

An Empirical Study Based on the Impact of Weather Factors on the Shanghai Stock Exchange 50 ETF

Zihan He

*School of Economics and Finance, Central University of Finance and Economics, Beijing, China
2024310406@email.cufe.edu.cn*

Abstract. In addition to rational analysis and judgment in the stock trading market, subjective factors such as the psychological emotions of investors should also be considered. The weather is one of the subjective factors that affect emotions. Many scholars from various countries have conducted extensive research on how weather factors affect investor decisions and have developed behavioral theories on how weather affects finance. This paper studies the 50ETF of the Shanghai Stock Exchange, rather than the individual investors, as an example. Multiple regression analysis and random forest analysis method are used to explore the effects of temperature (TEMP), rainfall (RAINFALL), wind speed (WIND), sunshine duration (SUN), humidity (RH), and total short-wave radiation (SW) on the stock market closing price (CLOSE), yield (RET) and trading volume (VOL). It is concluded that weather factors have a significant impact on the closing price and trading volume of the stock market, but weather factors do not affect the yield. A cross-sectional comparison of multiple weather variables revealed that temperature is the most decisive factor. Behavioral theory analyzes how weather affects finance, establishing connections between weather and stock market data across different regions, and thus provides valuable insights for future investor decisions.

Keywords: weather, stock market, multiple linear regression, feature importance assessment

1. Introduction

In recent years, the intensification of climate change and the frequent occurrence of extreme weather events have gradually drawn academic attention to their impact on stock market stability. Researchers have conducted extensive research on the relationship between meteorological factors and stock markets in various regions, such as New York, Australia, and Washington. In China, a study examined the impact of meteorological factors on the Shenzhen stock market, using the E Fund Shenzhen 100 ETF as an example. Be advised that papers in a technically unsuitable form will be returned for retyping. After returning, the manuscript must be appropriately modified.

Li explored the impact of temperature and precipitation on stock returns of specific industries and companies from the perspective of weather risk using the DCC-GARCH-CoVaR model [1]. Research has found that the construction and building materials industries are more likely to experience increased financial risks under extremely low temperatures, while the coal industry has a higher risk spillover effect under both extremely high and low temperatures [1]. Roush conducted a

multivariate regression analysis on the New Zealand stock market and weather (temperature, humidity, wind speed). He found that extreme weather (high/low temperature) reduced trading volume, while mild weather had higher trading volume [2]. Levy combined weather and investor sentiment theory to analyze abnormal trading volume in the U.S. stock market and concluded that severe weather (such as snowstorms) causes a sharp drop in trading volume, but then a rebound effect occurs [3]. Goodfellow demonstrated the impact of weather on stock market liquidity through research [4]. Panetsidou uses event research methods to find investors who include weather alerts in asset pricing, highlighting the importance of providing regular information during extreme weather events. The above is a study of the weather and stock market by many scholars [5]. Muhlack, N used a generalized autoregressive conditional heteroscedastic (GARCH) time series model to analyze the effects of weather on the German stock market index (DAX, MDAX, SDAX and TecDAX) between August 2003 and July 2017, and concluded that among the weather variables studied, air pressure was the only factor that had a potentially persistent impact on the German stock market [6].

Based on this, this paper takes the Shanghai Stock Exchange in China in the past year as an example and uses multiple linear regression and random forest analysis to explore the impact of weather on the Shanghai stock market.

2. Method

2.1. Date selection

This article selects data from the CHINA SECURITIES INDEX from July 20, 2024, to July 18, 2025, from the SSE 50 ETF data, including yield, closing price, and trading volume. In terms of meteorological factors, local data from Shanghai from July 20, 2024, to July 18, 2025, were selected, including temperature (TEMP), rainfall (RAINFALL), wind speed (WIND), humidity (RH), and total short-wave radiation (SW). The correlation between meteorology and the stock market is more about short-term sentiment and trading behavior. One year's data can capture fluctuations in different seasons and weather types, and whether there is an impact without long-term data can be determined. Table 1 is a summary of data and weather data.

Table 1. Descriptive statistics of logarithms of weather variables

Name	Sample Size	Minimum	Maximum	Average value	Standard Deviation	Median
Weather	242	1	8	2.393	1.085	2
Wind speed and direction	242	1	73	33.521	19.379	35
Minimum temperature	242	-3.5	29.1	15.093	9.362	15.5
Maximum temperature	242	0.8	34.1	18.763	9.339	20
Average temperature	242	4.1	39.1	23.128	9.797	23.9
Minimum perceived temperature	242	-9	35.9	15.504	12.628	14.95
Maximum perceived temperature	242	-4.4	39.7	19.207	12.526	19.85
Average perceived temperature	242	-0.6	45.8	23.692	13.019	24.9
Humidity(%)	242	31	95	70.24	12.572	72
Precipitation (mm)	242	0	106.8	2.944	9.582	0
Sunshine duration (h)	242	0	13.01	8.101	3.969	9.29
Total shortwave radiation	242	1.37	29.21	15.839	7.119	14.925

The independent variables in this paper are temperature (TEMP), rainfall (RAINFALL), wind speed (WIND), sunshine duration (SUN), humidity (RH), and total shortwave radiation (SW); the dependent variables are the closing price (CLOSE), return rate (RET), and trading volume (VOL) of the stock.

2.2. Model section

The formula for multiple linear regression is as follows:

$$CLOSE = \alpha_0 + \alpha_1 WIND + \alpha_2 PRES + \alpha_3 RH + \alpha_4 TEMP + \alpha_5 SW + \alpha_6 SUN + \varepsilon \quad (1)$$

$$RET = \beta_0 + \beta_1 WIND + \beta_2 PRES + \beta_3 RH + \beta_4 TEMP + \beta_5 VIS + \beta_6 SUN + \varepsilon \quad (2)$$

$$VOL = \gamma_0 + \gamma_1 WIND + \gamma_2 PRES + \gamma_3 RH + \gamma_4 TEMP + \gamma_5 VIS + \gamma_6 SUN + \varepsilon \quad (3)$$

Where $\alpha_0, \beta_0, \gamma_0$ are the intercept terms, representing the baseline predicted values of the dependent variable when all independent variables are zero. $\alpha_1 - \alpha_6$, $\beta_1 - \beta_6$ and $\gamma_1 - \gamma_6$ are the regression coefficients, measuring the average change in the dependent variable for each unit change in the corresponding independent variable. ε is the random error term, representing additional influencing factors not captured by the model, and satisfies assumptions such as zero mean and homoscedasticity.

Since this paper uses multiple independent variables, we can use the feature importance evaluation principle of the random forest analysis method. Random forest is an ensemble learning algorithm based on decision trees. It generates multiple sub-datasets from the original training set through sampling with replacement, and randomly selects feature subsets when constructing the nodes of each decision tree. During prediction, classification tasks use the voting results of multiple trees to determine the category, while regression tasks take the average of the predictions from multiple trees. The principle of feature importance assessment is to compare multiple independent variables horizontally to determine the influence of each independent variable. MDI, also known as Gini importance, evaluates the importance of a feature by measuring the sum of the impurity reductions for each feature across all trees [7].

3. Result

Table 2. The impact of weather variables on closing prices

	Unstandardized coefficients		Standardized coefficient	t	p	Collinearity diagnostics	
	B	Standard error	Beta			VIF	Tolerance
Constant	3489.083	123.36	-	28.284	0.000*	-	-
Humidity(%)	-0.416	1.432	-0.024	-0.29	0.772	2.224	0.45
Precipitation (mm)	-1.645	1.424	-0.073	-1.155	0.249	1.278	0.783
Sunshine duration (h)	-33.816	7.3	-0.624	-4.632	0.000*	5.761	0.174
Total shortwave radiation	19.507	5.237	0.646	3.725	0.000*	9.536	0.105

Average temperature	-12.052	2.14	-0.549	-5.632	0.000* *	3.015	0.332
Wind speed and direction	0.996	0.688	0.09	1.449	0.149	1.218	0.821
R^2	0.259						
Adjust R^2	0.241						
F	F(6,235)=13.721,p=0.000						
D-Wvalue	0.179						
Note: Dependent variable = Close							
* p<0.05 ** p<0.01							

As shown in Table 2, the F test proves that the combined effect of weather significantly affects the closing price. Among them, three weather factors have significant effects (based on $p < 0.01$): sunshine duration, total shortwave radiation, and average temperature. In addition, among sunshine duration (VIF = 5.761), total shortwave radiation (VIF = 9.536), and average temperature (VIF = 3.015), sunshine and shortwave radiation have VIF > 5, indicating strong collinearity.

Table 3. Impact of weather variables on trading volume (n=242)

	Unstandardized coefficients		Standardized coefficient	t	p	Collinearity diagnostics	
	B	Standard error	Beta			VIF	Tolerance
Constant	51694.46	9734.926	-	5.31	0.000* *	-	-
Humidity(%)	156.61	113.006	0.119	1.386	0.167	2.224	0.45
Precipitation (mm)	-82.482	112.387	-0.048	-0.73 4	0.464	1.278	0.783
Sunshine duration (h)	1058.778	576.1	0.255	1.838	0.067	5.761	0.174
Total shortwave radiation	-1018.463	413.248	-0.44	-2.46 5	0.014*	9.536	0.105
Average temperature	-387.807	168.866	-0.231	-2.29 7	0.023*	3.015	0.332
Wind speed and direction	58.76	54.267	0.069	1.083	0.28	1.218	0.821
R^2	0.215						
Adjust R^2	0.195						
F	F (6,235)=10.710,p=0.000						
D-Wvalue	0.362						
Note: Dependent variable = Volume (M Shares)							
* p<0.05 ** p<0.01							

Table 3 shows a significant F-test, indicating that the combined effect of weather variables has an impact on trading volume. Significant influencing factors include total shortwave radiation and

average temperature. For example, total shortwave radiation has a B value of -1018.463, a Beta value of -0.44, and a p value of 0.014* <0.05. A marginally significant factor is sunshine duration, with a p-value of 0.067, close to 0.05, indicating a marginally significant positive impact. Humidity, precipitation, and wind speed and direction all had no influencing factors.

Table 4. Impact of weather variables on yield (n=242)

	Unstandardized coefficients		Standardized coefficient	t	p	Collinearity diagnostics	
	B	Standard error	Beta			VIF	Tolerance
Constant	-0.298	0.842	-	-0.354	0.724	-	-
Humidity(%)	0.005	0.01	0.053	0.55	0.583	2.224	0.45
Precipitation (mm)	-0.007	0.01	-0.051	-0.696	0.487	1.278	0.783
Sunshine duration (h)	-0.01	0.05	-0.03	-0.191	0.849	5.761	0.174
Total shortwave radiation	0	0.036	0.001	0.005	0.996	9.536	0.105
Average temperature	0.002	0.015	0.015	0.134	0.893	3.015	0.332
Wind speed and direction	0.001	0.005	0.02	0.281	0.779	1.218	0.821
R^2	0.004						
Adjust R^2	-0.021						
F	F (6,235)=0.171,p=0.984						
D-Wvalue	1.857						

Note: Dependent variable = Change (%)

* p<0.05 ** p<0.01

The adjusted R^2 =-0.021 (negative value) from Table 4 indicates that the model's explanatory power is almost zero, even worse than using the mean prediction. F test results: F(6,235)=0.171, p=0.984 (much greater than 0.05). All p-values are much greater than 0.05, and no variable passes the significance test. It is concluded that weather factors cannot affect the stock market returns. This conclusion is consistent with the impact of Korean meteorological factors on the Shenzhen stock market, and also confirms that weather factors will not cause asset pricing imbalances [8].

The above data shows that the factors affecting stock market trading volume and volatility are sunshine duration, total shortwave radiation, and average temperature. To further explore the influence of these three factors, a random forest analysis method was used.

Table 5. Feature weight values

item	Weight value
Wind speed and direction	0.074
Average temperature	0.458
Humidity (%)	0.118
Precipitation (mm)	0.095
Sunshine duration (h)	0.132
Total shortwave radiation	0.124

For example, in Table 5, where the dependent variable Y is trading volume, it is found that temperature's explanatory power for the forecast target is 3-6, that of the other variables, confirming the centrality of temperature in the weather-stock market relationship. The same conclusion holds true when the dependent variable Y is the closing price (Table 6).

Table 6. Model evaluation results

index	illustrate	Trainin g set	Test set
R-squared value	Fitting degree index, the larger the better, between 0 and 1	0.91	0.362
Mean absolute error (MAE)	L1 loss, the average difference between the true value and the fitted value, the closer to 0, the better	3541.43 1	11353.1 61
Mean Squared Error (MSE)	L2 loss, mean squared error, the closer to 0, the better	230615 64.77	199167 450.8
Root Mean Square Error (RMSE)	MSE square root, average gap value	4802.24 6	14112.6 7
Median absolute error (MAD)	The absolute value of the residual of the predicted value from the median is not affected by outliers. The smaller the better	2735.42 6	9273.49 3
Mean absolute percentage error (MAPE)	Average error percentage, not affected by outliers, the smaller the better	0.148	0.135
Explained variance EVS	Measures the model's ability to explain data fluctuations, ranging from [0,1], the larger the better	0.91	0.395
Root mean square logarithmic error (MSLE)	When RMSE is the same, it penalizes under-prediction more (uses less)	0.009	0.089

4. Discussion

Hirshleifer and Shumway also explored the relationship between weather factors and returns. Using empirical research methods, they found that people tend to be more positive when the sun is shining and may be more inclined to buy stocks. At the same time, people may mistakenly attribute their good mood to positive economic outlook expectations, which indicates that sunshine is positively correlated with stock returns [9]. Some researchers, building on the findings of this study, have further confirmed that people's emotions can shift when weather factors change, leading to more optimistic or pessimistic valuations and, consequently, more aggressive, impulsive, or hesitant decision-making, ultimately affecting stock market returns. This research conclusion is inconsistent with the conclusion that weather has no impact on stock market returns, which was obtained by taking the Shanghai and Shenzhen stock markets as examples. The reason may be that different studies selected different time spans, which will affect the research conclusions and may have an impact in the short term. However, long-term data show that other economic and political factors have a more significant impact on stock market returns, thus masking the role of weather factors. The difference may also lie in investors, with institutional investors being less affected by short-term non-economic factors such as weather than individual investors. For example, Cheng Wanyun and others extracted investor sentiment indexes through text mining and verified the positive impact of individual investor sentiment on stock returns [10]. There are also studies that show that, whether through public bidding trading systems or computerized trading systems, weather (sunshine duration and humidity levels) has no impact on stock prices and will not affect stock yields [11].

This research has always been a hot topic in behavioral economics, but there is still a problem of multicollinearity, with some variables having $VIF > 5$. It is recommended to adopt a more complex time series model based on this study and include more control variables, such as macroeconomic index, tax policy, etc. The VIF of some variables in this study is > 5 , and correlation analysis can be performed, including Pearson's correlation coefficients between each correlation variable, and find variable pairs with extremely high correlation. For variables with high correlation, it is possible to consider eliminating variables with relatively little effect on interpreting dependent variables.

5. Conclusion

This paper uses linear regression and random forest analysis to study the closing price, yield, trading volume, and six weather variables of the SSE 50ETF. By analyzing the data with the dependent variables being closing price or trading volume, respectively, it is concluded that weather factors have a significant impact on the closing price and trading volume of the stock market. Given that the dependent variable is return, the p-values are all greater than 0.05, indicating that weather factors do not affect stock returns. Subsequently, by exploring the significance of the six influencing factors, it was concluded that temperature is the decisive factor, showing a strong correlation with the closing price, trading volume, and the current forecast target. Specifically, for every 1°C increase, the closing price decreases by 12.05 points, and trading volume decreases by 3.878 million lots. The secondary influencing variable, sunshine duration, is significantly negatively correlated with closing price ($B = -33.8$). Shortwave radiation is significantly negatively correlated with trading volume ($B = -1018.5$). All weather variables in the return rate (rise and fall) model are insignificant.

Although factors such as weather will not affect the stock market's returns, they can also provide investors with some insights. For example, when encountering extreme weather events, one should ignore short-term fluctuations and stick to the original strategy, because weather does not affect the direction of returns. High temperatures are accompanied by a sharp drop in trading volume. It's advisable to wait and see or invest lightly in oversold growth stocks, as shrinking trading volume can trigger a technical rebound. While weather factors can significantly impact stock market trading volume and closing prices, investors should not blindly let weather factors influence their investment decisions.

References

- [1] Li, J. (2022). Study on the risk spillover of weather risk to the stock market: Taking the construction and coal industries as examples [Doctoral dissertation, Central University of Finance and Economics].
- [2] Keef, S. P., & Roush, M. L. (2007). The New Zealand stock market and weather: A test of the cloudy sky effect. *Applied Financial Economics*, 17(12), 1539–1547.
- [3] Kaplanski, G., & Levy, H. (2012). Sentiment and stock prices: The case of aviation disasters. *Journal of Banking & Finance*, 36(1), 282–294.
- [4] Goodfellow, C., Schiereck, D., & Verrier, T. (2010). Does screen trading weather the weather? A note on cloudy skies, liquidity, and computerized stock markets. *International Review of Financial Analysis*, 19(2), 77–80.
- [5] Panetsidou, S., & Synapis, A. (2025). Do markets react to weather? Stock price reactions to weather alerts. *Economics Letters*, 255, 112551.
- [6] Muhlack, N., Soost, C., & Henrich, C. J. (2021). Does weather still affect the stock market? *Schmalenbach Journal of Business Research*, 74(1), 1–35.
- [7] Agarwal, A., Kenney, A. M., Tan, Y. S., Tang, T. M., & Yu, B. (2023). Integrating random forests and generalized linear models for improved accuracy and interpretability (Version 2). arXiv.
- [8] Han, W., & Yu, S. (2020). Quantitative analysis of the impact of meteorological factors on the Shenzhen stock market: Taking E Fund Shenzhen 100 ETF as an example. *China Business Review*, (20), 115–120. (in Chinese)

- [9] Hirshleifer, D., & Shumway, T. (2003). Good day sunshine: Stock returns and the weather. *The Journal of Finance*, 58(3), 1009–1032.
- [10] Cheng, W., & Lin, J. (2013). Investors' bullish sentiment by social media and stock market indices. *Journal of Management Science*, 26(5), 111–119.
- [11] Pardo Tornero, Á., & Valor, E. (2002). Spanish stock returns: Rational or weather-influenced? *SSRN Electronic Journal*.