

Weather Impacts on Stock Market

—Evidence from Hong Kong Stock Market Between Financial Crisis

Yun SUN

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

Shaosong WANG*

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

Abstract—Previous research has explored the link of weather, mood and behaviors. In particular, some studies demonstrated weather impacts on stock returns. However, most literature included the sample period of financial crisis when they link weather and stock market. In this paper, we investigate the relationship of daily cloudiness and Hong Kong stock market between two financial crises from 1999 to 2006, with 1,824 samples. We believe this is important, since individuals' decisions are more likely to be calm to trade out of financial crisis period. Consequently, the weather impacts on stock market are more convincing if these impacts could still be found out of financial crisis period. OLS regression and logistic model are used to test the hypothesis. After controlling for January, Monday and seasonality, we find that lower cloudy cover could induce higher stock return between financial crisis period of 1997 and 2008 in Hong Kong.

Keywords—Behavioural Economics; Weather; Financial Crisis; Hong Kong Stock Market

I. INTRODUCTION

Behavioral finance has been established to test people's irrational behaviors in recent years. Conventional economics theory assumed that people are rational and the market is efficient [1], therefore, people should behavior rationally and trade in the market by fundamental news. However, some anomalies exist in economics and financial market, particularly in stock exchange, such as Herding behaviors [2]. Consequently, people seem not always rational, and their behaviors could be influenced by many surrounding factors, such as other individuals (i.e. herding), weather etc.

Previous studies have explored the links between weather and mood [3] and between mood and decisions [4]. Therefore, it is not surprising that some literature established links between weather and decision [5]. In particular, Saunders' [6] firstly found weather could significantly influence people's economical/financial decisions; indicating cloudiness decreased the stock return on the New York Stock Exchange. After that, many other weather variables, such as temperature [7], air pressure [8] etc.

However, the weather and economical/financial decisions have not been explored a lot in Hong Kong. Hirshleifer and Shumway's study [9] focused on 26 cities in the world, including Hong Kong from 1982 to 1997. In this paper, we only focus in Hong Kong stock exchange from 1999 to 2006,

which is between two financial crisis in 1997 and 2008. We believe this is important, since individuals' decisions are more likely to be calm to trade out of financial crisis period. During the crisis, most people are under high pressure, and the weather impacts may not be accurate since individuals could be easily influenced by other factors. Therefore, our data exclude the financial crisis period, which, we believe, could bring a more accurate picture of weather impacts on Hong Kong stock market.

We try to explore the relationship between weather and Hong Kong stock return. Therefore, we employ the stock and weather data from Yahoo Finance and Hong Kong Observatory, respectively, including 8 years daily data from 1999 to 2006. Our findings suggest that cloudiness, the most important weather factor, could significantly influence Hong Kong stock market.

The reminder of this paper is organized as follows: Section II is literature that examined the links between weather, mood and stock market. Section III is data and methodology. The results are presented in Section IV and conclusion is in Section V.

II. LITERATURE REVIEW AND HYPOTHESIS

It has been demonstrated that weather could significantly influence mood. In particular, good weather induces mood and bad weather brings negative mood [10]. For example, cloudiness, higher temperature and wind are negatively correlated with mood [11]. Some literature has also explored a link between weather and decision-making, via the chain of mood. In particular, higher temperature can lead to violence and suicide [12], while rainy days could induce decision accuracy [13].

Some studies have established the relationship between weather and decision-making in economics and finance area. For example, cloudiness, as the most importantly weather factor, has been found a negative impact on stock return [6], as well as temperature [7] etc. Furthermore, some literature [14] control for Halloween (1 from April to October, 0 otherwise) dummy, since weather is seasonal. To sum up, weather, particularly for cloudiness, has been explored a link with stock market via mood. However, Hong Kong, as one of the most important economical area in Asia, has not been studied a lot. Moreover, humidity has normally been ignored by literature.

Humidity is not only a common weather phenomenon, more importantly, it could significantly influence individuals' mood [10], and in turn, decision-making. Furthermore, weather factors are highly correlated; therefore, controlling for other weather phenomena could bring a more accurate picture of weather impacts on stock market. Consequently, we need to control for ranges of weather factors to improve the accuracy of our test. Based on these, we develop our hypothesis is as follows:

H0: The Hong Kong stock return is significantly influenced by cloudiness, and this impact is negative.

III. DATA AND METHODOLOGY

A. Weather data and independent/controlling variables

In order to examine our hypothesis in this paper, we need to link two databases: Hong Kong weather data and Hong Kong stock market data. We employed the daily weather data from Hong Kong Observatory, including daily raw cloudiness, rainfall, temperature, air pressure, wind speed and humidity from 1999 to 2006. In particular, since weather data is highly seasonal, therefore, we follow the method of Goetzmann and Zhu [15] who firstly calculate the monthly average weather factors from raw data, then use raw weather data minus the monthly average weather factors. This process named deseasonalize.

Cloudiness is the main independent variable in this study, however, fail to control for other weather factors may lead to inaccurate regression results, since weather factors are highly correlated. Furthermore, we control for January and Monday effects [7], as these two effects could significantly influence stock return. Finally, we control for Halloween as seasonal weather factor. Previous studies normally define Halloween as a dummy variable, equaling to 1 if it is from May to October (i.e. summer) and 0 (i.e. winter) otherwise. However, summer in Hong Kong is much longer than most countries in the world. Therefore, we define Halloween as 1 if it is from April to November and 0 otherwise. The full independent and controlling variables are illustrated in Tab. I.

TABLE I. DESCRIPTION OF INDEPENDENT AND CONTROL VARIABLES

Variable Type	Variables	Description	Raw Data Unit / Code
Intendent variable	<i>Dcloud</i>	Deseasonalized Cloudiness	Okta 0-9 (No Cloud- Overcast)
Controlling variable	<i>Drain</i>	Deseasonalized Rainfall	Millimeter (mm)
Controlling variable	<i>Dtemp</i>	Deseasonalized Temperature	Celsius (°C)
Controlling variable	<i>Dpres</i>	Deseasonalized Air Pressure	Sea level pressure (hPA)
Controlling variable	<i>Dwind</i>	Deseasonalized Wind Speed	Meter / Second
Controlling variable	<i>Dhum</i>	Deseasonalized Humidity	Humidity %
Controlling variable	<i>Halloween</i>	Halloween Dummy	1 = April to November, 0 otherwise
Controlling variable	<i>January</i>	January effect Dummy	1 = January, 0 otherwise
Controlling variable	<i>Monday</i>	Monday effect Dummy	1 = Monday, 0 otherwise

B. Stock data and dependent variables

The stock data is employed from Yahoo Finance, which contains daily stock information from 1999 to 2016. Most literature calculated the stock returns with indexes from different stock exchanges, such as Dow Jones, FTSE 100 and DAX 30 etc. We, therefore, calculated Hong Kong stock return with daily Hang Seng Index. The equation of stock return is as follows:

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

In addition, we need to control for the stock return_(t-1), since our daily data is time serious, and unit root may exist. Therefore, we control for lag return to eliminate the possible unit root [6]. Then, we link two databases, weather and stock market data, with time. We then have 1,824 sample to test our hypothesis in the paper.

We use both OLS regression and logistic model to test our hypothesis. In particular, Logistic model will be the robust test of OLS regression. If the results from these two models are not significantly different, we then believe our results are convincing. These two models are as follows:

$$\text{Return}_t = \alpha_t + \beta_1 \text{Return}_{t-1} + \beta_2 \text{Dcloud}_t + \beta_3 \text{Drain}_t + \beta_4 \text{Dtemp}_t + \beta_5 \text{Dpres}_t + \beta_6 \text{Dwind}_t + \beta_7 \text{Dhum}_t + \beta_8 \text{January} + \beta_9 \text{Monday} + \beta_{10} \text{Halloween} + \varepsilon_t \quad (2)$$

$$P(\text{Return}_t > 0) = \frac{1}{1 + e^{-\{\gamma_1(\text{Dweather}_t + \text{January} + \text{Monday} + \text{Halloween})\}}} \quad (3)$$

Where: Dweather represents for deseasonalized weather factors

IV. RESULTS

A. Exploratory Test

We firstly examine the correlation test between weather factors and stock return. We can find deseasonalized cloudiness is significantly correlated with stock return (Pearson Correlation Coefficient is -0.07, t-value is 0.005). In particular, the correlation is negative, indicating that the higher the cloudiness, the lower the stock return. Other controlling weather variables are not significantly correlated with stock return. Based on the correlation results, we can simply predict cloudiness plays key role in Hong Kong stock returns. However, correlation test is only an examination of relationship with two variables, not cause-effect relationship. In other words, if we want to exam whether or not cloudiness can significantly cause the movement of stock return, we need further test, i.e. regression and logistic analysis.

TABLE II. RESULTS OF OLS AND LOGISTIC REGRESSIONS (T-VALUES IN BRACKETS)

Variables	OLS regression	Logistic regression
Lagged market return	0.26311 (11.614)***	
Deseasonalized Cloudiness	-0.00033 (-1.965)**	-0.07152 (-2.246)**
Deseasonalized Rainfall	0.00026 (0.874)	0.02379 (0.420)
Deseasonalized Temperature	0.00005 (0.341)	-0.00195 (-0.072)
Deseasonalized Air Pressure	-0.00003 (-0.385)	-0.01297 (-0.774)
Deseasonalized Wind Speed	-0.00022 (-1.000)	-0.03310 (-0.790)
Deseasonalized Humidity	-0.00002 (-0.045)	0.00897 (1.301)
January	-0.00049 (-0.489)	-0.04517 (-0.235)
Monday	-0.00003 (-0.044)	0.13931 (1.175)
Halloween	0.00002 (0.041)	0.04616 (0.410)

***significant at 1% level
**significant at 5% level

B. Confirmatory Test

To conform the exploratory results, we conduct the OLS regression test. The OLS regression results are shown in the second column of Tab. II. In this table, we can find that cloudiness could significantly (at 5% significant level) influence the stock return. Not surprisingly, this impact is negative; indicating that lower cloudiness (i.e. sunshine) could significantly induce the stock return in Hong Kong stock exchange. This result is consistent with most literature (e.g. Saunders [6]), that morning sunshine can increase the stock return. The possible reason for that is because individuals' mood is induced by lower cloudy cover, which in turn, brings more optimism estimation of stock return. Therefore, more bullish sentiments would be happen in stock exchange, and, in turn, induce the stock return. However, we cannot find any other weather factors significantly influence stock return, which is not in line with literature's findings (e.g. Cao and Wei, [7]). A possible reason is because people in Hong Kong do not really care about the weather factors like temperature, since air conditions are everywhere in Hong Kong, and they are comfortable when they stay in air condition room and trade in stock via computer. Whatever the reason is, we can find that cloudiness negatively influence the stock return, which could support our hypothesis.

C. Robustness Test

To further test our results are robustness, we try to examine logistic regression, which is shown in the third column of Tab. II. Strikingly, we find, again, cloudiness is negatively correlated with stock return, and the p-value is even smaller, indicating cloudiness is statistical more significant than OLS regression. One more time, our result is in line with literature [6], that cloudiness reduces stock return. More importantly, the result is consistent with our OLS result, which supports our

hypothesis that cloudiness could significantly negative affect Hong Kong stock return. However, we still cannot find any other weather factors bring significant impacts. Again, it seems that individuals in Hong Kong are not significantly influenced by weather factors, except cloudiness.

V. CONCLUSION

Previous literature explored that weather can significantly influence individuals' mood, which in turn, affect decision-making processes. Some studies discovered the weather impacts on stock return. However, these studies cover the data period of financial crisis. We believe it would be more accurate if we control for the data, excluding financial crisis period, since people are more struggling to trade during financial crisis, and their trading behaviors could be easily influenced by many surrounding factors, not only weather. Therefore, in this paper, we try to skip the financial crisis period to examine the real weather impacts on stock return, from 1999 to 2006. Using daily data and regression analysis, we find that cloudiness could negatively influence the stock return in Hong Kong stock exchange. We believe our methodology are robustness, since we examine our hypothesis by OLS and Logistic regressions, and the results are very similar. However, this paper has some limitation, as we only use daily data to examine the relationship. Weather and stock price change very frequently, and we think daily data may not completely reflect the frequency of changes in weather and stock return. Further studies are recommended to use hourly data if it is available.

ACKNOWLEDGMENT

We would like to thank Research and Technology Administration Office of Macau University of Science, who supports this project. Project code: FRG-16-008-MSB.

REFERENCES

- [1] Fama, Eugene F. "The behavior of stock-market prices." *The journal of Business* 38.1, 1965: 34-105.
- [2] Trueman, Brett. "Analyst forecasts and herding behavior." *Review of financial studies* 7.1, 1994: 97-124.
- [3] Keller, M.C., Fredrickson, B.L., Ybarra, O., Côté, S., Johnson, K., Mikels, J., Conway, A., Wager, T.. A warm heart and a clear head: The contingent effects of weather on mood and cognition. *Psychological Science*, 16(9), 2005: 724-731
- [4] Loewenstein, G. F., Weber, E.U., Hsee, C.K., Welch, N.. Risk as feelings. *Psychological Bulletin*, 127(2), 2001: 267-286.
- [5] Wyndham, H.C.. Adaptation to heat and cold. *Environmental Research* 2(5), 1969: 442-469
- [6] Saunders, E.M. Stock prices and Wall Street weather. *The American Economic Review*, 83(5), 1993: 1337-1345.
- [7] Cao, M., Wei, J. Stock market returns: A note on temperature anomaly. *Journal of Banking and Finance*, 29,1559-1573.Chang, S.C., Chen, S.S, Chou, R.K., Lin, Y.H. 2008. Weather and intraday patterns in stock returns and trading activity. *Journal of Banking and Finance*, 32(9), 2005: 1754-1766.
- [8] Schneider, Michael. "Under pressure: Stock returns and the weather." 2014
- [9] Hirshleifer, D., Shumway, T. Good day sunshine: Stock returns and the weather. *Journal of Finance*, 58(3), 2003: 1009-1032.

- [10] Howarth, E., Hoffman, M.S. A multidimensional approach to the relationship between mood and weather. *British Journal of Psychology*, 1984: 75(1), 15-23.
- [11] Denissen, J.J., Butalid, L., Penke, L., Van Aken, M.A. The effects of weather on daily mood: A multilevel approach. *Emotion*, 8(5), 2008: 662-667.
- [12] Hsiang, S. M., Burke, M., Miguel, E. Quantifying the influence of climate on human conflict. *Science*, 2013: 341(6151) doi:10.1126/science. 1235367.
- [13] Forgas, J.P. Goldenberg, L., Unkelbach, C. Can bad weather improve your memory? An unobtrusive field study of natural mood effects on real-life memory. *Journal of Experimental Social Psychology*, 45(1), 2009: 254-257.
- [14] Jacobsen, B., and Marquering, W. Is it the weather? Response. *Journal of Banking and Finance*, 33(3), 2009: 583-587.
- [15] Goetzmann, W.N., Zhu, N. Rain or shine: where is the weather effect? *European Financial Management*. 2005. 11(5), 559-578.