IMPACT OF WEATHER ON STOCK RETURNS AND VOLATILITY - A STUDY ON PAKISTANI STOCK MARKETS AND SELECTED INDUSTRIES

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ABSTRACT: *Last few years have come up with various theoretical and empirical evidences which support the work of financial modeling for the markets with less than rational investors. Such investors base their trading strategy on psychological factors like mood and emotions. Weather condition is one of the factors which have substantial impact on investor decisions. Present study examines the impact of weather (temperature) on stock market returns and volatility in Pakistan during the years 2002 to 2012. This study analyses the relationship among the temperature of Karachi, Lahore and Islamabad on KSE 100, LSE 25 and ISE 10 Index respectively. It also examines the relationship between weather and returns of two industries namely Food & Beverages and Textile. This study uses ARCH/GARCH and Regression Models for the purpose of estimation. Results from this method lead to the conclusion that KSE-100 index is positively related to the temperature of Karachi and ISE 25 index is negatively related to the temperature of Islamabad, however, LSE 25 index is not affected by the temperature of Lahore. Similarly, Food and beverages index is positively related and Textile index is negatively related to the temperature of Karachi. This shows that investors are not rational and weather has an impact on their decisions. These variations in results can be attributed to the difference in the behavior of the citizens of the respective city. Like citizens of Karachi face warm weather in comparison to Lahore therefore, they are positively affected by such conditions whereas residents of Islamabad are more comfortable in moderate to cloudy weather hence they are negatively affected to high temperature. The results also suggest that food and beverages sector is more profitable while textile sector is less profitable in summer. Pakistan, like other developing countries needs to integrate climate changes into development actions by better planning and making stronger policies with long-term vision.*

Key Words: ARCH/GARCH Models, Financial Economist, EMH, Arbitrage Forces

1. INTRODUCTION

During the last decade behavioral finance (BF) has emerged as a new approach to examine different market anomalies in both emerging and developed markets. BF is a fast growing field that studies the behavior of financial practitioners (investors). According to traditional finance, financial practitioners act in a completely rational and self-interested way. They tend to take in account all the information available to them and act accordingly. Theories in Traditional finance like Efficient Market Theory, EMH [1] and Modern Portfolio Theory [2] follow the hypotheses of rational investors and efficient markets. After several years of research it is evident that traditional approach is not sound enough to explain the relationship between performance of stock market and investors' trading behavior due to the fact that investor does not tend to behave rationally all the time. Likewise it is apparent that irrational investors are there in the market, and generate random transactions [3]. Many authors like [4], believed that social science theories can explain the importance of efficiency of financial markets in a right manner, and they can reveal various stock market anomalies, bubbles along with market crashes. A quite new theory, called as behavioral finance, has emerged and can explore all the psychological biases that are present in the financial markets. "In divergence to traditional finance, which take a note of how people should act in order to maximize their wealth, behavioral finance inquire into how people factually behave in a financial setting" [5].

Behavioral finance is the study of numerous social, cognitive, and emotional factors that can affect the decision making of individual investor or institutions. Furthermore it also explains the result of this decision making on market prices and returns. In other words, inefficiency of financial markets is investigated with the help of psychological theories and perspectives are studied in BF. While, the classical finance believed that markets are efficient, investors are rational and it's impossible to outperform the market in the long-run. It has been argued that mood, feelings and emotions play a significant role while making decisions. After the emergence of BF many researchers have argued that mood/feelings are associated with decision making of investors, for example, [6], and [7] in their theories try to link mood and feelings with decision-making. However, [8; 9; 10] and [11] explained the significance of feelings and emotions in decision making. Mood itself can be persuaded by situational and environmental agents, in a comprehensive study that surrounded many weather variables. [12] Discovered that humidity, temperature and amount of sunshine endeavor the highly regarded influence on mood. While others have added in this argument that mood is also influenced by environmental factors such as weather (temperature, cloud cover, sunny days) that in turn affect the decision making. [13], was the first to connect the investors' behavior with weather conditions. However, there is evidence that weather influence the attitudes and mood of investors [14; 15]. On sunny days, Investors rate their life satisfactions higher than

on cloudy or raining days [16]. While, According to [15], during sunny weather investors socialize and transmit more which increases the amount of information (news) and also the stock market returns and volatility. This study has taken into account one of the anomalies i-e., temperature anomaly. According to this anomaly temperature has an impact on investor mood which in turn affects his/her decision making.

Industries are of immense importance in the economic development of any country. As long as agriculture is providing raw materials to the industries, it is helping many industries in Pakistan. Cotton which is also a significant export of Pakistan and raw material of textile industry is a major crop of Pakistan. Pakistan is the world's 4th largest producer and supplier of cotton according to Food and Agriculture Organization of The United Nations. Agriculture had contributed in Pakistan's development in these various ways, e.g. it's a foreign exchange earner, helps in infrastructure development, sustaining the population, source of employment, supports industries, increases the tax revenue of the country (as agriculture engages in 43.61% contribution of Pakistan labor force). Agricultural sector of Pakistan has made significant contribution to its GDP (21.4% as per [17], 2012-13). When the GDP of a country grows, economic development takes place.

This research will investigate the impact of weather (temperature) on stock market returns and volatility. In this regard, this research is carried on three major indices of Pakistan: KSE-100, LSE-25, ISE-10 for a period of 11 years i-e from 2002 to 2012. Moreover, two sectors are identified that have Agriculture based products including Food & Beverages and Textile. The impact of Karachi's temperature is analyzed on the returns of these industries.

Rest of the paper is organized as follows: section 2 provides the relevant review of literature, section 3 discusses the research methodology and models. Results are discussed in section 4 and section 5 gives the conclusion.

2. LITERATURE REVIEW

There exists a substantial academic literature on the effect of weather on stock returns and volatility. Some support the view that weather has a positive impact on the stock market returns while others support the contrary school of thought that weather has a negative impact on the stock market returns, some are even found negating the importance of weather with reference to the stock market returns. Researches including [18;19;20;21;22;23;24;25]argue that good weather affects investors' mood and they, in turn, can wrongly attribute optimistic feelings such as that point to the favorable projection of financial markets (although it is just a fine weather effect). [26] Investigated that Investor's mood is greatly affected by the lack of sunlight which also affects the buying and selling power of individuals regarding asset and equity. Weather has an effect on returns and volatility of the shanghai stock market and it can be concluded that weather can affect investor decision making that will affect stock returns. [27] Analyzed that Mood is a huge indicator in a financial market for making investment decision. Investors give primary importance to the information which they get from their mood, and they are not required to apprehend the detail information of the future value of the stocks. On sunny days people behave more positively than on cloudy days which affect their investment decision [11]. They anticipate the fact that bad weather (rainy days) cause investor to feel depressed, lazy and wish to remain at home and such investors mood also affect the stock market returns and also suggest that weather impact also exist in stock returns. Happiness is more affected by current hourly temperature than average temperature, suggested by [13]

A parallel reasoning holds for negative relationship between weather and stock returns. [28] Suggest there is weak relationship between weather and stock returns. However, [29], finds that temperature and stock returns are negatively correlated. [30], recommends that weather has no affect on stock market returns, and that, Amsterdam exchange index is not affected by changes in weather. [31] Claim that cloudiness and the length of time are some of the factors which affect investor mood and hence their decision making while investing in stocks. They conclude that cloudiness and length of time are inversely related to market volatility and the strength of association varies with the location with respect to the equator. [32] Analyze the influence of weather on the investment in the Czech and U.S. stock market and conclude a weak relation between the two variables. Most extensive study so far is done by [33], where 25 international stock markets are considered and find that the negative correlation is statistically significant in individual countries, i.e. the higher the temperature, the lower the stock returns. Market player are more interested to buy the stock when weather is good and sell when it is bad [24].

Our study tends to analyze the relationship between weather (temperature) and stock returns with the help of ARCH (I,I) and OLS. Extensive research has already been done in different countries because the topic carries immense importance. But from Pakistan's point of view very little research is carried on the topic and especially no study is found where the temperature effect is analyzed on the mood of the investors investing in Pakistani stock markets including KSE, LSE and ISE. Similarly no study is carried on selected industries where impact of temperature is analyzed on industries which include food & beverages and textile.

Based on the literature review we develop the following research hypotheses.

H1: Temperature has significant impact on stock returns using KSE-100 index, LSE-25 index and ISE-10 index.

H2: Temperature has significant impact on stock volatility using KSE-100 index, LSE-25 index and ISE-10 index.

H3: Temperature has significant impact on agri. based product selected industries which include food & beverages and textile.

3. RESEARCH METHODOLOGY

The present study has incorporated average of daily weather data and stock return data of Karachi stock exchange, Lahore stock exchange and Islamabad stock exchange during period of 11 years from 2002 to 2012. Daily temperature data is gathered from Pakistan Metrological Department (PMD), and average temperature is calculated using the average of 24 hour temperature readings on daily basis. The impact of Karachi, Lahore and Islamabad's weather has been checked on Karachi, Lahore and Islamabad Stock Exchange respectively. In this regard, KSE 100 Index, LSE 25 Index and ISE 10 Index have been used. Furthermore, two industries are selected which are most affected by the temperature namely Food & Beverages and Textile. The impact of temperature on these industries is analyzed

separately. The selected industries are chosen from Karachi stock exchange since it is the largest stock exchange of Pakistan and represents most of the major sectors of Pakistan. For simplicity index of each sector is calculated using the market price of shares and number of shares. The daily index return is calculated as natural logarithmic price relatives given in the following equation:

$$R_t = ln\left(\frac{KSE_t}{KSE_{t-1}}\right)$$

This is for KSE whereas similar method is used to calculate the return of other indices. Moreover, index of each industry is also calculated for analysis purpose.

ARCH/GARCH Models are used in the current study depending upon the assumptions of each model. The first ARCH model was presented by [34]. The model suggests that the variance of the residuals at time t depend on the squared error terms from the past periods. Engle simply suggested that it is better to simultaneously model the mean and the variance of a series when we suspect that the conditional variance is not constant.

Consider the simple model:

$$Y_t = \propto + \beta X_t + \mu_t$$

Where X_t is an n*k vector of explanatory variables and β is a

k*1 vector of coefficients.

Normally, it is assume that μ_t is ideally, independently distributed with a zero mean and a constant variance σ^2, or in mathematical notation:

$\mu_t \sim iid\ N(0,\sigma^2)$

[35] idea starts from the fact that he allows the variance of the residuals (σ^2) to depend on past history or to have heteroskedasticity because the variance will change over time. One way of allowing for this is to have the variances depend on one lagged period of the squared error terms as follows:

$$\sigma^2 = h_t = \gamma_0 + \gamma_1 \mu_{t-1}^2$$

Which is basic ARCH (1) process.

Engle ARCH (1) model simultaneously models the mean and variance of the series with the following specification:

$$Y_t = \propto + \beta X_t + \mu_t \qquad (A)$$

$$\mu_t \sim iid\ N(0,\sigma^2)$$

$$\sigma_t^2 = \gamma_0 + \gamma_1 \mu_{t-1}^2 \qquad (B)$$

In ARCH (q) model, the variance equation has the following form:

$$\sigma_t^2 = \gamma_0 + \gamma_1 \mu_{t-1}^2 + \gamma_2 \mu_{t-2}^2 + \cdots + \gamma_q \mu_{t-q}^2$$

In summation form, the above equation can be written as:

$$\sigma_t^2 = \gamma_0 + \sum_{j=1}^{q} \gamma_j\, \mu_{t-j}^2$$

Also

$\gamma_i \geq 0\ \forall\ i = 0,1,2,3,\ldots,q$

Where:

X_t = Set of Explanatory Variables

σ_t^2 =Conditional variance at time t

$iid\ N(0,\sigma^2)$ = Ideally, independently distributed with a zero mean and constant variance σ^2

Y_t = Set of Dependent Variables

μ_t = Disturbance term

Where equation (A) is called the mean equation and equation (B) is called the variance equation. The ARCH (1) model says that when a big shock happen in period $t-1$, it is more likely that the value of $\mu_t$will be bigger as well. That is, when $\mu_{t-1}^2$is small, the variance of the next innovation $\mu_t$is also small. The estimated coefficient of γ_1 has to be positive for positive variance.

ARCH provided a framework for the analysis and development of time series models of volatility. However the ARCH model is only the starting point of the empirical study and relies on a wide range of specification tests. One of the drawbacks of ARCH specification, according to [33] is that it looks like a moving average specification than an auto regression. The GARCH (1, 1) model can be generalized to a GARCH (p, q) model—that is, a model with additional lag terms. From this, a new idea is developed to include the lagged conditional variance term as autoregressive terms [35].

A high ARCH order is needed to capture the dynamic behavior of conditional variance. The Generalized ARCH (GARCH) model of [35] fulfils this requirement as it is based on an infinite ARCH specification which reduces the number of estimated parameters from infinity to two.

The general GARCH (p, q) model has the following form:

$$Y_t = \propto + \beta X_t + \mu_t$$

$$\mu_t \sim iid\ N(0,\sigma^2)$$

In that case, the GARCH (p, q) model (where p is the order of the GARCH terms $\sigma^2$and q is the order of the ARCH terms μ^2) is given by:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \cdots + \alpha_q \mu_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + \cdots + \beta_p \sigma_{t-p}^2$$

In summation form, the above equation can be written as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i\, \mu_{t-i}^2 + \sum_{i=1}^{p} \beta_i\, \sigma_{t-i}^2$$

Where:

σ_t^2 =Conditional variance at time t

$iid\ N(0,\sigma^2)$ = Ideally, independently distributed with a zero mean and constant variance σ^2

μ_t = Disturbance term

The above can be described as, the value of the variance scaling parameter σ^2now depends both on the past values of the shocks (the q MA terms), which are captured by the lagged squared residual terms, and on past values of itself (the p AR terms), which are captured by lagged σ^2terms.

It is clear from the last equation that for $p = 0$, the model reduces to ARCH (q). The simplest form of GARCH (p, q) is the GARCH (1, 1) model, which has the following form:

$$Y_t = \propto + \beta X_t + \mu_t \qquad (C)$$

$$\mu_t \sim iid\ N(0, \sigma^2)$$

$$\sigma^2 = h_t = \gamma_0 + \gamma_1 h_{t-1} + \gamma_2 \mu_{t-1}^2 \qquad (D)$$

Where equation (C) is called the mean equation and equation (D) is called the variance equation. This model specification usually performs very well and is easy to estimate because it has only three unknown parameters.

We here used ARCH/GARCH model for Karachi, Lahore, Islamabad, Food and Beverages and Textiles data since it does not fulfills the assumptions of regression analysis and mainly because of the presence of heteroskedasticity and auto-regression in their data.

4. DATA ANALYSIS AND DISCUSSION

The descriptive statistics is presented in the following table 4.1

Table 4.1 Descriptive Statistics

	Mean	Med	Max	Min	Std. Dev.
KSE-100	8892.9	9665.4	16943.2	1330.7	3995.9
ISE-10	1565.8	1589	1778.3	1411.6	94.4
LSE-25	3416.3	3278.8	5739.6	1300.9	940.9
F & B.	4173.2	3108.7	15640.6	947.4	3122.4
Textiles	921.4	1004.4	1462.2	236.3	328.3
KHI (°C)	26.8	28.3	35.2	11.2	4.4
LHR (°C)	24.1	25.9	40.9	3.8	7.9
ISl (°C)	22.2	23.5	40	5.6	7.9

Mean value of KSE 100 index is 8892.880 while the median value is 9665.365 which is the central value of KSE 100 index. The maximum value of KSE-100 index is 16943.190 and minimum value of 1330.73 during the study period. The deviation from mean value for KSE-100 index is 3995.856. Similarly the mean value for ISE 10 index is 1566 with relatively small standard deviation of 94.4. The LSE 25 index has the mean value of 3416 with a standard deviation of 941. The descriptive statistics shows that the mean value of Karachi temperature (26.79°C) is high among three cities followed by Lahore (23.84 °C) and lowest for the Islamabad (21.75°C). Regarding skewness, KSE-100, ISE-10, Food & Beverages and Tobacco are positively skewed while the rest of the variables are negatively skewed.

The impact of weather on different stock markets and selected industries is carried out separately for each of the stock market and industry. The following section present and explain these results in detail.

4.1: Impact of Weather (temperature) on stock market indices:

The impact of weather (temperature) on stock market indices of Pakistan is carried out by analyzing the impact of Karachi, Islamabad and Lahore temperature on KSE 100 index, ISE 10 index and LSE 25 index respectively.

Firstly, the impact of Karachi temperature is analyzed on KSE-100 index. In order to test the auto regression and heteroskedasticity, the results are presented in table 1(A) in the Appendix. The results in table shows that KSE (-1) has significant probability that assures the presence of auto-regression. Similarly Table 1(B) in appendix presents significant chi square and resid^2(-1) values, which confirms the presence of heteroskedasticity. After meeting the conditions of ARCH/GARCH Model estimation, results are presented in following table 4.1.

Table 4.1: Model Estimation (Impact of Karachi's temperature on KSE 100 index)

Dependent Variable: KSE				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*TEMP				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.0020	0.0000	7.9820	0.0000
KSE(-1)	0.0720	0.0200	3.5150	0.0000
Variance Equation				
C	9.54E-06	0.0000	14.0060	0.0000
RESID(-1)^2	0.1880	0.0140	13.2710	0.0000
GARCH(-1)	0.7681	0.0127	60.2144	0.0000
TEMP	0.0002	1.83E-05	9.1874	0.0000
R-squared	0.0094	Durbin-Watson stat		1.8985
Adjusted R-squared	0.009			

The results in the above table shows that mean equation has a significant probability of KSE(-1) which infers that past returns of KSE 100 index can predict future returns of KSE 100 index. According to variance equation resid (-1)^2 also has a significant probability i-e past volatility of KSE 100 index can predict future volatility of KSE 100 index. Furthermore significant GARCH (-1) reflects that the results stated above are also persistent. Furthermore TEMP also has a significant probability which leads us to the acceptance of alternative hypothesis H1,and interpretation that temperature has a significant impact on KSE-100 index returns, moreover positive value of its coefficient infers that this relationship is positive i-e increase in temperature increases the index returns and vice versa.

These results are consistent with the study conducted by [18] which conclude that on sunny days people behave more positively than on cloudy days which affect their investment decision. Another study by [23], has claimed that the influence of cloud cover has negative impact on stock returns. Stating it the other way; sunny days have positive impact on stock returns. [23] also proved that temperature does have an impact on stock returns.

Secondly, the impact of Islamabad temperature is analyzed on ISE-10 index. The results in table 2 (A) in the appendix shows that KSE (-1) has significant probability that assures the presence of auto-regression. Similarly Table 2(B) in appendix also presents significant chi square and resid^2(-1)

Table 4.2: Model Estimation (Impact of Islamabad's temperature on ISE 10 index)

Dependent Variable: ISE				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*TEMP				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	211.9810	86.9303	2.4385	0.0147
ISE(-1)	0.8701	0.0546	15.9314	0.0000
Variance Equation				
C	3460.7100	597.0000	5.7999	0.0000
RESID(-1)^2	0.6520	0.4257	1.5317	0.0000
GARCH(-1)	-0.0402	0.0337	-1.1932	0.0000
TEMP	-98.8809	17.0766	-5.7905	0.0000
R-squared	0.7003	Durbin-Watson stat		2.7655
Adjusted R-squared		0.6981		

values, which confirms the presence of heteroskedasticity. The results of ARCH/GARCH Model estimation are presented in following table 4.2.

The results show that probability of ISE(-1) is less than 0.05 (significant) for mean equation and it can be concluded that past returns of ISE 10 index can predict future returns of ISE 10 index. Moreover, resid(-1)^2 in Variance equation also has a significant probability ($p<0.05$) which means past volatility of ISE 10 index can predict future volatility of ISE 10 index. Significant value of GARCH (-1) shows that the results are persistent. Furthermore above table shows that results are significant (probability of temp is <0.05, we will accept alternative hypothesis H1) the relationship between temperature and ISE 10 index is negative because of the negative sign of temperature coefficient i-e greater the temperature lower the value of ISE 10 index.

This result is in accordance with the results of [29] who found that stock markets returns are negatively related to temperature.

Thirdly, the impact of Lahore temperature is analyzed on LSE-25 index. The results in table 3 (A) in the appendix shows that KSE (-1) has significant probability that assures the presence of auto-regression. Similarly Table 3 (B) in appendix also presents significant chi square and resid^2(-1) values, which confirms the presence of heteroskedasticity. The results of ARCH/GARCH Model estimation for impact of Lahore temperature on LSE-25 index are presented in following table 4.3.

The results show that mean equation has a significant probability of LSE(-1) which infers that past returns of LSE 25 index can predict future returns of LSE 25 index.

Table 4.3: Model Estimation (Impact of temperature of Lahore on LSE-25)

Dependent Variable: LSE				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*TEMP				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	8.5112	3.4883	2.4400	0.0147
LSE(-1)	0.9983	0.0010	1004.0820	0.0000
Variance Equation				
C	142.0538	12.7582	11.1343	0.0000
RESID(-1)^2	0.1667	0.0147	11.3754	0.0000
GARCH(-1)	0.7989	0.0140	57.2658	0.0000
TEMP	0.1743	0.7330	0.2378	0.8120
R-squared	0.9954	Durbin-Watson stat		1.805
Adjusted R-squared	0.9954			

According to variance equation resid(-1)^2 also has a significant probability i-e past volatility of LSE 25 index can predict future volatility of LSE 25 index. Furthermore significant GARCH (-1) reflects that the results stated above are also persistent. Furthermore TEMP has insignificant probability which leads us to the rejection of hypothesis H3, and interpretation that temperature does not has a significant impact on LSE 25 index returns.

These results are consistent with the study by [31] and who recommended that weather has no affect on stock market returns, and that, Amsterdam exchange index is not affected by changes in weather. Our results support another study by [38], who concluded that weather, does not have any impact on stock returns. Our results suggest that weather of Lahore does not have any impact on LSE 25 index.

4.2: Impact of Karachi Weather (Temperature) on Selected Industries Indices:

Similar to above analysis, the impact of Karachi weather is also analyzed on selected industries indices which include Food & Beverages and Textile. Both of these industries are from agri based products which is a major and largest sector of Pakistan Economy.

The table 4 (A) in the appendix shows that findex (-1) has significant probability that assures the presence of auto-regression. Furthermore, Table 4 (B) presents significant chi square and resid^2(-1) values, which confirm the presence of heteroskedasticity. The results of model estimated are presented below in 4.4.

Table 4.4: Model Estimation (Impact of Karachi temperature on Food & Beverages index)

Dependent Variable: FINDEX				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*TEMP				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.0007	0.0002	3.4940	0.0005
FINDEX(-1)	-0.1140	0.0235	-4.8475	0.0000
Variance Equation				
C	6.96E-05	3.46E-06	20.137	0.0000
RESID(-1)^2	0.3527	0.0144	24.420	0.0000
GARCH(-1)	0.3382	0.0244	13.819	0.0000
TEMP	0.0001	4.26E-05	3.9503	0.0001
R-squared	0.0115	Durbin-Watson stat		2.0118
Adjusted R-squared		0.0112		

The results in the above table shows that mean equation has a significant probability of findex (-1) which infers that past returns of food and beverages index can predict future returns of food and beverages index. Variance equation also explains that resid (-1)^2 also has a significant probability i-e past volatility of food and beverages index can predict future volatility of food and beverages index. Furthermore, significant GARCH(-1) reflects that the results stated above are also persistent. Furthermore TEMP also has a significant probability (accepting the alternative hypothesis H3) which leads us to the interpretation that temperature does have a significant impact on food and beverages index returns. Moreover positive value of its coefficient infers that this relationship is positive i-e increase in temperature increases the index returns and vice versa.

These results are consistent with the previous studies like the research by [19]and [36] who found that weather and specifically temperature has an impact on the stock markets of the respective cities. Whereas [18] beside others found that temperature has a positive impact on stock market returns.

Similarly impact of Karachi temperature is analyzed on textile sector index. Table 5 (A) and 5 (B) shows the results of autocorrelation and heteroskedasticity and confirm the presence. The estimated results are presented in following table 4.5.

In the above table the probability of KSE (-1) is greater than 0.05 (insignificant) for mean equation and it can be concluded that past returns of textile index cannot predict future returns of textile index. Moreover, resid(-1)^2 in Variance equation has a significant probability ($p<0.05$) which means past volatility of textile index can predict future volatility of textile index. Significant value of GARCH (-1) shows that the results are persistent. Furthermore, Above table shows that results are significant(probability of temp is <0.05, accepting alternative hypothesis H1, but the relationship between temp and textile index is negative because of negative sign of temp coefficient i-e greater the temperature lower the value of textile index

Table 4.5: Model Estimation (Impact of temperature of Karachi on Textiles index)

Dependent Variable: KSE				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*TEMP				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	6.97E-05	0.0004	0.1624	0.8710
TINDEX(-1)	-0.0355	0.0203	-1.7497	0.0800
Variance Equation				
C	1.18E-05	1.63E-06	7.2573	0.0000
RESID(-1)^2	0.0643	0.0049	12.999	0.0000
GARCH(-1)	0.9198	0.0056	161.990	0.0000
TEMP	-0.0005	0.0001	-4.4181	0.0000
R-squared	0.0025	Durbin-Watson stat		2.0380
Adjusted R-squared		0.0022		

Our results are consistent with the study by [38]. They also found that weather and stock returns are negatively correlated and concluded that high temperature will affect the investors decision making negatively that in turn will decrease the value of stock returns and vice versa. Another study by [33], supports our result, in that 25 international stock markets were considered and they found that the negative correlation is statistically significant in individual countries, i.e. the higher is the temperature, the lower the stock returns.

5. CONCLUSION

This study tends to explore the influence of weather (temperature) on stock returns and volatility. The results lead to the conclusion that KSE-100 index is positively related to the temperature of Karachi and ISE 25 index is negatively related to the temperature of Islamabad. However, LSE-25 index is not affected by the temperature of Lahore. Moreover, Food and beverages is positively related and Textile sector is negatively related to changes in temperature of Karachi. Results are different for each city and industry. The results of the current study suggest that temperature anomaly is present for Karachi (KSE-100 index) and Islamabad (ISE-10 index) only. Furthermore, in KSE 100 index there is a temperature anomaly for food & beverages and textile sectors. Additionally, results also suggested that in ISE 10 index and textile sector, low temperature results in high returns. But for KSE 100 index and food & beverages sectors, temperature and stock return/ index are positively related that means "high temperature can lead to higher stock returns since aggression and apathy have competing effects on risk-taking" [29]. These variations in results can be attributed to the difference in the behavior of the citizens of the respective city. Like citizens of Karachi face warm weather in comparison to Lahore therefore, they are positively affected by such conditions whereas residents of Islamabad are more comfortable in moderate to cloudy weather hence they are negatively related with high temperature. Pakistan, like other developing countries needs to integrate climate changes into

development actions by better planning and stronger policies with long-term vision. From investor point of view, they can take help from researches like these to understand their generalized behavior towards temperature and take decisions accordingly. Incorporating such knowledge will make them a better and more profitable investor.

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APPENDIX

Table 1 (A): Test for Auto-regression (Impact of temperature of Karachi on KSE-100)

Dependent Variable: KSE				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.00081	0.00027	2.9408	0.0033
KSE(-1)	0.11854	0.01908	6.2112	0.0000
R-squared	0.01406	Durbin-Watson stat		1.9976
Adj. R square	0.0137			

Table 1 (B): Test for Heteroskedasticity (Impact of temperature of Karachi on KSE-100)

Heteroskedasticity Test: ARCH				
F-statistic	291.0930	Prob. F(1,2703)		0.0000
Obs*R-squared	262.9867	Prob.ChiSquare(1)		0.0000
Dependent Variable: RESID^2				
Method: Least Squares				
Variable	Coefficient	Std. Error	tStatistic	Prob.
C	0.00014	9.19E-06	15.31044	0.0000
RESID^2(-1)	0.3117	0.0182	17.0614	0.0000
R-squared	0.0972	Durbin-Watson stat		2.1071
Adj. R-squared	0.0969			

Table 2 (A): Test for Auto-regression (Impact of temperature of Islamabad on ISE-10)

Dependent Variable: ISE				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.3702	5.0472	2.4509	0.0143
ISE(-1)	0.9953	0.0020	498.9513	0.0000
R-squared	0.9913	Durbin-Watson stat		2.1251
Adjusted R-squared	0.9913			

Table 2 (B): Test for Heteroskedasticity (Impact of temperature of Islamabad on ISE-10)

Heteroskedasticity Test: ARCH				
F-statistic	517.8517	Prob. F(1,2466)		0.0000
Obs*R-quared	418.5027	Prob. Chi-Square(1)		0.0000
Dependent Variable: RESID^2				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1391.394	255.1568	5.4531	0.0000
RESID^2(-1)	0.4389	0.0193	22.7564	0.0000
R-squared	0.1926	Durbin-Watson stat		1.8544
Adjusted R-squared	0.1922			

Table 3 (A): Test for Auto-regression (Impact of temperature of Lahore on LSE-25)

Dependent Variable: LSE				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.6865	4.8757	2.1918	0.0285
LSE(-1)	0.9972	0.0014	724.6409	0.0000
R-squared	0.9954	Durbin-Watson stat		1.8047
R square	0.9954			

Table 3 (B): Test for Heteroskedasticity (Impact of temperature of Lahore on LSE-25)

Heteroskedasticity Test: ARCH			
F-statistic	404.8896	Prob. F(1,2703)	0.0000
Obs*R-squared	347.0413	Prob.ChiSquare(1)	0.0000
Dependent Variable: RESID^2			
Method: Least Squares			
Variable	Coefficient	Std. Error	tStatistic	Prob.
C	2515.968	192.4100	13.0761	0.0000
RESID^2(-1)	0.3789	0.0188	20.1219	0.0000
R-squared	0.143583	Durbin-Watson stat		2.181776
Adj. R-quared	0.143229			

Table 4 (A): Test for Auto-regression (Impact of Karachi temperature on Food & Beverages)

Dependent Variable: FINDEX				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0011	0.00028	4.0639	0.0000
FINDEX (-1)	-0.1112	0.01908	-5.8279	0.0000
R-squared	0.0124	Durbin-Watson stat		2.0187
Adj. R-squared	0.0120			

Table 4 (B): Test for Heteroskedasticity (Impact of Karachi temperature on Food & Beverages)

Heteroskedasticity Test: ARCH			
F-statistic	498.3055	Prob. F(1,2704)	0.0000
Obs*R-squared	421.0762	Prob. Chi-Square(1)	0.0000
Dependent Variable: RESID^2			
Method: Least Squares			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.00012	1.40E-05	8.8976	0.0000
RESID^2(-1)	0.39448	0.0177	22.3227	0.0000
R-squared	0.155608	Durbin-Watson stat		1.9302
Adj. R-squared	0.1553			

Table 5 (A) : Test for Auto-regression (Impact of Karachi temperature on Textiles)

Dependent Variable: KSE				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.44E-05	0.00049	0.17169	0.8637
KSE(-1)	-0.0532	0.01918	-2.7747	0.0056
R-squared	0.0028	Durbin-Watson stat		2.0048
Adjusted R-squared	0.0025			

Table 5 (B): Test for Heteroskedasticity (Impact of Karachi temperature on Textiles)

Heteroskedasticity Test: ARCH			
F-statistic	50.5205	Prob. F(1,2707)	0.0000
Obs*R-squared	49.6316	Prob. Chi-Square(1)	0.0000
Dependent Variable: RESID^2			
Method: Least Squares			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0006	3.11E-05	18.2143	0.0000
RESID^2 (-1)	0.1354	0.0190	7.1078	0.0000
R-squared	0.0183	Durbin-Watson stat		2.0212
Adj. R-squared	0.0179			