992–2016    | Descriptive Statistics, and Correlations | Weather factors had played an important role in the stock market                                                                                       |
| Kathiravan. C. et al. (2019), China, Japan, Hong Kong, India, and Singapore | Investor behavior and weather factors: evidence from Asian region | Temperature, humidity and wind speed | Stock Market                   | 2003–2017    | Descriptive Statistics, ADF Test, VAR Module and Granger Causality | Weather factors did have statistically significant influence on the Stock Exchange                                                                 |
| Andriakopoulos et al. (2019), USA and London | Is there still a weather anomaly? An investigation of stock and foreign exchange markets | Temperature                           | Stock Market                   | 2002–2018    | Descriptive statistics, Regressions | Weather factors did not significantly influence stock returns                                                                                           |
5. Systematic Literature Review

Figure 2 reports the systematic model, used for various articles published by academic researchers. The literature, relating to weather factors and stock market behavior, could be classified into the following categories:

(I) Year Wise Classification of the Publication.
(II) Country-Wise Distribution of Publications
(III) Methodology/Econometric Tools Adopted for Data Analysis.
(IV) Studies Based on Weather Variable Wise, and
(V) Citation-Based Analysis of Publication

6. Year-wise classification of studies

Table 2 show the results of the year-wise distribution of publications, collected during the study period from 1993 to 2019. It is noted from the Table and Figure that the concept of weather factors and the stock market has started gaining popularity from the nineteenth Century and articles have
also gradually increased on the same topic, over the study period. But the number of publication gradually increased at the beginning of the twenty-first Century (five publication in 2011, four publication in 2012, two publication in 2014, six publication in 2015, three publication in 2016, four publication in 2017, and five publication in 2018 and four publication in 2019). About 65% of the publications were published, during last 15 years.

7. Country-wise distribution of publications

Table 3 present the results of the country-wise distribution of publications, on weather factors and the stock market behaviour, during the study period, from 1993 to 2019. It is understood from the Table 3 that out of 51 studies, published globally, eight studies were from China, six from USA, five from UK and India each, four from Germany and Thailand, three each from Turkey, Australia, Ireland and Portugal and two from Belgium, France, Greece, New Zealand, Sweden, Korea, Malaysia, Indonesia, Finland, Sri Lanka, Japan, Hong Kong and Taiwan. The remaining countries like Canada and Czech Republic, published one paper each. It is interesting to record that, developed countries like the USA, China, and the UK had published more number of articles. Most importantly, the Southern Region dominated the publications in the area of weather factors and stock market behaviour.

8. Methodology/econometric tools adopted for data analysis

The frequency of tools used, for the data analysis in the research papers, relating to weather factors and stock market behaviour, during the study period, from 1993 to 2019, are presented in Table 4. It could be seen from the Table and the Figure that majority of research papers used Descriptive Statistics, for testing normality (33%), followed by regression (25%) for testing relationship between weather factors and stock markets behaviour GARCH model was used to the tune of 13%, for testing volatility, and Unit Root Test (10%), for testing the stationarity between weather factors and stock market behavior. There were other tests also used in few studies but they were not widely used. The other tools included ARMA, Auxiliary Analyses, Bin Tests, CAR, Correlation, Correlation Matrix, Duncan’s Multiple Range Test, Factor Analysis, F-test, Granger Causality, Kruskal
Wallis Test, Logit models, Pearson Correlation, Robustness Check, Spearman's Rank correlation test, Test Statistics, t-Test, and VAR Model.

9. Studies based on weather variable

Different weather variables were considered and they are presented in Table 5. It is understood from the Table that out of 51 studies considered by this study, 30% (35) of studies were related to temperatures, an important weather variables, followed by 18% of studies being related to humidity, 16% of study were related to wind speed, and 14% of study to cloud cover. But only 10% of the studies were related to sun shine, and 8% of the study to precipitation. Rest of variables were related to weather factors like rainfall by 3% of studies and Sky cover by 1% of the study. It is interesting to note that because of global warming and the greenhouse effect, majority of academic researchers

| No. | Country     | No of studies |
|-----|-------------|---------------|
| 1   | China       | 8             |
| 2   | USA         | 6             |
| 3   | UK          | 5             |
| 4   | India       | 5             |
| 5   | German      | 4             |
| 6   | Thailand    | 4             |
| 7   | Turkey      | 3             |
| 8   | Australia   | 3             |
| 9   | Ireland     | 3             |
| 10  | Portugal    | 3             |
| 11  | Belgium     | 2             |
| 12  | France      | 2             |
| 13  | Greece      | 2             |
| 14  | New Zealand | 2             |
| 15  | Sweden      | 2             |
| 16  | Korea       | 2             |
| 17  | Malaysia    | 2             |
| 18  | Indonesia   | 2             |
| 19  | Finland     | 2             |
| 20  | Sri Lanka   | 2             |
| 21  | Japan       | 2             |
| 22  | Hong Kong   | 2             |
| 23  | Taiwan      | 2             |
| 24  | Canada      | 1             |
| 25  | Czech Republic | 1   |
| 26  | Spanish     | 1             |
| 27  | Hungary     | 1             |
| 28  | Italy       | 1             |
| 29  | Austria     | 1             |
| 30  | South Africa| 1             |
| 31  | Pakistan    | 1             |
| 32  | Bangladesh  | 1             |
| 33  | Singapore   | 1             |

Sources: Developed by authors from Google Scholar as of 26 October 2019
Table 4. Details of frequency of econometric tools used for data analysis relating to weather factors and stock market movement

| Econometric Tools          | Total No. of Studies |
|----------------------------|----------------------|
| Descriptive Statistics     | 34                   |
| Unit Root Test             | 10                   |
| GARCH Model                | 13                   |
| Regression                 | 25                   |
| Others tests *             | 19                   |

Sources: Developed by authors.

Note: *Include ARMA, Auxiliary analyses, Bin tests, CAR, Correlation, Correlation Matrix, Duncan’s Multiple Range Test, Factor Analysis, F-test, Granger Causality, Kruskal Wallis Test, Logit models, Pearson correlation, Robustness check, Spearman’s rank correlation test, Test statistics, t-Test, and VAR Model.

Table 5. Weather factors wise grouping of publications

| S.No | Weather Factors   | No. of Studies | No. of Studies (%) |
|------|-------------------|----------------|--------------------|
| 1    | Temperature       | 35             | 30                 |
| 2    | Humidity          | 21             | 18                 |
| 3    | Wind Speed        | 19             | 16                 |
| 4    | Cloud Cover       | 16             | 14                 |
| 5    | Sun Shine         | 12             | 10                 |
| 6    | Precipitation     | 10             | 8                  |
| 8    | Rainfall          | 4              | 3                  |
| 9    | Sky Cover         | 1              | 1                  |

Sources: Developed by authors.

were sensitive to the impact of temperature, and these research studies identified found a temperature as an important factor, impacting the stock market.

10. Citation-Based Analysis

Table 6 summarizes the most impactful research articles in the area of weather effect and stock market behaviour and they are arranged in descending order of their citations, along with the year of publication. It is to be noted that out of 51 articles considered for this study, 48 articles reported citations while three articles received no citation. The Table clearly shows that Edward M. and Saunders, Jr were the most cited authors, with 913 citations for their research work entitled “Stock Prices and Wall Street Weather”, which was published in 1993. The research article, published by M. Cao, and J. Wei, with the titled “Stock market returns: A note on temperature anomaly” was the second most impacted research study, with 457 citations. Out of 48 research articles, only 16 articles were cited more than 50 times. 35 research studies were published during the last 10 years (2009 onwards). This clearly indicated that the studies on weather effect and stock market were popular among the researchers, during the last one decade.

11. Conclusion and future research implications

All human activities would be affected by the climate/environment changes, and certainly, weather does affect the individual decision-making, and their investment decision-making process. This paper primarily aimed to review the earlier research works, published in the area of weather factors and investment decisions. Present study identified 51 scholarly research papers, published by different journals from 1993 to 2019. The aim of the present study was to analyze the important characteristics of studies, which had contributed more in understanding the particular domain of weather and stock market. The present study adopted SLR model. It is clear that the research works carried out in the area
| S.No | Year of Publication | Details of Author’s | Title of Study/Article                                                                 | No. of Citations |
|------|-------------------|-------------------|----------------------------------------------------------------------------------------|-----------------|
| 1    | 1993              | Edward M. and Saunders, Jr | Stock Prices and Wall Street Weather                                                    | 913             |
| 2    | 2005              | M. Cao, and J. Wei | Stock market returns: A note on temperature anomaly                                     | 457             |
| 3    | 2005              | William N. Goetzmann and Ning Zhu | Rain or Shine: Where is the Weather Effect?                                             | 256             |
| 4    | 2005              | M. Dowling, B.M. Lucey | Weather, biorhythms, beliefs and stock returns- Some preliminary Irish evidence       | 121             |
| 5    | 1997              | Mark A. Trombley | Stock Prices and Wall Street Weather: Additional Evidence                               | 116             |
| 6    | 2003              | Angel Pardo and Enric Valor | Spanish Stock Returns: Where is the Weather Effect?                                     | 111             |
| 7    | 1997              | W. Kramer and R. Runde | Stocks and the Weather: An Exercise in Data Mining or Yet Another Capital Market Anomaly? | 106             |
| 8    | 2006              | T. Chang et al | Are stock market returns related to the weather effects? Empirical evidence from Taiwan | 100             |
| 9    | 2009              | S.-M. Yoon, S.H. Kang | Weather effects on returns: Evidence from the Korean stock market                      | 63              |
| 10   | 2010              | S.H. Kang et al. | Weather effects on the returns and volatility of the Shanghai stock market             | 63              |
| 11   | 2004              | Ekrem Tufan and Bahattin Hamarat | Do Cloudy Days Affect Stock Exchange Returns: Evidence from Istanbul Stock Exchange | 62              |
| 12   | 2016              | M. Kaustia, and E. Rantapuska | Does mood affect trading behavior?                                                      | 58              |
| 13   | 2002              | Keef and Roush | The Weather and Stock Returns in New Zealand                                            | 57              |
| 14   | 2012              | J. Lu and R.K. Chou | Does the weather have impacts on returns and trading activities in order-driven stock markets? Evidence from China | 54              |
| 15   | 2005              | Keef and Roush | Influence of weather on New Zealand financial securities                                | 53              |
| 16   | 2008              | O. Levy and I. Galili | Stock purchase and the weather: Individual differences                                  | 53              |
| 17   | 2011              | Christos Floros | On the relationship between weather and stock market returns                            | 38              |
| 18   | 2008              | Christos Floros | Stock market returns and the temperature effect: new evidence from Europe              | 30              |
| S.No | Year of Publication | Details of Author's | Title of Study/Article | No. of Citations |
|------|---------------------|---------------------|------------------------|-----------------|
| 19   | 2015                | M. Frühwirth, L. Sögner | Weather and SAD related mood effects on the financial market | 23              |
| 20   | 2009                | H.-C. Shu and M.-W. Hung | Effect of wind on stock market returns; evidence from European markets | 22              |
| 21   | 2009                | Andrew Worthington | An Empirical Note on Weather Effects in the Australian Stock Market | 19              |
| 22   | 2012                | Y.-H. Wang et al | Does weather impact the stock market? Empirical evidence in Taiwan | 18              |
| 23   | 2015                | G. Cao & Y. Han | Does the weather affect the Chinese stock markets? Evidence from the analysis of DCCA cross-correlation coefficient | 16              |
| 24   | 2012                | R. K. Brahmana et al | Weather, investor irrationality and day-of-the-week anomaly: case of Indonesia | 15              |
| 25   | 2015                | H. Shim et al. | Weather and stock market volatility: the case of a leading emerging market | 15              |
| 26   | 2018                | Kathiravan. C. et al | An Empirical Investigation of the Interlinkages of Stock Returns and the Weather at the Indian Stock Exchange | 15              |
| 27   | 2011                | Y.-M. Lee, K.-M. Wang | The effectiveness of the sunshine effect in Taiwan’s stock market before and after the 1997 financial crisis | 14              |
| 28   | 2017                | Kathiravan. C. et al | Effect of Temperature on Stock Market Indices: A Study on BSE and NSE in India | 11              |
| 29   | 2018                | Kathiravan. C. et al | On the relationship between weather and Agricultural Commodity Index in India: a study with reference to Dhaanya of NCDEX | 9               |
| 30   | 2018                | Kathiravan. C. et al | Stock market returns and the weather effect in Sri Lanka | 9               |
| 31   | 2010                | C. Goodfellow et al | Does screen trading weather the weather? A note on cloudy skies, liquidity, and computerized stock markets | 8               |
| 32   | 2016                | N. Apergis et al | (Unusual) weather and stock returns—I am not in the mood for mood: further evidence from international markets | 8               |
| 33   | 2011                | Sribuonchitta et al | Stock market returns and the temperature effect: Evidences from Thailand | 7               |

(Continued)
| S.No | Year of Publication | Details of Author’s | Title of Study/ Article | No. of Citations |
|------|---------------------|---------------------|--------------------------|-----------------|
| 34   | 2016                | Nikolaos Sariannidis (2016), Europe | The effect of weather on the European stock market: The case of Dow Jones Sustainability Europe Index | 6               |
| 35   | 2017                | M. F. Sheikh et al. | Weather Effects on Stock Returns and Volatility in South Asian Markets | 6               |
| 36   | 2015                | Cao et al. | Effects of climatic events on the Chinese stock market: applying event analysis | 5               |
| 37   | 2019                | Kathiravan. C. et al. | Investor behavior and weather factors: evidences from Asian region | 5               |
| 38   | 2014                | R. Brahmana et al | The Role of Weather on Investors’ Monday IRRATIONALITY: Insights from Malaysia | 4               |
| 39   | 2015                | R.K. Brahmana et al. | Does tropical weather condition affect investor behaviour? Case of Indonesian stock market | 3               |
| 40   | 2017                | Q. Li. Et al. | Relationship research between meteorological disasters and stock markets based on a multifractal detrending moving average algorithm | 3               |
| 41   | 2014                | Ic, Kahyaoglu and Odabas, | The effects of weather on investor behavior: a study on individual Turkish stock market investors | 3               |
| 42   | 2017                | N. Apergis and R. Gupta | Can (unusual) weather conditions in New York predict South African stock returns? | 2               |
| 43   | 2018                | Yi-Hsien Wang et al. | Relationship among Weather Effects, Investors’ Moods and Stock Market Risk: An Analysis of Bull and Bear Markets in Taiwan, Japan and Hong Kong | 2               |
| 44   | 2015                | Sveltana Vlady | The Effect of Climate Change on Australian Stock Equity Returns | 2               |
| 45   | 2019                | Anya Khatkhat | Weather, investor sentiment, and stock returns in the stock exchange of Thailand | 2               |
| 46   | 2011                | Pedro M. Silva et al. | Weather and stock markets: empirical evidence from Portugal | 1               |
| 47   | 2012                | Suzaida Bakar and Noraina Mazuin Sapuan | Are Stock Market Returns Related to the Weather Effects Factors? Empirical Evidence from Malaysia | 1               |
| 48   | 2019                | Farrukh shahzad | Does weather influence investor behavior, stock returns, and volatility? Evidence from the Greater China region | 1               |

Sources: Developed by authors from Google Scholar as of 26 October 2019.
of weather factors and stock market, over the study period had been gradually increasing, especially from 2009 to 2019. Majority of research publications on weather effect and stock market were carried out by researchers of developed countries, namely, USA, UK and Europe but there were many countries that did not pay adequate attention to research in the same area. Some studies used new econometric tools like DCCA Cross Correlation and ARDL approach, etc., along with the usual tools of correlation test, causality tests, etc. for better understanding. This is the first study that has been undertaken to overview the studies already done so far on weather effect and stock market. The present study also gives the scope for further research and future direction in the area of weather effect and stock returns. It is found from taking the literature of last two decades that the content analysis could be performed for the research studies on weather factors and stock returns. Hence, more research papers could be included and analyzed to offer more accurate inferences on the determinants of stock returns.

12. Limitations
a. The study found very few references particularly after 2016 due to non-availability and non-publication of articles.

b. The present study did not consider working paper series, thesis and unpublished papers.

c. This study ignored few important studies (Unpublished Working Papers).

d. The study did not offer Journal wise analysis.

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