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THE IMPACT OF WEATHER CONDITIONS ON STOCK RETURN: EVIDENCES FROM ISTANBUL STOCK EXCHANGE

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HAVA DURUMUNUN HİSSE SENEDİ GETRİSİNE ETKİSİ: BORSA İSTANBUL'DAN KANITLAR

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FOREWORD

It would be not possible to fulfill this goal without contribution and guidance of my family. I must thank my mother Fatma Fulya Köybaşıoğlu, my father Ahmet Köybaşıoğlu and my brother Arca Köybaşıoğlu for their priceless supports.

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LIST OF ABBREVATIONS

ABBREVATIONS	EXPLANATIONS
SAD	: Seasonal Effective Disorder
AIM	: Affect Infusion Model
MMH	: Mood Maintenance Hypothesis
WOM	: Word of Mouth

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ABSTRACT

This study investigates effects of weather-related mood factors to stock market returns and guide professional traders and investors on shifts on risk tolerances which caused by weather-related mood effects. Initial purpose of the thesis is to determine the relationship between weather variables and stock market returns whereas the second aim is to investigate the way that weather parameters influence stock gains.

Istanbul Stock Exchange returns were utilized with weather variables of Istanbul between 2000-2018. Relative temperature and relative wind independent variables were calculated to reflect mood conditions of investors in the best possible way. Binary weather variables (snow, rain, hail, fog, tornado) and weekday dummy variables were added into regression analysis to increase robustness of the study. In addition to weather effect, day-of-the-week anomaly was also tested. Findings of this thesis indicate that weather has significant effect on stock market returns. The direction of correlations between relative temperature parameters and stock return were mixed and supported both Affect Infusion Model and Mood Maintenance Hypothesis theories on decision making under risky situations.

Keywords: Market Anomalies, Mood Effect, Weather Effect, Volatility, Behavioral Finance

ÖZET

Bu çalışma hava durumu ile bağlantılı olarak oluşan duygu modu faktörlerinin hisse senedi getirisine olan etkilerini incelemek ve yatırım profesyonelleri ile yatırımcıları hava durumu ile bağlantılı mod etkilerinin neden olduğu risk toleransı değişikliklerinin olası yönü hakkında bilgilendirmektedir. Tezin asıl amacı hava durumu değişkenleri ile hisse senedi piyasası getirileri arasındaki ilişkiyi tayin etmek, ikinci amacı ise hava durumu ve borsa arasındaki bu ilişkinin yönünü incelemektir.

2000-2018 yılları arasındaki Borsa İstanbul verileri İstanbul ilindeki hava durumu verileri ile irdelenerek incelenmiştir. Yatırımcı modunu olabilecek en iyi şekilde yansıtabilmek amacıyla görece sıcaklık ve görece rüzgar hızı parametreleri hesaplanmıştır. Çalışmanın daha doğru sonuç verebilmesi için regresyon analizine ikili hava durumu değişkenleri (kar, yağmur, dolu, sis, kuvvetli rüzgar) ile haftanın günlerinden oluşan parametreler eklenmiştir. Haftanın günlerini içeren veri sayesinde sadece hava durumunun değil aynı zamanda haftanın günlerinin de borsa getirileri üzerindeki etkisi incelenmiştir. Tezin bulguları hava durumunun borsa getirisi üzerinde etkili olduğunu göstermiştir. Ancak, göreceli rüzgar parametresinin borsa getirisi üzerinde anlamı bir etkisi olmadığı görülmüştür. Parametrelerin borsa getirisi ile korelasyonunun yönü değişkenlik göstermiştir ve riskli durumlarda karar verme üzerine açıklanan Affect Infusion Model ve Mood Maintenance Hypothesis teorilerini destekler sonuçlar elde edilmiştir.

Anahtar Sözcükler: Piyasa Anomalileri Mod Etkisi, Hava Durumu Etkisi, Volatilite, Davranışsal Finans

SECTION I
INTRODUCTION

"*Somebody* woke up on the wrong side of bed this morning." can be counted as one of the most international idioms, if it had been said to you someday in your life, you most probably experienced a day which your mood was negative and perceived the world in a negative sense.

Our mood is a temporary state of our minds which influence how we perceive our environment. The Limbic System, being the oldest part of our brain, is the part that processes our mood state.

Empirical research on psychology has shown that there is a strong connection between our mood states and their effects on our life perceptions such as life satisfaction, risk tolerance, happiness, aggression, anxiety and skepticism (Schwarz & Clore, 1983; Keller, et al., 2005; Howarth & Hoffman, 1984; Johnson & Tversky, 1983; Isen & Geva, 1987; Forgas & Moylan, 1987; Isen & Patrick, 1983; Isen & Labroo, 2003). People make decisions based on past judgements, motivations and based on current affective moods (Forgas, 1995).

Researchers applied empirical studies in psychology into finance to investigate market anomalies caused by mood shifts and current moods of traders and investors. Weather, being one of the most influential mood shifters on humans, has a great role on decisions that people undertake in their daily life. Therefore, weather conditions have significant correlations with returns of financial markets (Saunders Jr., 1993; Kamstra, Kramer, & Levi, 2003; Cao & Wei, 2005; Hirsleifer & Shumway, 2003; Keef & Roush, 2005; Trombley, 1997).

There are contrary findings on how mood states effect risk perception; Affect Infusion Model (AIM) and Mood Maintenance Hypothesis (MMH) suggest different risk tolerance shifts based on same mood states. In addition, empirical studies have distinctive findings on how mood states derived by weather conditions

effect financial markets. Empirical studies are generally focused on investigating the impact of cloudiness on stock markets. Furthermore, studies which focus on other weather variables are utilizing raw data rather than investigating points that people feel most positive and negative to derive a relative weather variable.

To this end, our study differs from previous studies made by using Istanbul Stock Exchange returns in many respects. First, this thesis focuses on the relationship between relative weather variables and stock market returns to investigate whether weather conditions have influence on the level of stock prices. Second, recent studies have centered their attention on the effects of algorithmic trading on financial markets. An increasing number of investment banks and hedge funds use computer programs to buy and sell shares automatically. The decisions made by these computers are based on algorithms which are derived from a statistical model may eliminate human errors and has the potential to change the way how financial markets work.

On this basis, we investigate whether the impact of weather on stock returns has changed during our observation period. To this end, this thesis employs two sub periods. The first sub period begins on September 1, 2000, and ends on September 1, 2009 and the second sub period begins on September 1, 2009 and ends on May 15, 2018.

This study employs stock index prices of Istanbul Stock Exchange in comparison with the temperature, wind and weather conditions in Istanbul, Turkey.

The remainder of this thesis is organized as follows; Section II discusses current literature on affective mood states, judgements of well-being, relationship between mood and weather, perception of risk under mood states, the AIM, the MMH, effects of mood on willingness to take financial risks, stock returns and weather conditions, impact of weather on localized trading behavior and word of mouth effect between traders. Section III presents the data and methodology employed in this study. Section IV presents the results and concludes the thesis and describes further research topics to deepen the financial literature on the weather effect.

SECTION II
LITERATURE REVIEW

This paper brings together two different science areas, psychology and finance, to identify relation between human psychology and financial markets. Literature review first focuses on how moods of people change by environmental factors and how people act under influence of their moods. In the second part, this paper investigates does momentary investor moods effect markets and which way does weather conditions effect financial markets.

2.1. LITERATURE ON PSYCHOLOGY

2.1.1. Human Mood and Perceptions

One of the primary studies on effects of mood states on human behavior is Cunnighams's work on weather variables and helping behavior (Cunnigham, 1979). He investigated the effects on sunshine, temperature and wind on willingness of people to help others. (Cunnigham, 1979, s. 1948) states *"Helping or altruism is a behavior that has been found to vary as a function of the mood or emotional state of the subject"*. Thus, he prepared two separate experiments to control weather variables and identify effect of weather on behavior.

First experiment was made outdoors with 540 participants in Minnesota, The United States during summertime and wintertime. Conductors explained that they have a questionnaire consisting of 80 questions asked to how many questions can participants willing to answer. Weather variables were collected one hour before the experiment (13 weather variables including sunshine, temperature, humidity, wind and lunar phase).

The most statistically significant weather variable which influenced helping behavior was sunshine in both summer season and winter season. Participants were more helpful when the sky was shiny. Temperature was positively correlated with helping behavior in winter but negatively correlated in summer. People were more

helpful when humidity was low. Higher wind velocity increased helping behavior in summer, on contrary decreased helping behavior in winter. No association of lunar phase and helping was found in the partial correlations. In the second experiment Cunnigham, partially controlled weather variables by conducting second experiment in climate controlled restaurants. In the second experiment Cunnigham tested variations in amount of tip were given. Sunshine was related with amount of tip left on the table. People were sensitive to sunshine and temperature. Participants in the experiment were more satisfied and thus generous in sunny and warm days. Schwarz and Clore's study documented that effective mood states play an important role on how people define their life satisfaction and happiness (Schwarz & Clore, 1983). In order to find effect of mood to happiness and life satisfaction, Schwarz and Clore implemented two experiments. One experiment is depended on recent happy or sad experiments' and mood manipulation effect on mood of participants, second experiment depended on weather conditions effect on mood. In the first experiment, authors wanted to write down life events from 61 participants and asked their life satisfaction. This experiment was conducted to test whether a situational factor can affect mood even though that factor should not produce current mood. Participants were isolated from external factors in a soundproof room. They were also directed on their expectations about experiment room. Second experiment was conducted in the field by phone. Life satisfaction of 93 participants were tested in sunny and cloudy days. Interviewer primed the condition in some calls by stating they are conducting a research based on effects of weather on mood.

Moods of participants of the first experiment were affected from what they wrote on paper. Moods of participants who described sad life events were significantly lower than participants who wrote positive life events. Participants who were told room may feel them tense, tended to write negative life events and their life satisfaction was lower than other participants. This evidence supports hypothesis that momentary mood is used to express the quality of life.

Well-being of participant in the second experiment was significantly affected from weather conditions. People described themselves as happy and satisfied in sunny days. Priming manipulation on weather increased life satisfaction of participants. Both experiments showed that momentary moods were widely used to define general life satisfaction. When in positive mood, participants used their mood to define their life satisfaction without detailed explanation. When in bad mood, participants used irrelevant explanations to justify their current mood. Participants in positive mood reported their high satisfaction state regardless misattribution manipulations of interviewers. Current effective mood may be responsible for peoples' momentary changes in perceptions on their lives and therefore, their decisions.

Johnson and Tversky investigated whether external news or cases that affect mood can also affect peoples' perceptions of risk prevalence by conducting four different experiments and found that positive or negative external factors can affect risk perceptions as well as they affect mood (Johnson & Tversky, 1983). Authors conducted four studies with total of 553 participants. First study was made with 72 participants that composed of 4 different groups. All participants were asked to read some good or bad news reports and rank them on a 9 points scale about their moods (positive/negative). Instead of one control group, other 3 groups were given an additional case about a detailed death of a person. Participants also received 18 different death reasons and one specific data on one of those risks. Afterwards they assumed the prevalence of them. The participants were asked to make the ranking on a 9 points scale of their apprehension levels. According to the first test results, negative criticizing and apprehension levels, of the 3 experimental groups and global increase on prevalence perception were higher. Second study was run to test the local effect which means that how level of the criticism is affected by the relevancy between the case and the risk. In that study 186 participants ranked the stories according to their mood change, literate, interest levels, and also if they find the 7 given risks can be possibly relevant to their deaths. As in the first study, stories caused a negative feeling and even though there was a global increase of prevalence, again there wasn't any local raise. There was no relevancy between the risk and the

subject of the case. Effect of mood changes on risk assumption was the main focused point in the third test which was done with 191 participants. A pessimistic story which has no relevancy with risk, negative stories from life and nonfatal cases added to the list. According to the results, assumption of risk increases is in line with the pessimistic mood. The objective of the last experiment was to test if there is a decreasing effect of happy feelings on risk assumptions. A positive case was given to 108 participants, there was a significant decrease of concern levels, prevalence assumptions were lower.

When in good mood, people use their mood to define their action or decision without a detailed explanation; on the other hand, when in bad mood, people use irrelevant explanations to justify their action or decision caused by their mood (Schwarz & Clore, 1983). Therefore, if people seek reasons or excuses to legitimize their perceptions caused by their momentary mood, any manipulated external factor can be used to give people sources of excuse to understand how external factors influences one's behavior. Priming (Schwarz & Clore, 1983), content manipulation (Johnson & Tversky, 1983) and environment manipulation (Keller, et al., 2005) has been used in psychology experiments to investigate mood. Keller et al. investigated weather conditions' effects on psychological changes based on the seasons and time spent outside. Findings of the study showed that exposure to sunlight directly affects mood and cognition by increasing serotonin levels, temperature has significant effects on human psychology. Memory task peaks at 22 Celsius degrees and even though high temperature increases human moods, very high and very low temperatures are associated with low moods. However, people spent much of their time inside buildings especially in industrialized geographies. Purpose of this paper was to test hypothesis that degree of mood is affected by season and exposure to outside weather conditions.

Keller et al. conducted three studies with total of 605 participants. First study was made with 97 participants to test weather and mood in spring. During the test participants were asked to answer questions on their mood and to complete two tasks on memory and openness to new information. Participants who spent more

than 30 minutes outside at higher temperature and pressure were in higher moods. In the second study, 121 participants were manipulated at time that they spent outside and asked to complete a questionnaire on their mood and memory test. As in the first study temperature or pressure do not have direct effect to mood. However, moods of participants who were manipulated to be outside on high temperature and high-pressure days had higher moods. Moods of participants who were inside declined in warm and sunny days. In the last study, Keller et al collected information from 387 participants form U.S., Canada and Europe to test weather and mood across seasons and geographical locations. In the thirds test explicit and implicit moods were tested. Moods changes were asymmetrical. Cooler temperatures in towards fall did not predict higher mood. Warm days in spring were significantly improving moods of participants.

Subject to spending at least 30 minutes outside, people who spent their time inside reflected similar moods with who spent their time outside. However, people who spent less than 30 minutes outside in a warm and sunny day showed decreasing mood. Findings supported the hypothesis on time spent outside and seasons. Spring weather changes mood.

2.1.2. Judgmental Effects of Mood

In addition to priming manipulations, cost-benefit trade-offs and risk perceptions, lottery (Mano, 1992), roulette (Isen & Geva, 1987), were investigated to better understand effect of mood on human psychology. Those risk perception studies showed that positive mood is generating risk-averse behavior, on the other hand negative mood is causing risk-seeking behavior. This situation can be explained as people in negative mood want to reach to a healthy positive state, thus are prone to take risks to reach a better condition. People in positive mood, however, are prone to maintain their current good psychology by not taking severe risks. In other words, people in positive mood seek to maintain current mood state, this behavior is hypothesized as Mood Maintenance Hypothesis (MMH) (Isen & Patrick, 1983; Isen & Labroo, 2003).

Forgas hypothesized a contradictory theory, the Affect Infusion Model (AIM); "*Affect infusion may be defined as the process whereby affectively loaded information exerts an influence on and becomes incorporated into the judgmental process, entering the judge's deliberations and eventually coloring the judgmental outcome*" (Forgas, 1995).

According to AIM, affectively loaded information affects judgmental process and decisions. There are four infusion types in the Affect Infusion Model; direct access from past judgmental outcomes of a person, motivated decision processing, heuristic and substantive. Heuristic and substantive processing has no constructive detail and involves affective state in social judgements.

Affect infusion under heuristic processing is expected to be used by judges when there is lack of processing resources, low familiarity with the target. Forgas gives study of Schwarz and Clore (Schwarz & Clore, 1983) as an example to heuristic processing. In this study subjects who were called by phone were not able to use their mood as information in making their judgement on life satisfaction after they were told about weather effect.

Affect infusion under substantive processing relates to mood-congruent judgmental effect mediated by the kind of affect-priming memory mechanisms. A study conducted on participant who let them to videotaped for one day and then answered questions on their tape. Participant were asked to judge positive and negative behaviors of themselves and their partners. Happy subjects identified significantly more positive behaviors than sad subjects. The AIM implies that judgements about more complex stimuli, requiring more elaborate and substantive processing and made without the benefit of objective, videotaped evidence should show even greater mood effects.

"*Greater mood effects for judgements about self than for judgements about others have been found in literature. This can be explained by greater complexity and more extensive processing needed for self-referent information*" (Forgas, 1995).

In various studies subjects presented latency on reading skills and judgement regarding their mood. People in happy mode required less time to read a negative item and make a judgement on negative item.

Asymmetry between positive and negative mood effects on decision making can be evaluated under AIM. Heuristic decision-making process is used when judges seek to construct a judgement using various shortcuts. People use substantial processing when there is a need to engage in the selective, constructive processing of the available information and rely on a variety of learning, associative and memory processes.

When people are making decisions under lack of resources and low familiarity with the subject, they use heuristic process, which Forgas argues that when judges are in positive mood, they tend to perceive world in a positive manner and therefore prone to undermine existing risks (Forgas, 1995). AIM emphasizes that positive mood leads risk-taking decisions, on contrary, negative mood state fosters detail oriented point of view and risk-averse behavior. Decision makers who are in negative mood state focus on negative aspects and thus overshoot the existing risk level in their minds. Mood effects on decisions are possible when constructive processing is used, with affect-priming and affect-as-information as the two main affect infusion mechanisms.

Several studies in psychology link momentary effective mood state to weather, sunshine in most cases, as a factor drives the mood (Schwarz & Clore, 1983; Keller, et al., 2005; Howarth & Hoffman, 1984). Howarth and Hoffman investigated relationship between ten mood variables and eight weather variables. 24 male individuals were participated in this study. Each subject was given an envelope to mark their mood scales for 11 days. Tests were conducted in north hemisphere at wintertime in November and December. Authors reported high intercorrelations between multiple weather variables.

Anxiety and skepticism decreased when hours of sunshine increased and when temperature rose. On the other hand, anxiety increased with rain and snow.

Optimism increased with hours of sunshine. Stepwise multiple regression was utilized to find a linear combination of several weather variables. It has been found that humidity, temperature and sunshine showed significant effects on mood. Skepticism can be significantly predicted by sunshine, precipitation and barometric pressure. Number of sunny hours was a significant predictor of optimism. Even though, there were some significant correlations between some moods and weather variables, those relations were unable to be predicted by the regression.

In addition, a sunny and warm day is a good predictor even for people who spend their time inside, in their studies Keller et al. found that people who spend their time inside under the condition that they spend 30-45 minutes outside, reflected similar moods with who spend whole of their time outside (Keller, et al., 2005). Schwarz and Clore's study (Schwarz & Clore, 1983) where subjects were called by phone and asked their life expectations in sunny and cloudy days, they were not able to use their mood as information in making their judgement on life satisfaction after they were told about weather effect, is an important example to heuristic processing in AIM (Forgas, 1995).

2.2. LITERATURE ON FINANCE

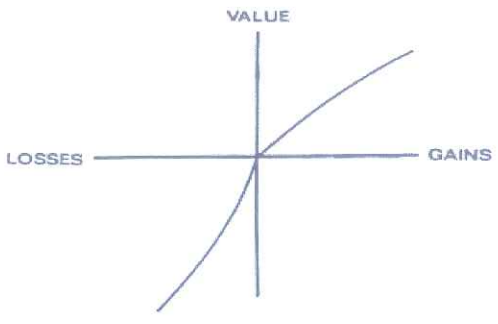
2.2.1. Traditional Finance

Traditional models in finance assume that investors and decision-makers are capable to quantitively investigate all possible outcomes and make cost-benefit analysis and decide on the optimal strategy based on their risk-benefit trade-offs (Markowitz, 1952; Sharpe, 1964). Therefore, traditional finance theory relies on cognitive decision making and does not investigate impact of emotions into financial judgements. However, psychology literature indicates that in fact, people do include emotions and mood shortcuts into process of decision making. This fact much likely can cause to anomalies at the market equilibrium. Moreover, this can affect market efficiency because the market does not have information on heuristic decision process of the agents who act based not on publicly available information but on their moods. No market agent, even the agent who act based on the individual moods, have information about effects of their current mood. Efficient capital

market theory assumes all amount of information must be publicly available to "fully reflect" the price of a security (Fama, 1970). In practice, no agent has full information on anomalies in the market.

In widely used Expected Utility Theory, utilities of possible outcomes are weighted based on their probabilities. However, Kahneman and Tversky addressed empirical effects which showed that people tend to divert from the Utility Theory on practical decisions, and proposed a new model called the Prospect Theory (Kahneman & Tversky, 1979). In Expected utility Theory people focus on final wealth. Utility function based on gains and losses instead of final wealth positions was first expressed by Markowitz (Markowitz, 1952). In Prospect Theory, Kahneman and Tversky developed Markowitz's ideas and found that people are risk averse over gains and risk seeking over losses (Kahneman & Tversky, 1979). People indicate greater sensitivity to losses than gains, this feature is defined as loss aversion. Utility function of losses show much more steeper value drop than it shows rise in gains. People become strongly risk averse when they lose and weak risk seekers when they gain. Steepness of value function in prospect theory is shown in Figure 1.

Figure 1: Proposed Value Function in Prospect Theory



Resource: (Kahneman & Tversky, 1979)

Applications of the theory and laboratory tests to real life can be observed in finance and insurance sectors where risk perceptions are critical. Thirty years after the Prospect Theory was published, Barberis investigated whether the Prospect Theory can find a permanent place in economics or not; after a comprehensive research he

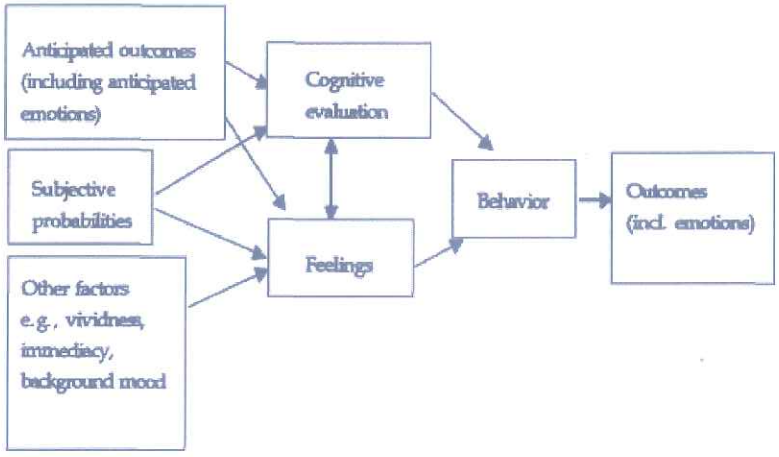
concluded that "*Even if we accept that the carriers of utility are gains and losses, it is often unclear what a gain or loss represents in any given situation.*" , "*One possible approach to studying this issue is to explain people, in an appropriate way, that they may be acting the way they are because of prospect theory preferences; and to then see if, armed with this information, they change their behavior*" (Barberis, 2013). Risk perception is a subjective rather than objective parameter in finance and thus, it is not easy to implement the Prospect Theory and experiments into financial algorithms. Barberis's study and Schwarz and Clore's experiments has a common break point, both show that after a person is informed about her/his decisions may be tied to a heuristic process (weather effect in Schwarz and Clore's study) she/he may probably eliminate non-quantitative decision-making methods and judge investment decisions based on expected utilities (Schwarz & Clore, 1983; Barberis, 2013).

2.2.2. Impacts of Feelings on Risk Taking

Investors, as humans, carry emotions and if not enlightened about their heuristic decision processes can diverge from cognitive decision-making process and add emotional reactions into their judgements. Loewenstein et al. argue in the Risk-as-Feelings hypothesis that emotions can most likely involve into decision making under risk in cases which immediate response is required or vividness, decision process can be influenced by current emotions and mood (Loewenstein, Weber, Hsee, & Welch, 2001). Risk-as-feelings hypothesis argues that feelings involve into decision process in risky situations, furthermore, guide people not only at the first time giving a decision, but also in later occurrences the emotion is being remembered, making emotional decision making a somatic marker. Cognitive and emotional processes jointly affect decisions, however, have different responses on probabilities and outcomes because of risk-related perceptions. Risk-as-feelings perspective of Loewenstein et al. is shown in Figure 2. Emotional responds influenced by situational variables. Not each person perceives risk and emotions from same point, vividness of emotional reaction can affect decisions and vivid imagers have higher mental responses. "*Fear as the emotional response experienced in risky situations reacts to probabilities and impacts in a manner that*

is very different from that explained in Expected Utility Theory. Fear depends on a variety of factors that are not part of financial models: fear peaks just before a threat is experienced and is highly dependent on mental imagery" (Loewenstein, Weber, Hsee, & Welch, 2001).

Figure 2: Risk-as-feelings Model



Resource: (Loewenstein, Weber, Hsee, & Welch, 2001)

Decision making under risk is also tied to psychological character and mental imagery of market agents. Fear, caused by uncertainty, is not an immeasurable parameter; it can be monitored. Testosterone and cortisol hormones are closely related the with confidence and fear respectively. Cortisol levels are associated with risk, uncertainty and uncontrollability. Study of Coates and Herbert showed that testosterone levels of traders are higher in the morning of days which they made significantly greater gains, on contrary, daily group average cortisol levels of traders were positively correlated significantly with market volatility (Coates & Herbert, 2008). Coates and Herbert utilized biological data of collected from traders to analyze relationship between financial risk taking and endogenous steroids. Level testosterone and cortisol hormones which have a significant role on risk perception were tested. Testosterone causes confidence and risk-taking behavior, whereas, cortisol levels are associated with uncontrollability and uncertainty. Therefore, authors hypothesized that testosterone levels would rise on days when traders made an above-average return on markets, on the contrary, cortisol levels should be high when traders were stressed and made above-average loss.

The study was conducted in a real trading floor with a real portfolio in London by 17 male traders. Participant traders were aged between 18 to 38. All traders were monitored in 8 working days. Each day two samples were collected from participants, one in the morning and one in the afternoon.

On the days which higher level of testosterone level was monitored in the morning sample, participants made significantly greater than gains in low-testosterone level days. However, no significant relation was found with market losses and cortisol levels.

Authors also investigated relation between market volatility with cortisol levels. Daily group average cortisol levels correlated significantly with market volatility. On the other hand, testosterone did not relate to market volatility with a statistical significance.

Volatility in markets are often associated with uncertainty, thus, study of Coates and Herbert can be jointly investigated with the risk-as-feelings theory. High cortisol levels show that traders, in fact have emotions and the course of a day in financial markets can be a fear factor effecting their financial decisions.

Decisions based on emotions are not limited to traders or investors. Moods and emotions effect daily life of each person in an economy. Collective feelings and moods can define general optimism or pessimism in a society. Social mood is an effective indicator of consumer, investor behavior and corporate decisions; stock markets being the primary medium to invest social mood in a society (Nofsinger, 2005).

Nofsinger evaluated effects of the general social mood to stock returns. A more optimistic society has more optimistic investors and consumers. Over-optimism can lead to market bubbles. In general, social mood is expected to lead the investment and economic environment in a society.

On risky decisions investors tend to balance cognitive decisions with their background moods. This is a widely investigated hypothesis and Nofsinger is also argues that this hypothesis must be working. Nofsinger emphasize three estimates

from a significant number of studies in financial economics. First estimation is social mood is an effective predictor of investor, consumer behavior and corporate decisions. Second prediction, efficient and emotional structure of stock exchange investments makes stock markets the first measurement reference of social mood. Third estimation, business and consumer activities follow the social mood. Therefore, the immediate respond in stock markets can be used as a predictor of future economic activity in a society.

Hypothesis indicated that forecasts on the economy will be at its peak when social mood is at the most positive manner. Market return is the foremost used data to evaluate investor sentiment. Effects of social mood can also be predicted by market volatility. General volatility in stock markets are high during times of negative social mood. General conflict or depression reflects to stock indexes.

Studies on relation between consumer confidence and stock market show that consumer and investor sentiment are significantly correlated. Corporate finance, mergers and IPOs decisions are also being influenced by social mood. Volume of merger deals in the United States coincides with stock exchange index value of S&P 500. Corporate finance, mergers and IPOs are affected from long term and lasting social mood changes and cycles. The time lag between stock market and business activities are shorter at decreases than the increases.

As stated by Nofsinger, effects of psychological conditions of investors on market returns are important to determine the social mood and general confidence to the economy. Thus, due its importance to economy, investor sentiment has been one of the primary research topics for behavioral finance. Researchers studied effects of different conditions affecting moods of investors from aviation accidents (Kaplanski & Levy, 2010). It has been shown that terrorism can also affect investors' mood (Drakos, 2010; Aksoy, 2014). Results of studies show that market reactions can vary between different countries (Kaplanski & Levy, 2010; Demir, 2015). Moreover, Bialkowski, Etebari and Wisniewski discourses positive mood effect of Ramadan religious celebrations on investors in fourteen Muslim dominant countries (Bialkowski, Etebari, & Wisniewski, 2012). Positive and negative effects

of soccer match on stock exchange were found (Palomino, Renneboog, & Zhang, 2009). Edmans et al. described three main requisites to be provided to study mood effect (Edmans, Garcia, & Norli, 2007). First requisite is variable must be strong enough to affect mood of people, second the effect of the variable must be widespread across the population and the third one is correlation of the effect must be similar within the population (Edmans, Garcia, & Norli, 2007). Under these circumstances, negative sentiment and anxiety rooted from a sudden and shocking development may cause irrational pricing of assets. In addition, it has been shown that good and bad news has role on volatility of the markets (Chen & Ghysels, 2011). Weather has been proven by many studies to have mood shifting effects on humans. Changes in weather occur all around a settlement, thus, widespread across the settlement population. Since, weather changes affect psychology, the effect can be assumed to be similar along the population. Therefore, weather is a good candidate to fulfill prerequisites of Edman et al.'s study.

In his pioneer study, Saunders studied effect of weather on financial markets and found a strong correlation between weather conditions in New York and daily returns of New York Stock Exchange (Saunders Jr., 1993). Saunders utilized local New York weather statistics and daily stock exchange returns as data. Closest point to New York Stock Exchange has been selected as the observation point. Different types of weather data were obtained; sunshine, cloud cover, precipitation, relative humidity, wind and temperature. Cloud cover was selected as the weather variable because it is significantly correlated with other weather metrics and previous search shows cloud cover is influential on mood. Different stock indexes were selected as stock data; daily percentage changes in Dow Jones Industrial from 1927 to 1989, weighted daily percentage changes of NYSE/AMEX from 1962 to 1989. Saunders explained that changes in stock market prices cannot fully be explained by rational variables such as economic news. Local weather conditions influence investor mood and sentiment and thus there is significant correlation between cloud cover and stock returns. Weather conditions can be counted as one of the elements which cause market anomalies.

Trombley brought another approach to Saunders's study by offering a different classification on cloud cover and used same data with Saunders (Trombley, 1997). Weather data consists of level of cloudiness scaled between 0 and 10, 10 being sky is fully covered by clouds. In his paper Saunders compared stock returns on fully covered days with 0 to 20 percent cloud covered days. This is the only comparison and does not includes clear sky days with fully cloud covered days. Trombley uses Duncan's Multiple Range Test for cloud cover classifications. Statistically significant differences are between 90 percent and 100 percent day returns and the 40 percent day returns.

Trombley found that weather effect is strongest in April, May and December, weaker in January, March, August and September. Effect does not exist in February, June, July, October and November. The weather effect is not clear and strong as Saunders explains. Trombley could not found any clear difference between clear days and cloudy days.

2.2.3. Influence of Weather on Financial Risk Tolerance

Weather conditions were first counted as one of the elements which cause market anomalies by Saunders (Saunders Jr., 1993) but Trombley (Trombley, 1997) showed that cloud cover or the way analyzing cloud cover is not enough to show effects of weather. Hirshleifer and Shumway widened studies on weather effect by utilizing weather and daily nominal stock markets returns of 26 markets from 26 different countries around the globe (Hirsleifer & Shumway, 2003). If people are perfectly rational, investors should not make decisions based on their moods, thus 26 selected stock markets should not be affected from weather conditions. Authors worked on sunshine because of three main reasons; measurability of sunlight, psychological effects of sunlight on people and data being not subject to data snooping. Hirshleifer and Shumway tested their hypothesis of sunshine positively affects investor mood and stock returns by using daily cloudiness and daily nominal returns of the stock markets. To do so, they used daily stock returns of stock exchanges in 26 different countries from 1982 to 1997. Because of high variability of returns, this work was examined by using data from 26 markets.

Weather data was collected from International Surface Weather Observations data set obtained from National Climatic Data Center. This data set has hourly weather recordings from 3000 locations around the world. Authors used sky cover metric of weather data set to investigate level of sunshine. In order to eliminate seasonality Hirshleifer and Shumway calculated deviation between cloudiness of the measured day and average expected cloudiness of that day in a year. In addition to cloudiness; raininess and snowiness were also examined regarding their correlations with stock returns. It has shown that sunshine effect is independent of raininess and snowiness. Statistically significant relationship was found in comparison of cloudiness of a day and daily stock market returns in that day. As an addition to Saunders's work on correlation between New York weather and S&P500 index, Hirshleifer and Shumway's work concludes that sunshine effect is present internationally. However, only low transaction costs make weather based trading feasible. Authors recommend being aware of moods. By doing so investors can eliminate mood based errors.

Articles from psychology have proven that sunshine and duration of sunshine has significant effect on human psychology (Schwarz & Clore, 1983; Keller, et al., 2005) with effects additional weather variables on moods (Howarth & Hoffman, 1984). Other factors which driven by changes of duration of sunlight can also cause changes on financial indices. Kamstra, Kramer and Levi investigated effects of lack of sleep caused by daylight saving changes on financial indices (Kamstra, Kramer, & Levi, 2000). Stock indices in Canada, the United Kingdom, Germany and the United States were utilized. Time period includes approximately 30 years of span depending data availability in selected stock exchanges between years 1967 and 1998. Lack of sleep caused by daylight saving changes can lift effectiveness of weekday effect anomaly on market returns after the weekend of spring and fall daylight saving time changes by 200 to 500 percent times

In addition to enhancing weekday effect, daylight duration can also affect markets through a longer period of time (Kamstra, Kramer, & Levi, 2003). Authors argued that seasonal differences in day lengths can be linked into variations at returns on equity. Psychologists define seasonal affective disorder as a psychological

condition which many people get affected from and occurs when daylight lasts fewer than average. In this article authors expected lower returns in autumn (before winter season) and higher than normal returns in spring (right after winter season). Investors who are affected from seasonal affective disorder were predicted to lower their risk, shifting their investment balance into safer financial instruments. Kamstra, Kramer and Levi tested connection between day lengths and stock returns while controlling precipitation, temperature and cloudiness.

It has been expected that investor mood towards to the winter solstice will strongly show SAD effect, on the other hand when days are becoming longer right after winter solstice, investor mood is expected to be positive. Therefore, based on relative location to solstice, days with the same day length are expected to have different returns. Authors added a dummy variable to calculations to be able to show asymmetric market returns on the days which have same day length.

Examined market data was from the United States, Sweden, the United Kingdom, Germany, Canada, New Zealand, Japan, Australia and South Africa, countries from different latitudes. United States S&P data has 70 years of span. Minimum data span was 3000 days of observation for New Zealand and maximum span is 19000 for the United States. Data from countries, which are in south hemisphere, were adjusted six months to overlap seasons with other countries.

Outcomes of this study confirms a significant relation between seasonal affective disorder and seasonal cycle at stock market returns. Higher SAD effects were found in countries which are closer to poles and far from the equator. Any SAD effect could be eliminated if all markets were fully integrated and investors were equal in numbers and wealth along hemispheres. However, markets are not fully integrated and investors did not divide between hemispheres equally.

Effects of seasonal affective disorder (Kamstra, Kramer, & Levi, 2003) are in line with the risk-taking behavior of the AIM of Forgas (Forgas, 1995). Investor mood towards to winter solstice strongly show seasonal affective disorder effect, risk-averse investor behavior is caused by affect infusion under substantive processing.

On the other hand, when days are becoming longer right after winter solstice, investor mood becomes positive than normally expected. Severer seasonal affective disorder effects were found in countries which are closer to poles of the earth and far from equator (Kamstra, Kramer, & Levi, 2003).

Biopsychological and environmental determinants predominantly being used to determine financial risk profiles. Mood is not included to those calculations. AIM and MMH conversely include mood as a factor to the decision process of making risky judgements. To examine effect of news on investors, Kliger and Kudryastev used analyst recommendations on stocks listed in New York Stock Exchange and compared stock price reactions to recommendation revisions between daylight-decreasing and daylight-increasing periods (Kliger & Kudryavtsev, 2014). The paper analyzed effect of MMH in financial markets by testing shocking bad news when investors are in good mood, continuous good news when investors are in bad mood and reaction to all kind of news when in good mood. MMH highlights people's tendency to keep current mood. MMH argues people in positive mood and tend to do not evaluate their choices elaborately to maintain their good mood. Therefore, positive moods are counted together with risk avoidance and bad moods are associated with risk-seeking behavior.

To examine effect of news on investors grouped by their mood Kliger and Kudryavstev used analyst recommendations on stocks listed in New York Stock Exchange. They compared stock price reactions to recommendation revisions between daylight-decreasing and daylight-increasing periods. Historical stock price and trading volume were retrieved from finance.yahoo.com. The analysis includes 2746 analyst recommendation revisions for 1373 companies listed in New York Stock Exchange. Authors defined daylight increase period between December 23 and June 22. On the other hand, day decrease period is from June 23 to December 22. Around 66% of recommendation revisions were made in day decrease period. In hypothesis, negative abnormal returns following downgrades are expected to be larger during day-increase than during day-decrease period. Positive abnormal returns following upgrades are different during day-increase than during day-decrease periods.

They found that decreases in stock prices after recommendation downgrades in daylight-increasing periods were stronger than daylight-decreasing periods. According to MMH people in positive mood tend to avoid evaluating their choices elaborately in sake of keeping their positive mood state as it is. Thus, positive mood state is accepted as an adjuvant of risk avoidance. Financial studies searching for mood effect on investors conclude different motivational outcomes of the mood effect when mood is positive. Therefore, there can be contrary decisions rooting from a positive mood. Grable and Roszkowski aimed to validate either AIM or MMH at their study on participants by asking risk-tolerance evaluation questions and concluded that people in positive mood tend to take riskier financial decisions compared to people in neutral mood, supporting AIM (Grable & Roszkowski, 2008). Relation between mood and financial risk tolerance was investigated by conducting a survey to 460 employed respondents. Grable and Roszkowski aimed to validate either AIM or MMH in their study.

71% of the participants women and 29% were men. They were asked risk-tolerance evaluation questions. Grable and Roszkowski added 11 control variables (environmental and biopsychological), 3 independent mood variables (happy, neutral, gloomy) and 1 dependent variable (risk tolerance score). Moods of participants were asked after they finish risk assessment questionnaire.

The results of the study indicates that risk tolerance can be predicted by mood. People in positive mood tend to take riskier financial decisions compared to people in neutral mood. Financial knowledge and education levels were positively correlated with risk seeking behavior. Findings of the study are in line with AIM, which claims people in happy mood focus on positive aspects and have risk-taking behavior.

Authors examined infusion of moods into risk taking behavior of investors and compares AIM and MMH. Research was done with 460 participants aged between 18 and 75 years. The two models on effects of emotions on financial decisions (AIM & MMH) lead to opposing predictions about the influence that positive and negative moods on risk tolerance.

Decisions that are influenced by emotions and moods tend to be easier, faster, and often more efficient than decisions made using a cognitive system. Good mood had an especially strong influence on women when the stated probabilities were high for gains and low for losses.

In their comprehensive research on role of emotions in decision making process of investors Lucey and Dowling highlighted the Risk-as-feelings model and AIM (Lucey & Dowling, 2005).

Two areas in market research have examined effect of mood and feelings in investor decision-making. First area is mood misattribution, which argues that environmental and body factors effect equity pricing. Second area of research is effect of image on investor decision making. Argument in the second area was image of a stock shows emotions in investors that partially drive their investment behavior. Authors investigated these areas comprehensively in this paper. Lucey and Dowling highlighted model of Loewenstein on when making decision under risk and uncertainty feelings have great impact. Lucey and Dowling also highlighted study of Forgas arguing that feelings influence decision-making depending on how risky and uncertain the decision is.

Images of a stock on investors is another factor that scholars studied while examining effects of feelings on stock exchanges. People's decision-making is guided by the images and feelings that are tied with the process. In this study of MacGregor et al. (MacGregor, Slovic, Dreman, & Berry, 2000) participants were asked to rate their perceptions and future performance expectations on 20 industries. Results confirmed that image on stocks showed a significant role on investing. Participants invested biased on their images on stocks rather than rational reasoning.

Financial decisions involving cognitive processing at some point involve emotional shortcuts and have influences the judgement making. Equity pricing, therefore, is affected by the emotions of investors. Negative mood states foster focus on details and utilizing detailed financial models, whereas positive affective states heuristic decision-making. Both economic psychology studies and decision-making

integrated, may feature findings of Forgas at a study on effects of weather on equity markets.

Lucey and Dowling found that researches on environmentally induced mood effects have limited theoretical backgrounds. Studies must have richer hypotheses with greater theoretical support. However, limiting weather effect on stock market returns is preventing a universal consent of the heuristic decision-making processes. Investigation of different asset types: bonds, commodities and derivatives can improve acceptance that emotions actually have a role on financial decisions. Identifying existing anomalies in finance that can be explained by investor feelings is another improvement area. Investor feelings can potentially explain some of the anomalies in the Efficient Markets Hypothesis.

Keef and Roush aimed to examine impact of other weather variables as well and investigated effect of wind, temperature and sunshine on three financial securities; government bonds, interest rates of bank bills and stock. They have found, in fact, neither sunshine is the only predictor of financial markets nor stock market is the only equity that sensitive to weather effect; temperature and sunshine are good predictors of government bonds and bank bills respectively (Keef & Roush, 2005).

Keef and Roush investigated effect of the weather on three financial securities; government bonds, interest rates of bank bills and stock exchange. Research focused on weather variables observed from two cities which have impact on New Zealand financial market.

Bank bill interest rates, government bond yields and the rates of return of the NZX10, NZX40 and NZX indexes were examined in the study. Investigated weather variables were sunshine (cloudiness), wind speed and temperature in Auckland and Wellington.

Span of weather variables cover a time range between 1 January 1980 and 14 October 2002. Data on weather variables were retrieved from National Institute of Water and Atmospheric Research Ltd. Authors investigated effects of de-seasonalized weather variables. Data on bank bills and government bonds were retrieved from Reserve Bank of New Zealand, NZX indices were retrieved from Index Department of the NZX.

Controls on international events were added into the examination. This control is to sort out international event effects on investigated financial securities. Authors selected three corresponding Australian financial securities as control variables. Securities were checked for each day.

Sunshine exhibits a negative effect on bank bills. Same effect was not discovered on government bonds. Wellington's wind does not influence the interest rates of New Zealand government bonds. Wellington's wind has a significant negative influence on stock returns. Stock returns of larger firms are more susceptible to the influences of wind speed than are the returns of smaller firms. Institutional investors are prone to level of the wind than are individual investors. It is contrary to the prices of larger firms are believed to be more efficient than are the prices of smaller firms because of greater institutional involvement. Authors found that the higher level of the sunshine factor, the lower the returns of the stock indices. This result was contrary to previous findings on sunshine effect on investor moods and return on stock indices. Bank bills were positively affected from increase in sunshine. Prices in stock exchange were negatively correlated with the wind levels in examined cities.

There was the influence of temperature on the interest rates of government bonds of 2 and 5 years but not on the 10-year bonds. Influence of sunshine observed on stock returns. But it is surprisingly negative.

Retail involvement is rates from higher to lesser by NZX > NZX40 > NZX10 > government bonds > bank bills. Sunshine has effect on bank bills but has no effect on government bonds and stock indices.

In addition to sunshine and daylength, temperature is another significant parameter in human psychology and shifts in mood. Very hot or very cold temperatures can cause aggression and apathy (Wyndham, 1969; Howarth & Hoffman, 1984). Although, can be weaker in summertime, impact of temperature on stock markets can be greater than Seasonal Affective Disorder (SAD) or cloud cover (Cao & Wei, 2005). Based on literature on psychology, Cao and Wei hypothesized market returns to be high in cold weather, low or high in hot weather depending on changing risk-taking behavior of investors by temperature.

Study included stock exchanges in Australia, Britain, Canada, the United States, Germany, Sweden, Taiwan and Japan. Stock index data were retrieved from DataStream and weather data was collected from Earth Satellite Corporation. Sample size of stock index and temperature variables is 39 years lying between July 3, 1962 and July 9, 2001. Two types of tests were utilized, first a regression same with Saunders (Saunders Jr., 1993), second a test similar to Hirshleifer and Shumway (Hirsleifer & Shumway, 2003) and Kamstra et al. (Kamstra, Kramer, & Levi, 2003). Just as Saunders (Saunders Jr., 1993) did, Cao and Wei grouped temperatures and compared mean returns in each group. They also checked seasonality by dividing a year span into two groups, summer and winter. Correlation is negative for all markets in both summer season and winter season. This type of test can explain association between variables but cannot show precise correlation and cannot control any known anomalies that previously found like Monday effect. Cao and Wei added findings of Saunders, Hirshleifer and Shumway and Kamstra et al. as cloud cover and SAD explanatory variables into their regression model. Impact of temperature was statistically greater than SAD or sunshine. Cao and Wei noted the fact of the negative correlation between temperature and returns of nine stock markets as an anomaly due to fact that traders usually work indoors at regulated temperatures.

Temperature, cloudiness, precipitation and day lengths were jointly utilized by Symeonidis, Daskalakis and Markellos to find effects of weather on market volatility (Symeonidis, Daskalakis, & Markellos, 2010). Three deseasonalized weather variables, effect of absolute deviations from seasonal averages and extreme weather condition dummies were used to increase robustness of the model. Authors utilized ARCH-type model on the same data which Hirshleifer and Shumway (Hirsleifer & Shumway, 2003) used, consisting of stock exchanges of 26 stock exchanges between 1982 and 1997. All weather variables were retrieved from International Surface Weather Observations. Variables were deseasonalized by subtracting from each observation its weekly average. Then, deviations were calculated as the absolute deseasonalized values. Top or bottom 20 percentiles were counted as extreme conditions and reserved as dummy values. Symeonidis et al.

used GJR-GARCH (1,1) process to model historical volatility. Two-tailed test as in Hirshleifer and Shumway (2003) was used. In addition to historical volatility, implied volatility and realized volatility were also tested.

SAD effect (length of night) and sky cover were found significantly negatively correlated with volatility. Temperature showed positive correlation with volatility. Favorable weather conditions (long days, sunshine and warmer temperature) lead to good mood and increased trading and volatility.

On the other hand, Shim et al. compared historical and implied volatility of South Korean stock market with weather conditions and found that negative mood is correlated with increased volatility (Shim, Kim, Kime, & Ryu, 2015). Historical volatility and weather conditions estimations were calculated by using GJR-GARCH. South Korean KOSPI200 options were used as market data. Weather condition variables consisted of temperature, wind, humidity and cloud cover in Seoul, South Korea. All variables were deseasonalized by following the same algorithm in the work of Symeonidis et al. (Symeonidis, Daskalakis, & Markellos, 2010). Weather data was divided into three parts, global financial crisis being the breakpoint. Three parts are 2003-3007, 2008 and 2009-2013. Authors found that market volatility increases in cloudy and rainy days. Volatility of KOSPI 200 significantly influenced by humidity. Volatility index increased with rain.

Along with market returns, volatility is one of the commonly investigated market indicators in recent studies. Effect of weather variables to market turnover, the ratio of traded shares in a day to whole shares in the market, was studied by Lu and Chou (Lu & Chou, 2012). Authors examined relation between weather-related moods and stock index returns, volatility and liquidity. They selected an order-driven stock market, the Shanghai Stock Exchange in China. Cloud cover ratio, temperature, humidity, pressure, visibility and wind speed were used as weather variables. Cloud cover ratio was consolidated under five identical pieces. Authors used day-lengths to identify effects of SAD on markets by using Onset/Recovery. Onset/Recovery represents changes in the percentage of people suffering from SAD. Onset/Recoveries are maximum at autumn and minimum at springtime, equinox

dates being the peak and bottom. Turnover, returns, liquidity and volatility variables used to determine respond of Shanghai Composite Index to weather variables. Well-known intraday patterns were controlled by dummies.

Cloud cover was positively correlated with illiquidity and negatively to volatility. On cloudy days volatility and trading volume was smaller. Market liquidity was higher in warm days. Wind was correlated with trading volume and volatility. Negative Onset/Recovery ratios implied that traders were reluctant to trade when they suffer from SAD. Market liquidity negatively influenced from SAD.

Authors explained the difference between quote-driven market and order-driven market as the location of investors. Investors in quote-driven market are from the same geographical whereas, orders can be given from any geolocation in order-driven markets. Therefore, impact of weather on stock returns are expected to be limited in order-driven markets.

Authors reached to the conclusion that in fact, mood changes caused by weather do not affect stock returns. Weather variables are correlated with a decrease in market turnover and liquidity but not with market return. These results are consistent with the argument of (Lucey & Dowling, 2005) that *"feelings influencing investor decision-making do not necessarily equate to feelings having an effect on equity prices"*.

Majority of literature investigating impact of weather on financial instruments utilized local weather variables and stock returns. Although there are studies tried to differentiate weather variables (such as temperature, wind, pressure, daylength) and selected different stock market around the globe to broaden the perspective, at some point they lack comparing apples to apples because weather is by nature a local parameter whereas stock market return is related with more extensive geography since anyone can invest in a stock market from any location in the world. This fact can cause inefficiencies especially in countries which have more than one stock exchanges and large lands like the United States where a return of a stock market is compared only with the local weather conditions of the stock market is located. Loughran and Schultz took a different approach on investigating effects of

weather on stock returns (Loughran & Schultz, 2004). First, they focused on geolocations of investors. Because not all investors are located in the very same city that a stock exchange was built in. Second, they studied orders submitted into stock exchange. Because, order-submitting investors are the ones who are setting the prices in the market.

Stock portfolios in 25 cities of the United States were utilized to study the correlation between stock returns and weather. Return value was calculated based on city, not market index. Therefore, weather effect can be investigated more precisely. This method can also how small investors be affected from weather. Authors tested effect of local weather conditions on returns of locally headquartered stocks in NASDAQ. In general NASDAQ companies are smaller in size than New York Stock Exchange companies. Loughran and Schultz selected NASDAQ on possibility to find greater local weather bias than other exchanges. Logit model was utilized just as Hirshleifer and Shumway's model (Hirsleifer & Shumway, 2003). Model works on probability of above zero stock return to cloud cover.

Authors found that trading volumes of NASDAQ stocks significantly change based on time zone differences, severe natural conditions like snowstorms and religious holidays. Loughran and Schultz were unable to find a significant correlation between local weather and local stock gains. Stocks get slightly effected from weather conditions, however this change is very limited and trading costs do not let an investor to weather invest. They found weak correlation between weather in New York and stock returns. Authors believed professional investors in New York should not be affected from weather as small investors do. On the other hand, they noted that if professional investors slightly make decisions based on their weather affected moods, this will significantly impact market returns. NASDAQ equities are too small to attract professional investors but a strong correlation was not observed on local investors' behavior and weather.

Study of Loughran and Schultz showed that even though can be weak, weather effect is present both in the markets where professional traders dominant and local markets which consists of local investment firms and local traders. Professional

traders are expected to be more rational than local investors. The fact that weather effect has similar outcomes in both heavily professional-trader dominated markets and local markets can lead one to questioning the information flow between market players.

Seasholes and Ning utilized local stock market transactions to investigate asymmetry between portfolios of local and whole traders caused by asymmetrical information flow (Seasholes & Ning, 2010). Authors tested whether purchases of local stocks predict future positive returns and whether sales predict future negative returns.

Holding-based calendar-time portfolios and transactions-based calendar-time portfolios use monthly returns obtained from Center for Research in Security Prices. Authors tested standard performance analysis on individuals' local portfolio holdings. Individuals' local portfolios do not generate abnormal performance, alpha values of portfolios are not statistically different from zero. Individuals may not have value-relevant information about the local stocks they hold.

249.555 local stock transactions between 1991-1996 have been inspected and Seasholes and Ning tested if individuals have value-relevant information, the local stocks that they buy should outperform the local stocks that they sell.

Local buys underperformed local sells. Individuals appear to have no value-relevant information about the local non-S&P 500 stocks they trade. Findings of this study is showing that individuals do not have value-relevant information on the local stocks.

Information flow between local traders and local firms do not involve value-relevant information. Therefore, local traders do not have an information flow which they can gain benefit against professional traders. If both local investors and professional traders have similar sets of data, how do they get affected from weather conditions similarly? Can traders who are severely affected from weather develop an impact on other traders? Even far away from stock company, fund managers in a city trade similar stocks. Hong, Kubik and Stein examined word of mouth (WOM)

effect between investors and developed a hypothesis not related to local stock preference but on WOM effect between fund managers (Hong, Kubik, & Stein, 2005). Their assumption was that fund managers in the same city interact with each other more frequently than any other fund manager far away from them. Those communications and information sharing lead to similar portfolios between managers in close geographical perimeter.

Hong, Kubik and Stein utilized data on mutual fund holdings retrieved from CDA Spectrum. Authors focused on both locations of fund families and locations of company headquarters that were invested. Timespan was between March 1997 and December 1998, with periods of a quarter. Peer group effects were examined in 15 cities of the United States. Authors used ordinary least squares regression on the data pool.

Own-city effect exceeded other-city effect 15 out of 16 cities in the pool. Any given fund manager was more sensitive to the trades of fellow fund managers in the same city than to the trades to other managers in other cities.

An investment decision made under impact of mood may spread among traders and fund managers via WOM effect. Furthermore, there are other medium which WOM effect can spread instantly, social media is a good example to those mediums. Mood states in Twitter and its effect on stock markets were investigated by Nofer and Hinz to better understand the effect chains between traders and opinion leaders (Nofer & Hinz, 2015). Stock markets are priced by risk appetites of investors and risk perception is affected from moods of investors. General mood in Twitter can be a good predictor of stock market returns. Nofer and Hinz aimed to first examine predictability of stock returns by social media, mood then applied a trading strategy to a different time period.

Both offline and online social world has been researched and evidences were shown that stock markets are affected from investor sentiment. This paper hypothesizes that increased positive social mood in Twitter leads to higher returns in stock markets.

Dataset of social media consisted of 100 million tweets published between January 2011 and November 2013 in Germany. After collecting data Nofer and Hinz integrated number of followers into the study dated between December 2012 and November 2013. Dataset was segregated into two, one period for constructing the trading strategy and one for the test of the strategy.

To extract moods in tweets, authors modified profile mood states that consists of 19 adjectives refer to 5 different mood dimensions. They expanded 19 adjectives to 529 by using synonyms from dictionary. Then, for each day, they drove a Social Mood Indexed based on how many times a positive word is used in tweets out of total "mood" words used in tweets. This study was made on general social media mood instead of focusing only to investors' social media mood due to lack of social media account information. For further analysis Nofer and Hinz calculated a weighted social media index by multiplying positive and negative words with the follower numbers of the Twitter accounts.

To calculate unbiased stock returns, market anomalies were controlled (calendar anomalies, tax dummies, national holidays, lunar cycle) and investor sentiment proxies (trading volume, market volatility and consumer confidence).

No significant relationship between Twitter mood and stock returns was found. However, when weighted social media index was utilized to examine relationship with stock returns, the result was positively correlated.

The fact that opinion leaders in the population can impact market prices can be taken as if market-makers or influencers are sensitive to weather conditions, whole market can be significantly become open to anomalies caused by weather.

Goetzmann and Zhu utilized local trading activities to investigate weather effect on stock markets (Goetzmann & Zhu, 2005). A panel database consisting of individual investor accounts was used in this paper. Database contained details on geolocations of individual investors who were based in five major cities in U.S. New York, Los Angeles, San Francisco, Chicago and Philadelphia. Data set covered a time frame of 6 years between January 1991 and November 1996. By

using database and weather conditions authors tested four different hypotheses: mood-induced trade, weather-related micro-economic and macro-economic effects and data mining. Relation between weather and liquidity in the market was also investigated in order to understand effect of weather to liquidity and thus market volume.

Data set contained information on trade date, trade quantity, price level and security information. Geolocations were tracked by using zip code information from the same data set. Five selected major cities cover 40% of all individual trade records in the whole data set. Weather condition was investigated by utilizing daily total sky cover, density of cloud cover in sky dome.

Correlation between cloudiness and lower market returns was confirmed. Goetzmann and Zhu found no evidence on weather caused change in trade volume, no evidence on weather caused macro-economic effects. Authors found weak evidence on micro-economic effects of weather conditions and some correlation between weather and data-mining hypothesis. Liquidity examination showed that when weather related liquidity changes were controlled, weather effect on market becomes insignificant. Authors interpreted this as *"evidence that the behavior of market-makers, rather than individual investors, may be responsible for the relation between returns and weather"*, *"One potential explanation is that on cloudy days, market makers become less active or more risk-averse"* (Goetzmann & Zhu, 2005).

Istanbul, financial capital of Turkey, is located at the 41st latitude experiencing four seasons, hot and shiny summers, cold and snowy winters and rainy springtime. Hirshleifer and Shumway were the first who examined Istanbul's reaction to weather (Hirsleifer & Shumway, 2003). Istanbul was the 7th out of 26 financial hubs that has the highest standard deviation of cloud cover. Its unique position and developed financial sector makes Istanbul one of the strongest candidates to investigate weather effect on stock exchange and bonds.

Tufan and Hamarat studied effects of cloudiness on Istanbul Stock Exchange (Tufan & Hamarat, 2004). To investigate the effect, they utilized Turkish State Meteorological Service weather database and daily closing values of BIST100 Index. They used local weather condition reports for Istanbul. Time period of the study is between October 26, 1987 and July 26, 2002. Cloudiness is rated between 0 to 10, 10 being fully covered sky. Study found that cloudiness has no effect on returns of Istanbul Stock Exchange.

Zeren and Gumus investigated weather anomalies in stock markets of Belgium, France, Greece and Turkey (Zeren & Gumus, 2015). Timespan of research was 12 years, between 2001 and 2013. In their study, Zeren and Gumus aimed to find relationship between stock market returns of four different countries and local humidity and temperature levels. To utilize data authors used time varying bootstrap causality test. They obtained a positive correlation for all countries. In some intervals, humidity and temperature levels were observed the stock market. Weather conditions may have an effect on investors' mood in some periods.

Tuna and Bektur examined effects of temperature changes on returns and trading volume of Istanbul Stock Exchange. Daily BIST 100 return index and total trade volume data was utilized for 4772 days between November 1987 and December 2006. Temperature data was retrieved from Forestry and Water Affairs of Turkey Meteorology General Office. Data was tested by utilizing Granger causality test, Hacker-Hatemi-J Causality test and Hatemi-J Asymmetric Causality test. Market return and volume rose with temperature. In addition, when temperature was declining market return and volume also diminished. Authors reported a positive correlation between temperature and stock returns.

SECTION III
DATA & METHODOLOGY

3.1. DATA

According to the Banks Association of Turkey banks, which form 60% of total bank assets in Turkey, are headquartered in the European peninsula of Istanbul. The remainder, 25% is located in the Anatolian peninsula of Istanbul and 15% in Ankara. Based on Public Disclosure Platform's database 120 out of 123 investment firms in Turkey are based in Istanbul.

Based on data retrieved from Central Securities Depository of Turkey, between 2005-2016 stock holders who live in Istanbul were holding on average 72% of total balances owned by local investors. The ratio of total holdings of local investors to total shares in Borsa Istanbul was 46%. Istanbul's share in total shares in Borsa Istanbul was 46% between 2005 and 2016. Almost half of total public shares in Borsa Istanbul and almost three fourths of total public shares owned by locals was managed from Istanbul. In addition, Borsa Istanbul is also based the European part of Istanbul.

Given the above statistics, Istanbul can be accepted as the financial capital of The Republic of Turkey.

Thus, the observation point of weather condition variables was selected as Istanbul Ataturk International Airport which is located at European peninsula of Istanbul.

Weather data was retrieved from wunderground.com. Data consists of daily meteorological events (rain, thunderstorm, snow, fog, hail and tornado) and maximum, average, minimum values of temperature, humidity, atmospheric pressure, dew point, visibility and wind. Rain, snow, fog, hail, thunderstorm and tornado events were included to the model as binary independent variables.

Existing literature on effects of temperature to human psychology indicates that memory tasks peak at 22 Celsius degrees (Allen & Fischer, 1978), rising temperature increases helping behavior in winter but decreases in summer (Cunnigham, 1979), and even though warm weather decreases anxiety and skepticism, very high temperatures are associated with low potency (Howarth &

Hoffman, 1984). In addition, explicit moods of people who spent more than 45 minutes outside when temperature was 14 Celsius were lower than people who spent more than 45 minutes outside, contrary when temperature was 28 Celsius people who spent more time outside had higher moods (Keller, et al., 2005). Therefore, relative changes in temperature to the 22 Celsius reference point were calculated. Higher mood is expected around 22 Celsius room temperature and lower mood towards both ways.

People have tolerance limits to wind speeds at urban areas. Wind tunnel tests on pedestrians indicate that wind speeds above 4-5 m/s can cause discomfort on people (Potvin, 2000; Koss, 2006). Data on windspeeds were rearranged to reflect comfort thresholds. 13 km/h (3,6 m/s) wind speed was determined as the reference point (0 km/h) and wind speeds below the reference point were neglected, whereas wind speed above threshold were rearranged to begin from reference point. In the 20th century Sir Beaufort declared a wind scale between 0 and 9. This scale helps sailors to indicate severity of weather, 0 being calm and 9 being strong gale. 3,6 m/s wind speed coincides with Beaufort 3, gentle breeze. At Beaufort 3, wind is expected to extend light flags, sway small branches, flap clothes and disrupt human hair.

Daily net changes at temperature were calculated and introduced as independent variable to the model. Relative temperature changes to 22 Celsius utilized in the regression. Relative temperature calculation methodology is shown in Figure 3.

Figure 3: Relative Temperature Calculation Logic

Time interval of each dataset is between September 1st, 2000 and May 15th, 2018. In total, dataset contains 6466 working days. Binary weather variables have different number of instances out of 6466 days. Those instances and total number of days which average wind speed is above 13 km/h (relative wind variable is greater than 0) are listed in Table 1.

Table 1: Descriptive Statistics (Whole Sample)

Variable	Rain	T. storm	Fog	Snow	Hail	Tornado	Relative Wind
Instances	2052	412	125	266	7	2	3512
Percentage in total sample	31,7%	6,4%	1,9%	4,1%	0,1%	0,0%	54,3%

Note: Rain, T. storm, Fog, Snow, Hail and Tornado are binary weather variables. Number represent total number of days which those weather variables were observed. Total number of days which relative wind was greater than zero (average wind speed higher than 13 km/h) is shown in the table.

3.2. METHODOLOGY

We investigate the impact of weather variables on equity returns by the following specification.

$$r_t = \beta_0 + \beta_1 RT + \beta_2 RW + \beta_3 D_t^{Rain} + \beta_4 D_t^{Snow} + \beta_5 D_t^{Hail} + \beta_6 D_t^{Fog} + \beta_7 D_t^{Tornado} + \beta_8 D_t^{Monday} + \varepsilon_t \quad (1)$$

Where r_t is the daily return at time t for BIST 100 index. RT indicates relative changes in temperature to the 22 Celsius reference point. RW shows relative wind variable. As mentioned previously13 km/h wind speed was determined as the reference point (0 km/h) and wind speeds below the reference point were neglected, whereas wind speed above threshold were rearranged to begin from reference point. We follow Beaufort methodology and employ a wind scale between 0 and 9. D_t^{Rain} is a dummy variable which equals 1 for rainy days and 0 otherwise. D_t^{Snow} is a dummy variable which equals 1 for snowy days and 0 otherwise. D_t^{Hail} is a dummy

variable which equals 1 when it hails and 0 otherwise. D_t^{Fog} is a dummy variable which equals 1 for foggy days and 0 otherwise. $D_t^{Tornado}$ is a dummy variable which equals 1 for Tornado days and 0 otherwise. D_t^{Monday} is a dummy variable which equals 1 for Mondays and 0 otherwise and ε_t is the error term. Coefficients are estimated via OLS with HAC standard errors.

We initially run the OLS regression in (eq.1) for the full sample. Then, in order to see whether the impact of weather on stock returns has changed during our observation period, we employ two sub periods. The first sub period begins on September 1st, 2000, and ends on September 1st, 2009 and the second sub period begins on September 1st, 2009 and ends on May 15th, 2018.

SECTION IV
RESULTS & CONCLUSION

4.1. RESULTS

We investigate the impact of various weather variables (Relative Temp, Relative Wind, Rain, Snow, Hail, Fog, Tornado) on BIST 100 index prices with specification 1. In preliminary regressions for the day of the week effect, we found that Monday had the most significant effect on markets and we used Monday dummy variable as an independent variable in our regression. When looking at the results, we first see that temperature changes towards 22 Celsius positively effect stock market returns. In a similar vein, Hail, Fog, Tornado variables are found to have significant effects on stock returns. In line with the existing literature, we also document significant Monday anomaly for daily returns of BIST 100 index. Table 2 shows results obtained from whole sample. To better understand the relation between returns and

temperature the sample was divided into two equal-length pieces and was regressed on various weather variables.

Before beginning our estimation for the sub-periods, we also take a quick look at the descriptive statistics of each sub-period. Table 3 presents the total number of observations for the corresponding weather variable in each sub-period.

Table 2: Effect of Weather Variables on Stock Returns (Whole Sample)

Variable	Coefficient	Std. Error
C	0,000505	0,000444
Relative Temp.	0,000264	0,000148*
Relative Wind	0,0000997	0,0000673
Rain	-0,000236	0,000710
Snow	0,000885	0,001765
Hail	0,016705	0,009525*
Fog	-0,004530	0,002229**
Tornado	0,013569	0,000664***
Monday	-0,001527	0,000826*

Note: Table 2 shows the impact of various weather variables (Relative Temp, Relative Wind, Rain, Snow, Hail, Fog, Tornado) on BIST 100 index prices controlling for Monday effect. The full sample period includes 4443-day observations from September 1st, 2000 to May 15th, 2018. Coefficients are estimated via OLS with HAC standard errors. Response coefficients are reported with their respective standard errors. *, **, and *** indicate significance at the 10, 5 and 1 percent levels, respectively.

Table 3: Descriptive Statistics of First and Second Pieces of the Sample

Variable	Rain	T. storm	Fog	Snow	Hail	Tornado	Relative Wind
First Half	985	190	67	148	1	1	1874
Second Half	1067	222	58	118	6	1	1638

First half of the sample covers time between September 1st, 2000 and September 1st, 2009. Temperature, wind and whole weather events except snow have significance effects on equity returns in this period. Impact of temperature and wind was much stronger in the earlier half of the whole sample. Contrary to expectations, wind was positively correlated in both first and second halves of the sample. regression results for the first (September 9th, 2000 to September 9th, 2009) and second sub-periods (September 9th, 2009 to May 15th, 2018) are displayed in Table 4 and Table 5 respectively.

Weather clearly had more significant and stronger impact in the first half. Weather effect can be limited by penetration of trading algorithms in the market. Thus, human factor can be diminished and market can be evolved into a more efficient stage. Snow is the only weather variable that had a greater significance level in the second half compared to the first. It is not easy to give an opinion on the closer relationship between snow and market returns. Both number of days with snowfall are very close in both samples. Tornado, can be perceived as heavy winds and both relative wind and tornado are positively correlated with stock returns. Relative wind variable is not found to have significant effects in both sub-periods. Tornado events have significant impact on stock market returns in both sub-periods. There was only one tornado event in both halves, therefore, it is hard to take out a solid outcome from this weather variable.

Table 4: Effect of Weather Variables on Stock Returns (First Half)

01.09.2000 to 01.09.2009

Variable	Coefficient	Std. Error
C	0,001170	0,000760
Relative Temp.	0,000501	0,000257*
Relative Wind	0,000146	0,000106
Rain	-0,000359	0,001292
Snow	-0,001566	0,002972
Hail	0,064804	0,001700***
Fog	-0,009669	0,003566***
Tornado	0,013102	0,000863***
Monday	-0,004313	0,001398***

Note: Table 4 shows the impact of various weather variables (Relative Temp, Relative Wind, Rain, Snow, Hail, Fog, Tornado) on BIST 100 index prices controlling for Monday effect. Sample period includes 2173-day observations from September 1st, 2000 to September 1st, 2009. Coefficients are estimated via OLS with HAC standard errors. Response coefficients are reported with their respective standard errors. *, **, and *** indicate significance at the 10, 5 and 1 percent levels, respectively.

Table 5: Effect of Weather Variables on Stock Returns (Second Half) 01.09.2009 to 15.05.2018

Variable	Coefficient	Std. Error
C	-0,000201	0,000436
Relative Temp.	0,0000145	0,000147
Relative Wind	0,0000344	0,0000651
Rain	-0,0000154	0,000647
Snow	0,003893	0,001466***
Hail	0,006840	0,003806*
Fog	0,000786	0,002320
Tornado	0,013853	0,000426***
Monday	0,001284	0,000824

Note: Table 5 shows the impact of various weather variables (Relative Temp, Relative Wind, Rain, Snow, Hail, Fog, Tornado) on BIST 100 index prices controlling for Monday effect. The full sample period includes 2190-day observations from September 1st, 2009 to May 15th, 2018. Coefficients are estimated via OLS with HAC standard errors. Response coefficients are reported with their respective standard errors. *, **, and *** indicate significance at the 10, 5 and 1 percent levels, respectively.

4.2. CONCLUSION

Empirical studies on psychology found strong connection between weather conditions and current effective mood states. Effects of weather on mood states have been shown as clear examples on theories related with decision making processes of humans. Judging under risky situations can lead to heuristic decision-making shortcuts which cause undermining facts and overvaluing effective moods. Financial decisions made under similar conditions is one of the field of interests of behavioral finance. Researches on effects of weather on stock market returns, turnover, volatility and volume indicate that there is a correlation between weather changes and performance of investment instruments.

Contrary findings on mood states' effects on shifts of risk perceptions lead to different theories on the decision-making process. AIM and MMH hypotheses made great contributions to understanding how people act in different mood states.

This thesis aimed to investigate relationship between changes in weather conditions and stock market returns to identify possible directions of correlations and significance of variables.

Results of regression analyses, except relative wind variable, indicate a positive relation between relative temperature which investors are expected to be in positive mood and stock market returns. This result is parallel with Affect Infusion Model theory which argues people in positive moods are tending to undermine risks and show risk-taking behavior. Risk-taking behavior lead to gains in financial markets. Effects of rain weather variable and Monday mood are also in favor to Affect Infusion Model. Both Monday variable and rain variable were negatively correlated with stock returns. Mondays are generally associated with depressive and negative mood which can cause to risk-averse decisions according to AIM. Weather must be cloudy in order that it is rainy or snowy. Cloud cover can cause to negative mood and therefore under AIM, rainy weather can lead to decrease in stock indices.

On the other hand, correlation between relative wind and stock market return was negative. It was expected that wind velocities above the comfort zone of people will lead to negative mood states. According to AIM, negative mood must lead to risk-averse behavior. We fail to document any evidence regarding this. Both hail and tornado can be counted as factors that trigger negative mood. Stock market return was positively correlated with hail and tornado. In the days with hail or tornado, market exhibited reactions which expected by MMH.

Mixed results prevent this thesis to declare a clear support neither for AIM nor for MMH.

Although results of the regression confirmed effects of weather on stock exchange, to determine an extensive effect, additional weather variables and additional parameters of various investment instruments must jointly be investigated. Besides return, volume, volatility and turnover of stock exchanges and 2 Yr. and 10 Yr. Government bonds may lead to a more sophisticated analysis. Individual data of investors will pave the way to deepen the analysis. Severity of weather effect can be better determined by utilizing data on age, gender, location, educational background, trading volume and statistical gains. Utilizing day length data with

weather data can pave the way to jointly investigating effects of changes in daylength and weather conditions on mood and investments. Clinical data on SAD cases will also improve the analysis on mood effects.

Penetration of trading algorithms in financial markets is decreasing human factors on financial decisions. Human errors, environmental factors, psychological factors are being depressed by increasing trading volume of algorithms with the help of dedicated datacenters built close to physical locations of financial markets. A broader historical analysis of mood effect on stock markets can confirm diminishing human factor on markets.

SECTION V
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