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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 widely 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 summarizes 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 mostly 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 in 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 others 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

(Continued)

Table1. (Continued)

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 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 Galili (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, Luxembourg, 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), t-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 influenced the market efficiency
Kang 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 did 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

(Continued)

Table1. (Continued)

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,	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	1995–2007	Descriptive Statistics and GARCH	Temperature impacted negatively the stock market
Lu and Chou (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)

Table 1. (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 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 Rantapaska (2016), Finland	Does mood affect trading behavior?	suniness, 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

(Continued)

Table 1. (Continued)

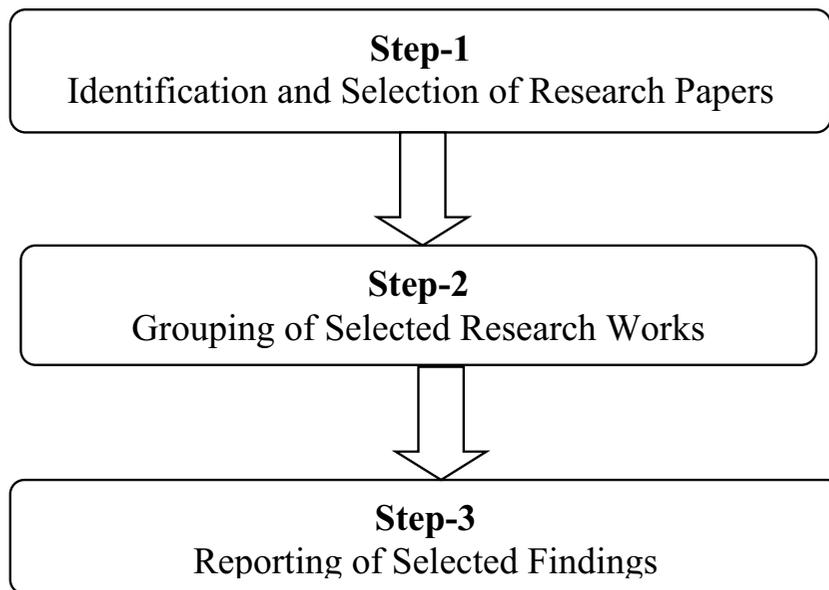
Details of Author's	Title of Study	Weather Factors	Name of Stock Market	Study Period	Tools	Findings and conclusions
Kathiravan. C. et al. (2017), India	Effect of Temperature on Stock Market Indices: A Study on BSE and NSE in India	Temperature	BSE Sensex and S&P CNX Nifty	2000–2015	Descriptive Statistics, 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, thunderstorm, 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, 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 excised 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)

Table 1. (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	Australian Stock Exchange	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		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
Andrikopoulos 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

Figure 1. Systematic Literature Review (SLR).



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

Figure 2. Classification of available literature in the area of weather effect and stock market.

Sources: Developed by authors

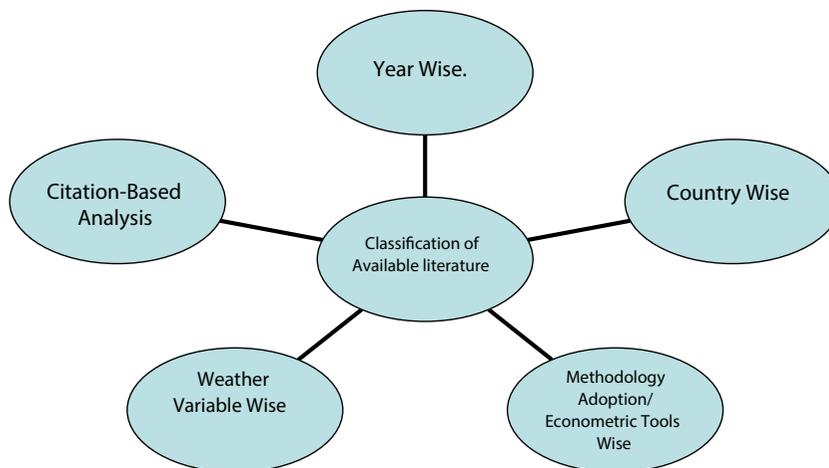


Table 2. Year wise grouping of publications on weather factors stock market

S.No	Year of Publication	No. of studies
1	1993	1
2	1997	2
3	2002	1
4	2003	1
5	2004	1
6	2005	4
7	2006	1
8	2008	2
9	2009	3
10	2010	2
11	2011	5
12	2012	4
13	2014	2
14	2015	6
15	2016	3
16	2017	4
17	2018	5
18	2019	4
Total		51

Sources: Developed by authors from Google Scholar as of 26 October 2019.

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

Table 3. Country wise distribution of grouping of publication on weather factors and stock market behaviour

S.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

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

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

Table 6. Impactful research articles on weather effect and stock market

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

(Continued)

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. Brahma 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	Sriboonchitta et al.	Stock market returns and the temperature effect: Evidences from Thailand	7

(Continued)

Table6. (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 Khanthavit	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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