

Stock Returns and the Weather Effect: the case of Ghana

Sampson Agyapong Atuahene¹
Kong Yusheng²
Geoffrey Bentum-Micah³

Abstract

The stock markets are an integral aspect of every economy. Over the last few decades, there has been a significant change in Ghana stock market returns (GSE). Our study examines the statistical and economic significance of investor sentiment, based on weather conditions/changes, on stock market returns. OLS models, assisted by unit root tests, were employed in analyzing the data obtained from the Ghana stock exchange platform from 2000 to 2017. From our literature review, we discovered that investors' perceptions play a central role in setting the direction of stock market returns. We tested whether weather variations influence investment decisions of investors; we discovered that temperature and cloud cover significantly influence stock market returns. This is

because mood changes are associated with variations in weather conditions. However, as per our regression coefficient, sunshine shows a statistically insignificant impact on investors' investment choices. Our regression analysis also revealed that precipitation, to a large extent, negatively influences stock market activities. Based on our findings, we concluded that stock brokerage firms, companies, and investors (foreign/local) must incorporate weather changes/effects when planning their investment outcomes.

Keywords: *Weather variables, stock market returns, investor sentiments, and emerging economies*

¹ School of Finance and Economics, Jiangsu University, Zhenjiang, China

² School of Finance and Economics, Jiangsu University, Zhenjiang, China

³ School of Management, Jiangsu University, Zhenjiang, China

Introduction

Investors' sentiments were primarily viewed as unpredictable a few decades ago, evolving erratically despite experts' attempts to predict the direction and magnitude of its effects. Today, thanks to behavioral finance and big data analysis, we can connect the dots and do the extraordinary (Picciotto, 2020). Apart from the impact of herd behavior, internet-led-access to information, trading, macro-economic factors, risk and cost factors, performance factors and confidence level of institutional investors, best-game in town factors, unquantifiable factors such as emotions, feelings, and sentiment account for changes in stock market conditions (performance). Sentiments are influenced by mood and fluctuate as the weather changes. In developing economies like Ghana, it is easy for weather conditions to affect brick and mortar markets (Christiaanse, Sinnecker, & Mossinkoff, 2001). Conversely, Online markets seem to be resistant to weather changes to a certain point. In the past, it was difficult to estimate how weather or mood swings could influence stock prices, returns, and stock market performance (Hirshleifer & Shumway, 2003; Bhattacharjee & Das 2020). However, now there are theories explaining how weather significantly (positively or negatively) relates to the stock market. Literature suggests that severe weather disturbs the general trade of stock and consumer movements (De Long et al., 1990). Share prices of companies move in different directions when weather conditions fluctuate. From research, the factors that influence stock market activities include:

- I. Company news
- II. The nature of the industry
- III. The sentiment of investors
- IV. The economy

Keeping a close eye on these factors helps in gaining a better insight into how the price of a share may behave. Research on investor behavior helps to decide whether to buy, sell or hold a stock (Mladjenovic, 2020). Sentiments connect to people's feelings and their perceptions while perceptions influence one's

final decision. Crucial economic shocks happen because of bad weather conditions, (disasters) changing people's mood (Klein, 2007). Perception is the process by which a person perceives an object by processing stimuli into subjective observable reality. Stimuli can be perceived by the consumer by going through different frameworks; the consumer selects the stimuli (incentives) depending on the information he has or the sentimental stage present. Mood swings influence people's perception as established by psychologists. Investors' perception impacts the choice of investment, and the type of investment packages they patronize. The linkage between weather and stock market returns has been long documented, especially in the literature on finance and psychology. It is evident that investors are largely responsive to economic and market fundamentals or new information when it comes to making investment decisions. Nevertheless, there have been controversies among scholars, researchers, and finance professionals concerning what triggers movement in equity prices in emerging equity markets (Olsen, 1998). Resolving the controversies demands explaining stock returns and relating share price variation to Mother Nature. Many researchers state that stock prices are not systematically affected by the local weather and that the changes in stock returns might simply be explained by seasonal anomalies such as the "Sell in May and go away" behavior. But from a different perspective, experts of behavioral finances say social moods can be associated with more disparity in valuation estimations among investors; bad weather inversely relates to market volatility (Hirshleifer, 2001).

Mostly, investors in developing and emerging countries have used the traditional financial theory called the efficient market hypothesis to determine the value of a portfolio by evaluating its maximum outcome with the Capital Asset Pricing Model (CAPM) and earnings per share. This theory is verifiable by scientific and econometric analysis, which makes it a very good predictor of the changes in the stock market. However, there is a contra discovery made by gurus in

equity markets that the changes or movements in equity markets can happen due to unexplainable factors (Iddon, Hettihewa, & Wright, 2015). For example, Mehra et al, (2002) found that there is a 6% gap between the rate of return and risk-free interest rates (Mehra & Sah, 2002). Wang, et al., suggested that people are concerned about the phenomena that the traditional finance theory is unable to explain, the Monday and January effects (Wang, Shih, & Jang, 2018). According to Harding & He, (2016), there have also been psychological studies to know if changes in weather have an impact on a person's mood or emotional state and whether changes in mood affect investors' decisions.

Merah and Sah, (2002) proposed that mood swings of investors might affect equity prices if investors' subjective preferences change over time. In the pricing of equities and other financial assets, investors' attitude is of major concern for financial analysts and it is seen as a key determinant of the value of most financial assets (Zou & Sun, 2012). There has been some kind of shift in the discussions of equity price movement to favoring investors' sentiment/emotions. This led to the introduction of "investor sentiment" as an independent variable in predicting stock market returns (Brown & Cliff, 2004). However, some researchers disagree with financial experts who have taken this new dimension considering investors' sentiment indices for measurement.

Research Objectives

Sunshine affects mood, and mood can shape behavior (Cunningham, 1979). It is then plausible to test if weather is related to economic outcomes such as market returns (Lee, Jiang & Indro, 2002). This paper re-visits the presence of weather's mood effect on stock returns from a new perspective by comparing whether weather changes have an influence on investors' mood and in effect, affects their investment decisions. We believe that individuals' sentiment is influenced by their mood, which swings when there is a change in weather conditions. In addition, the swing in mood can influence stock market returns; therefore,

we state the following research questions:

1. To what extent does sunshine influence stock market returns?
2. Do changes in temperature affect stock market returns?
3. To what degree does the sky/cloud cover impact stock market returns?
4. To what extent does precipitation as a weather variable explain fluctuations in stock prices?

The motivation of the study

We are looking at weather-related variables that might affect investors' perceptions towards various investment avenues, specifically equity investments. Investors' demographic profile and risk-taking ability also affect their perception. Investment decisions determine the success or failure of the investor in the stock market. However, there is a research gap to study the impact of weather condition factors on investment decisions in Ghana. This study will further help to better understand investors' psychology in respect of various investment avenues using changes in weather patterns as a guide.

Applicability

Investors want to invest their funds in markets that they understand or have relevant information. The findings of this study apply to all evolving economies such as India, Ghana, Brazil, Poland, Indonesia, Mexico, Poland, South Africa, South Korea, China, Nigeria, Saudi Arabia, Taiwan, Thailand, and even developed nations with robust stock market such as Germany, USA, Switzerland, Japan, and England. Good stock market analysis gives better information about where, who, what, and when an investor and/or investment entity must patronize an investment. The findings would, besides, help policymakers to tailor stock market dealings to the interests of the industrial players or parties involved.

Literature Review

The literature shows that the weather encourages people to adopt certain behaviors and that four factors - the sun, temperature, cloud cover and precipitation -

have the greatest psychological impact on investors (Finter, Niessen-Ruenzi, & Ruenzi, 2012).

First, a deep cleanup of Ghana's banking sector battered Ghanaian's stocks market (Jameaba, 2020). The Ghana Stock Exchange Composite Index became one of the worst performing equities benchmark in 2019 in dollar terms and has suffered as a government-led reorganization of banks reduced the flow of funding to companies and drained market sentiment (Tetteh, Adenutsi, & Amoah, 2019).

According to a Bloomberg report on Ghana, the world's second-largest cocoa producer has held seven peaceful polls since the end of the military regime in 1992, so investor concerns over the election largely focus on the risk that excessive government spending will fuel inflation and weaken the exchange rate. In 2016, the last election year, the budget deficit reached 8.7% of the gross domestic product against a target of 5.3%, inflation ended the year at 15.4%, without a single-digit target, while the cedi has weakened by 10% (Bukari, 2017). Investors/listed companies are worried about the recurrence of this phenomenon forgetting that other factors can as well change the dynamics of Ghana's returns/performance.

The climate of Ghana is tropical and there are two main seasons: the wet and the dry seasons (Lieberman, 1982). North Ghana experiences its rainy season from April to mid-October while South Ghana experiences its rainy season from March to mid-November. Ghana's economy relies heavily on climate-sensitive sectors, mainly on agriculture, energy, and forestry (Asante & Amuakwa-Mensah, 2015). About 70% of the population depends directly or indirectly on agriculture (fisheries, crop and animal farming, etc.) and the forest sector for both timber and non-timber forest products. The major climate change impacts affect all sectors, places, and people differentially, depending on the levels of vulnerability. Ghana's vulnerability to weather change is in large part defined by its exposure to the various impacts with droughts, floods, and sea erosion as the main drivers (Somorin,

2010). The most affected sectors in Ghana include the economic, social, and infrastructural groups. The cumulative effects on these sectors determine the impacts and vulnerabilities of various livelihood groups and places in the country. Our focus is on the changes that affect our stock market (Cinner et al., 2012). The electricity supply is currently vulnerable to climate change. About 67% of electricity generation in the country is from hydropower and 33% is from thermal generation using diesel (Energy Statistics, 2006), with a small contribution (less than 1%) from small-scale solar systems. By 2020, the energy supply is expected to be more diversified, according to the National Energy Plan for 2006-2020, with a larger contribution from natural gas and renewables, and potentially from nuclear power.

A bull market and bear market are used when describing the trends of securities (Gonzalez et al., 2005). Securities include stocks, bonds, commodities, and other types of investments. Investors, take a bullish or bearish stance, depending upon their outlook. To be bullish is to believe that an investment's price will rise. To be bearish is to believe that the price will fall. The bull market is the type most desired for the majority of investors. For new investors, understanding the bull and bear market systems helps to fathom what drives the stock market so that you can take advantage of the money-making opportunities that are present within (Loeb, 2007). A bear market is when a market experiences prolonged price decline. It typically describes a condition in which securities' prices fall 20% or more from recent highs amid widespread pessimism and negative investor sentiment. Bear markets are often associated with declines in an overall market or index like the S&P 500, but individual securities or commodities can also be considered to be in a bear market if they experience a decline of 20% or more over a sustained period of time - typically two months or more (Liu, Yao, & Chen, 2019). Bear markets also may accompany general economic downturns such as a recession.

Despite the best efforts by many highly trained economists and stock market specialists, there is a contradictory opinion about whether weather affects the performance of the stock market. One rational concept about the weather and Wall Street suggests that severe weather interrupts business processes, supply chains, and consumer movements, among other factors. Saunders (1993) stated that the financial media often blames a sluggish quarter of gross domestic product (GDP) growth or stock market performance on weather problems (Saunders, 1993). Attributable to the way of nature and mood, good weather keeps the mind and heart calm. On the other hand, heavy rain might lead to depression and a heavy heart. Individuals' intuitions and beliefs are diverse as well as their behaviors as humans, which are influenced by the weather and result in a change in mood during different situations (Kahneman, 2003).

Behaviorism or behavioral psychology is a concept centered on the idea that all behaviors are learned through conditioning and conditioning takes place through contact with the environment. As identified by behaviorists, our reactions to environmental stimuli form our actions. Behavioral finance studies the psychology of financial decision-making. Studies agree that good weather has a positive impact on investors' mood while making any decision (Sun et al., 2019). According to Xu (2015), there is strong evidence available for backing up to prove weather-mood and mood-decision lead to fluctuations in the stock market indices. Behavioral finance theory applied to stock market performance, which is a link to most mood swings and perceptions, is quite different from the financial theory that we know (Kumar & Kaushak, 2017). The established financial theory focuses on the trade-off between risk and return (Joshiyura, Mayank, and Shilpa Peswani. 2018). However, behavioral finance suggests investors are overconfident about making gains and oversensitive to losses. Thus, investors in a good mood are inclined to invest in riskier projects as they believe in the success of their intuition (Odlyzko, 2010). Psychologists try to explain how surroundings affect human behavior. Weather is one

of the main factors that influence a person's mood and the way one feels. Experiments have shown that cold makes people more predisposed to sadness and melancholy, but its influence on stock returns is slight and almost insignificant (Zadorozhna, 2009). Also, an argument has been made that heat, on the other hand, has a strong negative impact on human behavior and there are claims that violence increases rapidly during high-temperature periods of a year (Anderson, 1989).

The efficient market theory states that stock prices disclose all information, and that consistent alpha generation is impossible. This implies that the share prices are determined by the fundamental values of the companies. If this theory is correct, then it is unexpected that weather conditions could affect the value of companies' shares/stock. However, the behavioral finance literature suggests that, to some extent, anomalies in the stock markets may have arisen due to various climatic factors. This view questions the validity of the Efficient Market Hypothesis (EMH).

The efficient market hypothesis is a theory claiming that given the rational behavior of all investors, current market prices reflect the discounted future cash flows (Fama, 1970). That is, market players account for all possible events in their decision making and set prices accordingly. However, Hirshleifer (2001) argues that investors are irrational, and their decisions are affected by different subjective factors. This theory is often referred to as Deficient Market Hypothesis. The main idea of this theory is that wrong decisions by market participants cause securities to be priced incorrectly. In this research, we are interested in factors that influence investors' choices such as climate and weather, and emotions through which these two operate.

Chang et al. (2006) adopted the technique of threshold model GJR-GARCH to provide evidence for the relationship between stock exchange returns and three weather variables (cloud cover, temperature, and humidity). Research by Chang et. al. (2008)

emphasized the significant negative impact of temperature and cloud cover on stock returns. This gives investors an idea of how to trade in the Taiwan stock market (Chang et al., 2006). A similar study by Mirza et al. (2012) on two Pakistani stock markets reveals an adverse linkage between returns and temperature (Mirza et al., 2012). Wang (2011) concluded that knowledge, experience, and income are vital elements that sway younger generations' investing behaviors in mutual funds. Lalitha and Surekha (2008) focused on investors' education as a key determinant of stock market growth/performance. Ansari and Jana (2009) revealed that rational traders use both fundamental analysis and technical analysis as stock selection tools, which does not support the view of finance theorists. In an uncertain situation, the decision making process of noise traders will go through mental biases – self-attribution bias, loss aversion bias, confirmation bias, and overconfidence bias (Baker & Puttonen, 2017). As a result, noise traders will believe that some irrelevant information will be more important for price decisions and they will trade more.

Investor sentiment determines whether equities rise or fall in value. If there is a bull market, there is a strong stock market with rising prices and growing investor confidence (Brown & Cliff, 2005). This development is often related to a recovery in the economy or an economic upswing. If there is a bear market, you speak of a weak market with falling prices and low investor confidence.

The effect of negative sentiments on financial returns and volatility is usually found to be stronger than positive sentiment (Johnman, Vanstone, & Gepp, 2018). Chang et al. (2006) have confirmed the existence of a significant relationship between temperature, cloud cover, and stock returns. They included temperature as an explanatory variable into their model and found that stock returns are higher when the temperature is within normal bounds; though, they tend to be lower when it is extremely hot or cold and when the cloud cover is heavier (Horton et

al., 2016). Researchers argue that aggressive behavior is often a result of low temperature while both apathy and aggression can be consequences of high temperature (Cao & Wei, 2002).

Rain, wind, and clouds, according to a new study, generate "mild depression" that distracts even some of the market's most sophisticated participants, causing them to delay their responses to financial news. There is considerable scientific literature on the effect of the weather on stock returns. Researchers argue that good weather affects investors' moods and they, in turn, may wrongly attribute positive feelings as favorable prospects for financial markets (Dowling & Lucey, 2005).

Academic researchers such as Fisher and Statman, (2000), Hirshleifer and Shumway, (2003), Shao-Chi et al., (2008), Tsangyao et al. (2006) and Dowling & Lucey (2005) found a significant negative relationship between cloud cover and returns on stocks. On the contrary, some results indicate that the weather has an insignificant effect on investors (Jacobsen & Marquering, 2008; Krämer & Runde, 1997; Loughran & Ritter, 2004; Lu & Chou, 2012).

We put forward the following hypotheses:

- H1: There is a significant relationship between stock returns and temperature.
- H2: There is a significant relationship between cloud averages and stock market performance.
- H3: There is a significant relationship between precipitation and stock market performance.
- H3: There is a significant relationship between sunshine and stock market performance.

Data

Daily weather data of stock exchanges of Ghana available from Ghanaian Weather historical archives that contain weather station datasets from January 2000 to December 2017 have been used.

Research Methodology

Ordinary least square models have become important tools in the analysis of time-series data, particularly in financial and economic applications. Therefore, the OLS (Ordinary Least Squares) is used to test the hypothesis that there is any relationship between factors of weather and stock returns of Ghana Stock Exchange (GSE). This model is especially useful when the goal of the study is to analyze the impact or effects that independent variable(s) has on dependent(S). In our studies, the ordinary least square regression will be used to capture the lagged effect of the weather variable on the financial market variable. Linear

models (OLS) are used to test the relationship between stock market returns, spreads, and trading volumes, and weather variables.

OLS regression equations

$$IndexRet_t = \beta_0 + \beta_1 v_t + u_{t(1)}$$

$$Total\ stock\ return = \frac{(P_t - P_0) + D}{P_0} \quad (2)$$

P_0

P_0 = initial stock Price

P_1 = Ending Stock Price (Period 1)

D = Dividends

Table 1. Variables' description

Dependent variable	Short-code	Description	Unit of Measurement
Stock market performance / returns	R	The total return for a stock includes both capital gains/losses and dividend income, while nominal return for a stock only depicts its price change.	Total Monthly Stock Returns
Independent Variable			
Temperature	Temp	Temperature is a physical property of matter that quantitatively expresses hot and cold.	Celsius (Average monthly temperature)
Sunshine	Sun	Direct sunlight unbroken by cloud, especially over a comparatively large area.	Power density of sunlight in W/m ² (Watts per square meter).
Cloud averages	Cloud	Cloud cover (also known as cloudiness, cloud age, or cloud amount) refers to the fraction of the sky obscured by clouds when observed from a particular location.	Okta- indicating sky obscured by fog and/or other meteorological phenomena
Precipitation	Precip	Water that falls from the clouds toward the ground, especially as rain or snow:	Liter of rainfall per square meter.

Temp_t stands for the variable of temperature variation. Sun_t is the variable sunshine variation. Cloud_t is the variable of the cloud-average. Precip_t represents the variable Precipitation. The asymmetric volatilities

dummy variable is the S_{t-1}. If the ε_{t-1} < 0 it indicates that previous bad news led to an increase in the present variation value and that the leverage effect exists. R_{t-1} and R_{t-2} are auto-correlated periods of the stock market.

Table 2. Descriptive analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
Year	216	17881.73	1902.276	14610	21154
Stock	216	3512.335	2688.229	739.7	10890.8
Temp	216	26.7536	1.277814	24.0521	28.99625
cloud_avg	216	.0967529	.0689887	.0052051	.2880005
Sunshine	216	6.509259	1.518845	4	11
Precip	216	57.94477	52.08685	3.212221	291.587

Unit Root Analysis

First, stock market and weather data series are tested for stationarity and autocorrelation using ADF and Durbin-Watson tests. Unit root tests are essential as

previous studies have found that stock returns and weather time series might exhibit non-stationarity and autocorrelation.

Table 3. Unit Root test

	ADF Test		PP Test			DFGLS Test
	t-statistics	P. Value (z)t	Z(t) t-statistic	Z(rho) statistics	p. value	t-statistics
Stock	1.8180	0.3718*	1.900	6.462	.65428*	-1.264
Temp	10.894	0.000***	6.175	71.901	0.000***	-10.90
Cloud_Avg	6.7720	0.000***	6.865	83.455	0.000***	-4.679
Sunshine	7.6810	0.000**	7.241	88.663	0.000***	-7.169
Precip	9.2230	0.000***	8.650	105.389	0.000***	-6.947

Note: ADF test is Augmented Dickey Fuller. T-statistics is the test statistics values of the ADF results from Stata. PP test is Philip-pepron Notes: *** - significance at 1% level

With ADF, a p-value of less than 5% means you can reject the null hypothesis that there is a **unit root**. Augmented Dickey-Fuller and Phillips-Peron (with allowance for serial correlation) tests are conducted to test the null hypothesis of a unit root (non-stationarity)

in each series. In all cases, the null hypotheses are rejected at the .01 level and we conclude that the market and weather series are stationary and suitable for regression-based analysis.

Table 4 Regression Analysis

Stock R	Coef.	Std. Err.	t-Value	P> t	95% Conf. Interval
Temp	.1650218	.0799456	2.06	0.040	.0074275 .3226162
cloud_avg	4.133862	1.350381	3.06	0.002	1.471896 6.795828
Sunshine	.0225955	.0471506	0.48	0.632	-.0703511 .115542
Precip	-.0013971	.0011276	-1.24	0.217	-.0036199 .0008257
Cons	2.985023	2.101049	1.42	0.157	-1.156714 7.12676

Regression equations

$$\text{Stock } R_{t+1} = \alpha_0 + \beta_1 \text{Temp}_t + \beta_3 \text{Cloud_avg}_t + \beta_2 \text{Sunshine}_t + \beta_4 \text{Precip}_t + \varepsilon_{t(3)}$$

Results

$$\text{Stock } R_{t+1} = 2.9850 + 0.16502 \text{Temp}_t + 4.1338 \text{Cloud}_t + 0.02259 \text{Sun}_t + -.001397 \text{Precip}_t \quad (4)$$

Discussion And Analysis

As shown in Table 3, the significance of two weather variables (Temp and Cloud-Avg) provide statistical evidence for the effect of weather on stock returns (Stock R). This implies that temperature variation is a very important weather factor for stock investors interested in the African stock market, especially that of west Africa, where the countries have similar temperature conditions. In these cases, for H1 we accept the null hypothesis that Temperature (temp) has a significant impact on Stock Market Returns. The coefficient of Temp (Temperature) shows a 0.165 positive significant impact on stock markets. In economic norms, temperature has a 16% impact on stock returns. Usually, the temperature of Ghana provides warm and cozy feelings making investors feel pleasant and active resulting in excessive trade. The value is significant at all levels, thus 0.01, 0.05, 0.10 levels. The p-value is also less than 0.50 supporting the hypothesis that temperature variations have a significant impact on GSE stock market returns. The Cloud- avg (cloud cover averages) refers to the fraction of the sky obscured by clouds when observed from a particular location. Cloud cover thus plays an important role in the energy balance of the atmosphere and a variation in the cloud cover results in mood swings (sentiment changes) discussed by recent studies. Our regression coefficient of the Cloud_avg is 4.1338 indicating 41% substantial effects that Cloud_avg (cloud cover) has on stock market returns (stock R). The t-value is significant at all percentage levels and the P-value of 0.002, which is

less than 0.05, requires that we accept the null hypothesis that Cloud_avg has a significant effect on stock market returns. So definitely, the alternative hypothesis is rejected. This evidence coincides with the findings of Saunders (1993) and Hirshleifer and Shumway (2003), who interpret the positive association as a result that investors' mood is optimistic on less cloudy days and consequently raises stock market returns.

Sunshine and precipitation turn out to be insignificant at all percentage levels (1%, 5%, and 10%). Table 3 indicates that precipitation has an inverse relationship with stock market returns, as expected. Even though the relationship may be described as statistically insignificant, thus, -0.001 (-1%) effect, the direction of the effect makes economic sense. Many academics have concluded that heavy rain disrupts business activities. There is a significant negative effect of precipitation on stock market returns in Ghana because the country does not experience much/excess rainfall like the aforementioned countries. On the other hand, extremely long rainfall duration shows negative significant impacts on stock returns, as expected. Sunshine has a 2% positive impact on stock returns. The country has steady sunshine patterns and for years now, investors are adjusted to these patterns. Only if major weather (ecological) changes occur will it have an impact on stock returns; otherwise the impact will continue to be statistically insignificant.

Table 5 Summary of Significance

Stock Market Return			
	Significance of Impact (co-efficient)	The direction of impact (co-efficient)	Statistical significance (t-statistics Value)
Temperature	Significant	Positive	Statistically significant
Cloud Cover	Significant	Positive	Statistically significant
Sunshine	Insignificant	Positive	Statistically insignificant
Precipitation	Significant	Negative	Statistically insignificant

Note: As per Table 5, we have tackled the entire hypothesis that we developed.

Source: Authors' research

As a weather variable, **sunshine** does not show significant influence on stock returns in the Ghana Stock Exchange; a trading strategy based on this factor would not lead to earning excess returns. However, the results of **temperature, cloud cover, and precipitation** indicate that considering weather variables in an investment strategy can result in a higher payoff. Reflectively, trading based on the weather can be beneficial. However, weather conditions change all the time, leading to higher transactions as traders switch from one end of the stock trade to the other. Considering such transaction costs, it is questionable whether trading based on weather variable factors are operable.

Our literature review reveals that weather conditions affect an individual's emotional state or mood, preventing them from making rational decisions. It has been established that since the weather affects an investor's decisions, it will also affect stock returns and volatility. We discovered that high humidity could increase aggression by reducing discomfort and bellicosity, reducing attention and alertness. Extremely low temperatures can also increase aggression. In a study linked to an abnormality in stock returns, Cao and Wei (2005) claim that aggression can imply higher inventory returns as aggression can lead to higher risk and indifference can lead to a risk price. A compromise should be made between two rival effects.

Conclusion

Most research on weather conditions and its effect on stock market returns is conducted on major stock exchanges in developed economies. Mostly, academics have focused on the New York Stock Exchange, NASDAQ, Tokyo Stock Exchange, Shanghai Stock Exchange, London Stock Exchange among others, leaving out small but important stock exchanges that matter as well. An example is the Ghana Stock Market (GSE), following the Egyptian Stock Market in Africa. As per our findings and empirical analysis, sunshine does not significantly influence GSE returns; this finding corresponds with the finding of Pardo and Valor (2003) who also did not find a significant effect for hours of sunshine on Spanish Stock Market returns. Apart from sunshine, the other weather variables – temperature, cloud cover, and precipitation have a significant impact on the stock market. This is in line with major research studies including those of Cao & Wei (2005); Floros, (2011); Saunders, (1993); Lu & Chou (2012), who have all acknowledged that there is a significant effect of weather variables on stock market returns. Though their studies were carried out in advanced countries, our research corroborates with their conclusion with respect to the Ghana Stock Market since we also found that weather conditions present in Ghana have a significant effect on investors' sentiments (decisions) thereby affecting stock market returns.

This study is limited to the Ghana Stock Exchange, but in the future, it may be beneficial to examine some developing countries' stock markets comparable to our sample. Researchers can use our methodology to data sets for different countries to find out how extensive the impact of climate variables is on stock markets.

Generalizability

Typical finance studies advocate that financial markets move rationally and they are based on economic fundamentals. However, psychological elements

additionally affect investment choices and the mood of people substantially impacts the decisions they make. Weather does show up to affect the feelings and decision-making techniques of people as our results and other current research works have indicated. This study has essential implications for individual traders and financial establishments planning to make investments in the stock markets in developing economies such as the national stock market of India, which has improved two notches in the league table of the world's largest stock markets and currently ranks seventh with a market cap of \$2.1 trillion.

References

- Anderson, Craig A. (1989). "Temperature and aggression: ubiquitous effects of heat on occurrence of human violence." *Psychological Bulletin* 106, no. 1: 74.
- Ansari, Abdul Aziz, and Samiran Jana. (2009). "Stock Price Decision of Indian Investors." *The Indian Journal of Commerce* 62, no. 3: 23-31.
- Asante, Felix A., and Franklin Amuakwa-Mensah. (2015). "Climate change and variability in Ghana: Stocktaking." *Climate* 3, no. 1: 78-99.
- Bhattacharjee & Joy Das (2020). "Do Indian stock prices respond to domestic macroeconomic variables?" *NMIMS Management Review XXXVIII*, Issue 3, 55-71.
- Baker, H. Kent, and Vesa Puttonen. (2017). "How Behavioral Biases Can Hurt Your Investing', Investment Traps Exposed.": 107-145.
- Brown, Gregory W., and Michael T. Cliff. (2004). "Investor sentiment and the near-term stock market." *Journal of Empirical Finance* 11, no. 1: 1-27.
- Brown, Gregory W., and Michael T. Cliff. (2005). "Investor sentiment and asset valuation." *The Journal of Business* 78, no. 2: 405-440.
- Bukari, Gbensuglo Alidu. (2017). "Political Economy Analysis of Elections in Ghana's Fourth Republic (1992 To 2016)." PhD diss., University of Ghana.
- Cao, Melanie, and Jason Wei. (2002). "Stock market returns: A temperature anomaly." In *Working Paper, SSRN.com*.
- Cao, Melanie, and Jason Wei. (2005). "An expanded study on the stock market temperature anomaly." *Research in Finance* 22: 73-112.
- Chang, Tsangyao, Chien-Chung Nieh, Ming Jing Yang, and Tse-Yu Yang. (2006). "Are stock market returns related to the weather effects? Empirical evidence from Taiwan." *Physica A: Statistical Mechanics and its Applications* 364: 343-354.
- Chang, Shao-Chi, Sheng-Syan Chen, Robin K. Chou, and Yueh-Hsiang Lin. (2008). "Weather and intraday patterns in stock returns and trading activity." *Journal of Banking & Finance* 32, no. 9: 1754-1766.
- Christiaanse, Ellen, Ruben Sinnecker, and Marco Mossinkoff. (2001). "The impact of B2B exchanges on brick and mortar intermediaries: the Elemica case." *ECIS 2001 Proceedings*: 6.
- Cinner, Joshua E., Tim R. McClanahan, Nicholas AJ Graham, Tim M. Daw, Joseph Maina, Selina M. Stead, Andrew Wamukota, Katrina Brown, and Örjan Bodin. (2012). "Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries." *Global Environmental Change* 22, no. 1: 12-20.
- Cunningham, Michael R. (1979). "Weather, mood, and helping behavior: Quasi experiments with the sunshine samaritan." *Journal of Personality and Social Psychology* 37, no. 11: 1947.
- De Long, J. Bradford, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldmann. (1990). "Noise trader risk in financial markets." *Journal of Political Economy* 98, no. 4: 703-738.
- Dowling, Michael, and Brian M. Lucey. (2005). "Weather, biorhythms, beliefs and stock returns—some preliminary Irish evidence." *International Review of Financial Analysis* 14, no. 3: 337-355.
- Fisher, Kenneth L., and Meir Statman. (2000). "Investor sentiment and stock returns." *Financial Analysts Journal* 56, no. 2: 16-23.

- Finter, Philipp, Alexandra Niessen-Ruenzi, and Stefan Ruenzi. (2012). "The impact of investor sentiment on the German stock market." *Zeitschrift für Betriebswirtschaft* 82, no. 2: 133-163.
- Floros, Christos. (2011). "On the relationship between weather and stock market returns." *Studies in Economics and Finance*, doi.org/10.1108/10867371111110525
- Goetzmann, William N., and Ning Zhu. (2005). "Rain or shine: where is the weather effect?" *European Financial Management* 11, no. 5: 559-578.
- Gonzalez, L., Powell, J.G., Shi, J. and Wilson, A., (2005). Two centuries of bull and bear market cycles. *International Review of Economics & Finance*, 14(4), pp.469-486.
- Hirshleifer, David. (2001). "Investor psychology and asset pricing." *The Journal of Finance* 56, no. 4: 1533-1597.
- Hirshleifer, David, and Tyler Shumway. (2003). "Good day sunshine: Stock returns and the weather." *The Journal of Finance* 58, no. 3: 1009-1032.
- Horton, Radley M., Justin S. Mankin, Corey Lesk, Ethan Coffel, and Colin Raymond. (2016). "A review of recent advances in research on extreme heat events." *Current Climate Change Reports* 2, no. 4: 242-259.
- Harding, Noel, and Wen He. (2016). "Investor mood and the determinants of stock prices: an experimental analysis." *Accounting & Finance* 56, no. 2: 445-478.
- Iddon, Casey, Samantha Hettihewa, and Christopher S. Wright. (2015). "Value Relevance of Accounting and Other Variables in the Junior-Mining Sector." *Australasian Accounting, Business and Finance Journal* 9, no. 1: 25-42.
- Jacobsen, Ben, and Wessel Marquering. (2008). "Is it the weather?" *Journal of Banking & Finance* 32, no. 4: 526-540.
- Jameaba, Muyanja-Ssenyonga. (2020). "Digitization, FinTech Disruption, and Financial stability: The Case of the Indonesian Banking Sector." *Available at SSRN*.
- Johnman, Mark, Bruce James Vanstone, and Adrian Gepp. (2018). "Predicting FTSE 100 returns and volatility using sentiment analysis." *Accounting & Finance* 58: 253-274.
- Joshipura, Mayank, and Shilpa Peswani. (2018). "The Volatility Effect in Value and Growth Stocks: Evidence from India." *NMIMS Management Review XXXVI*, no. 1: 46-62.
- Kahneman, Daniel. (2003). "Maps of bounded rationality: Psychology for behavioral economics." *American Economic Review* 93, no. 5: 1449-1475.
- Klein, Naomi. (2007). *The shock doctrine: The rise of disaster capitalism*. Macmillan.
- Krämer, Walter, and Ralf Runde. (1997). "Stocks and the weather: An exercise in data mining or yet another capital market anomaly?" *Empirical Economics* 22, no. 4: 637-641.
- Kumar, Rakesh, and S. K. Kaushal. (2017). "Examining factors affecting consumers' attitude and purchase intention with special reference to electronic durable goods." *NMIMS Management Review* 35, no. 3: 25-45.
- Lee, Wayne Y., Christine X. Jiang, and Daniel C. Indro. (2002). "Stock market volatility, excess returns, and the role of investor sentiment." *Journal of Banking & Finance* 26, no. 12: 2277-2299.
- Lieberman, Diana. (1982). "Seasonality and phenology in a dry tropical forest in Ghana." *The Journal of Ecology*: 791-806.
- Liu, Chun-Yu, Shu-Nung Yao, and Ying-Jen Chen. (2019). "Icycanalysis: An R Package for Technical Analysis in Stock Markets." *IEICE Transactions on Information and Systems* 102, no. 7: 1332-1341.
- Loeb, Gerald M. (2007). *Battle for investment survival*. Vol. 36. John Wiley & Sons.

- Loughran, Tim, and Jay Ritter. (2004). "Why has IPO underpricing changed over time?" *Financial Management* : 5-37.
- Lu, Jing, and Robin K. Chou. (2012). "Does the weather have impacts on returns and trading activities in order-driven stock markets? Evidence from China." *Journal of Empirical Finance* 19, no. 1: 79-93.
- Mehra, Rajnish, and Raaj Sah. (2002). "Mood fluctuations, projection bias, and volatility of equity prices." *Journal of Economic Dynamics and Control* 26, no. 5: 869-887.
- Mirza, Hammad Hassan, and Naveed Mushtaq. (2012). "Stock Market Returns and Weather Anomaly: Evidence from an Emerging Economy." *Journal of Economics and Behavioral Studies* 4, no. 5: 239-244.
- Mladjenovic, Paul. (2020). *Stock investing for dummies*. John Wiley & Sons.
- Odlyzko, Andrew. (2010). "This time is different: An example of a giant, wildly speculative, and successful investment mania." *The BE Journal of Economic Analysis & Policy* 10, no. 1.
- Olsen, Robert A. (1998). "Behavioral finance and its implications for stock-price volatility." *Financial Analysts Journal* 54, no. 2: 10-18.
- Picciotto, Robert. (2020). "Evaluation and the Big Data Challenge." *American Journal of Evaluation* 41, no. 2: 166-181.
- Saunders, Edward M. (1993). "Stock prices and Wall Street weather." *The American Economic Review* 83, no. 5: 1337-1345.
- Somorin, Olufunso A. (2010). "Climate impacts, forest-dependent rural livelihoods and adaptation strategies in Africa: A review." *African Journal of Environmental Science and Technology* 4, no. 13: 903-912.
- Sun, Yuan, Xuan Liu, Guangyue Chen, Yunhong Hao, and Zuopeng Justin Zhang. (2020). "How mood affects the stock market: Empirical evidence from microblogs." *Information & Management* 57, no. 5: 103181.
- Tetteh, Joseph Emmanuel, Deodat Emilson Adenutsi, and Anthony Amoah. (2019). "The Determinants of Stock Market Return in Ghana: FMOLS and DOLS Approaches." *IUP Journal of Applied Finance* 25, no. 4.
- Wang, Alex. (2011). "Younger Generations' Investing Behaviors in Mutual Funds: Does Gender Matter?" *The Journal of Wealth Management* 13, no. 4: 13-23.
- Wang, Yi-Hsien, Kuang-Hsun Shih, and Je-Wei Jang. (2018). "Relationship among weather effects, investors' moods and stock market risk: An analysis of bull and bear markets in Taiwan, Japan and Hong Kong." *Panoeconomicus* 65, no. 2: 239-253.
- Xu, Cheng. (2015). "Are UK Financial Markets SAD?: A Behavioural Finance Analysis." PhD diss., University of Sheffield.
- Zadorozhna, Olha. (2009). "Does weather affect stock returns across emerging markets." *Unpublished Master's Thesis. Kyiv School Of Economics, Kyiv, Ukraine*.
- Zou, Huiwen, and Lei Sun. (2012). "The influence of investor sentiment on stock return and its volatility under different market states." In *2012 Fifth International Conference on Business Intelligence and Financial Engineering*, pp. 337-341. IEEE.

Sampson Agyapong Atuahene is a Ph.D. candidate in Management Science and Engineering at Jiangsu University Business School, China. His research interests focus on Financial Management, Industrial Economy and Accounting. He has published in a number of top journals. He can be reached at 5103181207@stmail.ujs.edu.cn or samxin8@gmail.com

Yusheng Kong is Professor and Doctoral Supervisor at Jiangsu University, School Finance and Economics China. His research interests focus on Financial Management, Accounting Control and Decision Making and Industrial Economy and Accounting. He has published in a number of journals. He can be reached at 1000001042@ujs.edu.cn

Geoffrey Bentum-Micah is a Ph.D. candidate in Management Science and Engineering at Jiangsu University Business School, China. His research interests focus on Health Policy and Service Marketing Management. He has published in a number of top journals. He can be reached at 5103181232@stmail.ujs.edu.cn