

# Weather Impacts on Chinese Stock Return

—Evidence from 7 Cities in China

Yun Sun

International Business Faculty  
Beijing Normal University, Zhuhai  
Zhuhai, China  
sam@bnuz.edu.cn

Haomin Zhang

School of Business  
Macau University of Science and Technology,  
Macau SAR, China  
hmizhang@must.edu.mo

Pu Wu

Macau University of Science and Technology  
Macau SAR, China  
1709853ebj20001@student.must.edu.mo

Shaosong Wang\*

School of Business  
Macau University of Science and Technology  
Macau SAR, China  
\* Corresponding Author  
sswang@must.edu.mo

**Abstract**—Behavioral economics believes that weather could influence the investor's sentiment, which in turn interferes with the investor's investment behavior and trigger the volatility of the stock market. This paper takes this as the research direction and combines China's weather variables with the stock market to conduct an empirical analysis. We collect the weather variables and calculate the weighted average to test the effects of temperature, humidity, dew point, wind speed, pressure. In addition, we establish a link between these weather variables and Shanghai Composite Index, from January 4, 2016, to January 4, 2019. The generalized autoregressive conditional heteroscedasticity (GARCH) model is used to fit the volatility of each weather variable with the stock index of the Shanghai Composite Index. The empirical results show that weather effect exists in China's securities market. This paper gives investors some suggestions to help them to view their investment behavior rationally and provides some reference value for market regulators and meteorological departments.

**Keywords**—behavioral economics; weather effect; stock index; GARCH

## I. INTRODUCTION

The weather is objective and uncontrollable. It directly affects the emotional values of people in daily life and drives people to produce relatively irrational behaviors, which in turn causes fluctuations in the stock market. On the other hand, the stock market is the indicator data reflecting the performance and development of listed companies. The two things that were originally irrelevant have been inextricably influenced by people's emotional fluctuations and irrational behavior. According to the book "Behavioral Economics" [1], which is written by Professor HA Simon, pointed out that human thinking ability is not endless. Bounded rationality is precise because such people do not pursue the utility of the paradigm in economics in terms of behavior. Instead, they will make the most satisfying choices according to their own perceptions of the surrounding environment and their limited thinking.

Weather is the best exogenous variable for studying the irrational behavior of financial markets. Based on Behavioral Economics, the weather could influence individuals' trading behaviors via mood. Specifically, good weather usually brings well performance in stock market. Conversely, bad weather could influence stock market in negative direction [2]. This paper tries to explore weather effects on Chinese stock market. Under the background of China's securities market, we examine whether the stock market could bring about the same fluctuations as the results of foreign securities market research, helping investors to clarify investment interference variables.

In this paper, we select five weather variables from seven representative Chinese cities (Shanghai, Shenyang, Beijing, Changsha, Guangzhou, Chongqing and Lanzhou) from January 4, 2016 to January 4, 2019. We link these weather indicators (temperature, pressure, humidity, dew point and wind speed), with the data of the daily closing price of the Shanghai Composite Index during the same period. After examining a series of data processing and analysis from GARCH model, we found that weather could influence the Chinese stock market significantly.

The remainder of the paper is as follows: Literature illustrates in Section II. Data and methodology in Section III and the results and discussions are listed in Section IV. The V section is the conclusion.

## II. LITERATURE REVIEW AND HYPOTHESIS

The impact of weather on people's behavior has always been examined in behavioral economics area. For example, Li, Duan and Li [3] found that the greater the humidity in the air, the higher the humidity, the easier it is. The feeling of low concentration and increased exhaustion has a significant impact on the investor's mood swings. In addition, the visibility indicator for the weather, that is, how far the observer can clearly see the object when it is far from the object, seems illusory. However, it also moves people's emotional values in a subtle way. When there is a haze with insufficient light and low

visibility, people's mood could become more depressed. Howarth and Hoffman [4] used ten emotional variables and eight weather variables to conclude that the three variables of temperature, humidity and sunshine duration could significant influence individuals' mood.

Some studies have explored the link between weather and stock market. For example, cloudiness has been found a negative effect on stock return [5], as well as temperature [6]. To conclude, weather could significantly influence stock market via mood. In this paper, we try to establish the link in Chinese stock market. We exam temperature, pressure, humidity, dew point and wind speed to explore whether this is an impact on the Chinese stock market. Based on these, we develop our hypothesis is as follows:

H1: The Chinese stock return is significantly influenced by weather variables.

H2: Temperature could positively influence the stock return in China.

**III. DATA AND METHODOLOGY**

**A. Weather data and independent/controlling variables**

To test our hypothesis in the paper, we try to establish links with weather and stock data. The daily weather data of 7 cities are collected from Weather Underground from 4<sup>th</sup> January 2016 to 4<sup>th</sup> January 2019, including temperature, pressure, humidity, dew point and wind speed. In particular, we deseasonalize weather data with the same method of Wang et al. [7], since weather is highly seasonal. As a result, we describe the weather data in Table I as follows.

TABLE I. DESCRIPTION OF INDEPENDENT AND CONTROL VARIABLES

Variable Type	Variables	Description	Raw Data Unit / Code
Intendent variable	Dtemp	Deseasonalized Temperature	Celsius (°F)
Intendent variable	Dpres	Deseasonalized Air Pressure	Sea level pressure (hPA)
Intendent variable	Dwind	Deseasonalized Wind Speed	Meter / Hour
Intendent variable	Dhum	Deseasonalized Humidity	Humidity %
Intendent variable	Ddewp	Deseasonalized Dew point	Celsius (°F)

**B. Stock data and dependent variables**

The stock market data is from Shanghai stock exchange index, which is also daily data from exactly the same period as weather data. Therefore, we calculate the stock return with daily Shanghai Stock Index. The equation is as follows:

$$\text{LogMarketReturn}_t = \text{Log}\left(\frac{\text{MarketPrice}_t}{\text{MarketPrice}_{(t-1)}}\right) \quad (1)$$

We use GARCH model to test our hypothesis. The following equation is the detailed description of the GARCH model used in this paper.

$$h_t = \alpha_0 + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \beta_j h_{t-j} = \alpha_0 + \alpha(B) \varepsilon_t^2 + \beta(B) h_t \quad (2)$$

**IV. RESULTS AND ANALYSIS**

**A. Basic Test**

We firstly take the correlation test and do not find the highly correlated variables, which mean our model does not suffer the issue of multicollinearity. The results are illustrated in Table II. Since weather and stock return are highly trended and we may have unit roots problem, we, therefore, exam the unit root with ADF test. The results are in Table III. Based on the results in this table, we can reject the null hypothesis and confirm that we do not have the issue of autoregression.

TABLE II. WEATHER VARIABLES CORRELATION COEFFICIENT MATRIX

Variable	DFS1	DLDI	DSDI	DWDI	DYQI
DFS1	1	-0.1214	-0.0050	-0.1127	0.0750
DLDI	-0.1214	1	0.7593	0.7245	0.2151
DSDI	-0.0050	0.7593	1	0.1853	0.3473
DWDI	-0.1127	0.7245	0.1853	1	-0.0141
DYQI	0.0750	0.2151	0.3473	-0.0141	1

TABLE III. INSPECT THE CONCLUSION

Variable	(c, t, k)	ADF	1% level	5% level	Stationarity
RSZ	(0,0,0)	-28.79327	-2.568125	-1.941256	Steady
DWDI	(0,0,10)	-16.57946	-2.568125	-1.941256	Steady
DYQI	(0,0,0)	-27.02266	-2.568125	-1.941256	Steady
DSDI	(0,0,8)	-14.49490	-2.568125	-1.941256	Steady
DLDI	(0,0,9)	-16.74672	-2.568125	-1.941256	Steady
DFS1	(0,0,16)	-13.61265	-2.568125	-1.941256	Steady

**B. GARCH(1,1) Test**

To exam whether our research hypothesis is accepted, we run the GARCH model to test our results, The GARCH (1,1)-GED results are shown in Table IV, as this model contains the minimum AIC and SC, which means the best-fitted model in this paper. In this table, we could find that temperature could positively influence the stock return. In addition, the impact of the dew point on the stock return is negative. These results confirm that weather could significantly influence Shanghai stock exchange, in particular, the higher the temperature, the higher the stock return. This result is in line with Yi [8] and Lu [9]. However, humidity and wind speed cannot significantly influence the stock return. A possible reason is that people are not sensitive with wind and humidity, but sensitive to temperature changes.

TABLE IV. PARAMETER ESTIMATION TABLE GARCH(1,1)-GED

Variable	Coefficient	Standard error	Statistical magnitude of Z	P value
The mean equation				
DWDI	0.000413	0.000172	2.403826	0.0162**
DYQI	-0.000328	0.000462	-0.710409	0.4775
DSDI	0.000126	8.55E-05	1.467557	0.1422
DLDI	-0.000338	0.000172	-1.959022	0.0501*
DFS1	-0.000106	0.000112	-0.949909	0.3422
C	0.000657	0.000238	2.754703	0.0059**
Variance equation				
C	1.04E-06	4.40E-07	2.352280	0.0187**
RESID(-1) <sup>2</sup>	0.051604	0.015337	3.364611	0.0008**
GARCH(-1)	0.933148	0.015095	61.81721	0.0000***

**C. Robustness Test**

To further exam whether our results are robustness or not, we exam the results with EGARCH (1,1). The results are shown in Table V and we can find that the results are not very different from GARCH-GED model, indicating our findings are robustness. More specifically, we find temperature still positively influences stock return in Shanghai. In contrast, dew points negatively affect Shanghai stock market. These results could confirm that weather could significantly influence Shanghai stock market.

**V. CONCLUSION**

Previous studies have explored the link between weather and mood and mood and decision-making. Therefore, we try to establish the relationship between weather and stock market, via the mood as the chain. To test our hypothesis, we collect data from 7 cities in China with the GARCH model. We find that weather could significantly influence the Shanghai stock market; in particular, a higher temperature can bring better stock performance. We believe our results are robustness since we control for related weather variables and take the EGARCH model as the further test. However, we still suffer some limitations, since our data is daily and we do not have individuals' trading data. Future studies are recommended to use hourly and individuals' data if available.

TABLE V. PARAMETER ESTIMATION TABLE EGARCH(1,1)-GED

Variable	Coefficient	Standard error	Statistical magnitude of Z	P value
The mean equation				
DWD1	0.000359	0.000165	2.173180	0.0298**
DYQ1	-0.000703	0.000311	-2.260080	0.0238**
DSD1	9.04E-05	8.09E-05	1.116366	0.2643
DLD1	-0.000303	0.000163	-1.860953	0.0628*

Cont. to TABLE V				
DFS1	-9.42E-05	0.000101	-0.929473	0.3526
C	0.000376	0.000220	1.708112	0.0876**
Variance equation				
C(7)	-0.101786	0.005066	-20.09330	0.0000
C(8)	0.056995	0.017678	3.224011	0.0013
C(9)	-0.066171	0.020213	-3.273674	0.0011
C(10)	0.994658	0.001522	653.4441	0.0000

**ACKNOWLEDGMENT**

We would like to thank the Program for Research Development of Beijing Normal University, Zhuhai, and International Business Faculty, who support this project (Project No. 201754021 and 201754024).

**REFERENCES**

- [1] Simon H A. Behavioral economics' and Satisficing.
- [2] Brown G W, Cliff M T. Investor Sentiment and Asset Valuation. *The Journal of Business*, 2005, 78(2):405-440.
- [3] Li, Z.F., Duan, M.F., Li, D. The impact of weather on the Chinese stock market. *Statistics & Information Forum*.33(10), 2018:35-43.
- [4] Howarth, E., Hoffman, M.S. A multidimensional approach to the relationship between mood and weather. *British Journal of Psychology*, 1984: 75(1), 15-23.
- [5] Saunders, E.M. Stock prices and Wall Street weather. *The American Economic Review*, 83(5), 1993: 1337-1345.
- [6] Hirshleifer, D., Shumway, T. Good day sunshine: Stock returns and the weather. *Journal of Finance*, 58(3), 2003: 1009-1032.
- [7] Wang, J.Q., Yi, C.L. Weather, seasonal emotional disorder and stock returns—Based on the study of shanghai composite index. *Statistics & Decision*.2005(6):79-82.
- [8] Yi, C, L. China's securities market price fluctuations .Doctoral dissertation. 2006.
- [9] Lu, J. An empirical study of weather effects in china's stock market. *China Soft Science*. 2011(6):65-78.