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**Article**

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# The Role of Weather on Investors' Monday Irrationality: Insights from Malaysia

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## ABSTRACT

Evidence supporting the weekend effect, also known as Monday Irrationality, has shown that conventional finance is unable to follow a rational behavior assumption. Many scholars have proposed a behavioral approach to explain this phenomenon; however, few studies have investigated this effect empirically. Interestingly, literature on weather patterns and the preliminary results of our study have identified a particular weather cycle that occurs on Mondays, when the temperature in Malaysia is higher compared with other days. Therefore, this paper aims to investigate the role of weather on investors' Monday irrationality. By analyzing the market index and size-based portfolio formation model from 1999 to 2010, this research study found that the weather influenced investors' mood, causing anomalous conditions in the market. Our findings conclude that the mood of investors plays an important role on investment decisions and the resulting Monday irrationality of investors.

## KEY WORDS:

weather; monday irrationality; psychological finance; malaysian stock market

**JEL Classification:** D03; G12; G14

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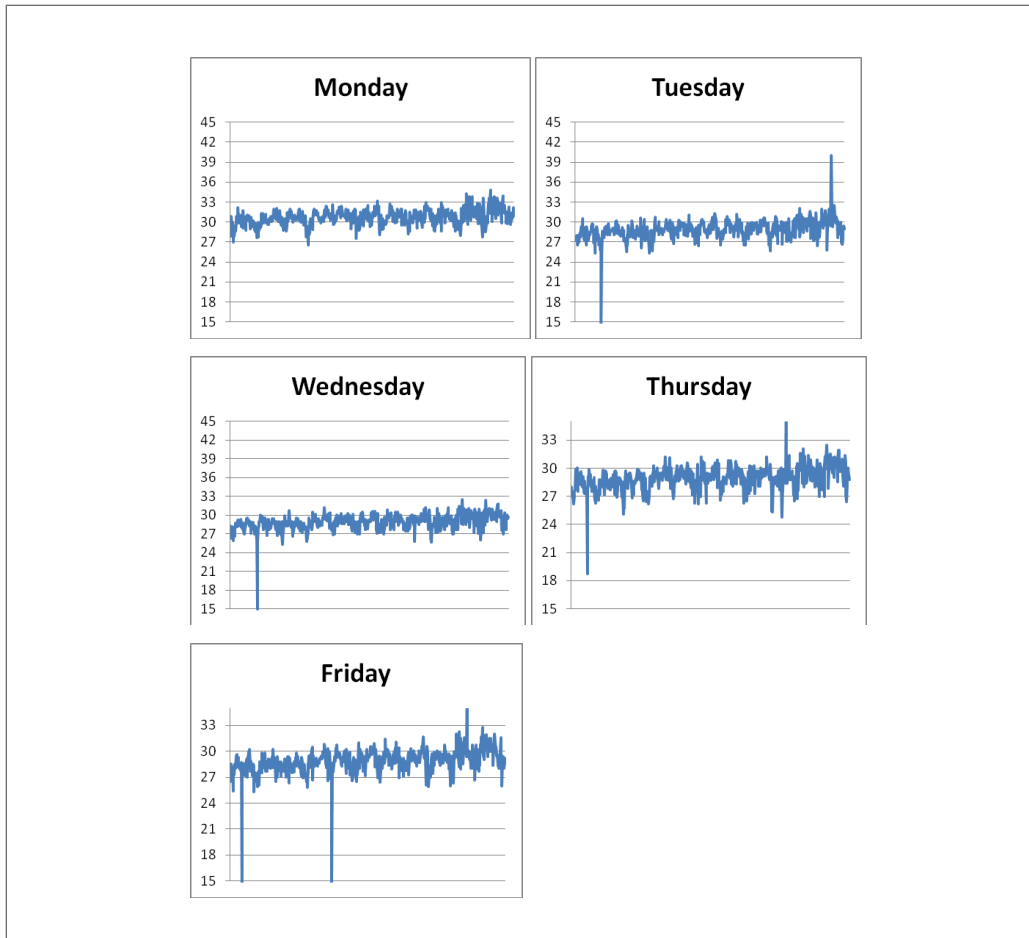
## 1. Introduction

To elucidate the mechanisms behind investor irrationality Monday irrationality phenomenon, one of several market anomalies, many scholars have proposed a behavioral approach (i.e., Brahmana, Hooy, & Ahmad, 2012a; Chin & Abdullah, 2013; Goetzmann & Zhu, 2005; Kudryavtsev, Cohen, & Hon-Sir, 2013; Ritter, 1988). However, it is rare to find research studies that empirically test the association between these anomalies and human behavior. Monday irrationality, popularly referred to as the Monday effect, is a phenomenon that has been largely unsolved. There is

much speculation on this topic and few studies that demonstrate any real results. The lack of empirical data indicates that this violation of the rational behavior assumption in finance has not yet been explained.

To confront this problem, this paper examines this anomaly from a psychological perspective by investigating mood sources, such as weather conditions, and analyzing them as drivers of investor irrationality as it pertains to the weekend effect. It is worthwhile to note that the weekend effect is a calendar anomaly that recurs on a particular day (usually Monday) and is negatively and significantly different from other days. The weekend effect demonstrates the irrationality of investors every Monday, when investors tend to be more aggressive or violate their utility function more frequently. Hence, this paper aims to examine the drivers behind Monday irrationality by hypothesizing that weather-induced mood is the source of this irrationality.

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**Figure 1.** The Temperature in Malaysia Based on Day of the Week.

Note: The y-axis is the temperature in degrees Celsius; the x-axis is the time period (1999-2010)

Interestingly, the scientific literature shows evidence for the effect of seasonal temperature on global weather patterns (see Forster & Solomon, 2003). Weather seasonality has been documented between Saturday and Monday, showing that it is relatively hotter on weekends compared with weekdays. This finding is in line with the Monday effect, an anomaly where investors are perceived as being irrational on Mondays. We have plotted a graph (Figure 1) to show that there is a corresponding weather anomaly. Our figure shows that the average temperature on Monday is relatively higher compared with other days of the week. The scientific literature and the figures below strengthen our

presumption that Monday irrationality (the weekend effect) is caused by weather-induced mood.

To elaborate on this topic from a psychological perspective, several scholars have reported that human psychology is a factor in making biased decisions; therefore, it has been hypothesized that the irrationality present during Monday trading is caused by psychological factors such as mood disorders (see Isen et al., 1978; Hechter & Kanazawa, 1997; Nurrunabi, 2011; Tvede, 2002). Empirical studies are also found in the economic literature regarding the relationship between mood and economic activity. One example is a study by Isen et al. (1978), which

found that people tend to go shopping when they are happy. Another example is a paper by Hechter and Kanazawa (1997), which found that rational choices in the decision making process are uncertain due to human values and conditions.

One factor that influences mood is weather. Many scholars have previously reported that a relationship between weather and human behavioral exists. Schwarz and Clore (1983) found that people receive greater satisfaction when the weather is sunny than when the weather is rainy. Howarth and Hoffman (1984) reported that weather is a factor that affects our emotional state. In a topical study, Hansen et al. (2008) investigated the relationship between high temperatures and mental, behavioral, and cognitive disorders. They surmised that high temperatures pose a salient risk to mental health by analyzing hospital admissions and mortalities that were attributed to mental, behavioral, and cognitive disorders between the years 1993 and 2006. This result is in line with two previous papers (Basu & Samet, 2002; Kovats & Kristie, 2006) that concluded that there was a connection between temperature and mental health.

In the financial literature, the relationship between weather and market behavior has been documented in many studies. One seminal paper written by Saunders (1993) found a relationship between the level of cloud cover and the equity returns in New York. This paper found that when the level of cloud cover was 100%, stock returns were significantly below average; however, when the level of cloud cover was 0-20%, the stock returns were significantly above average. Hirshleifer and Shumway (2003) documented the same result in broader markets for a longer period of time. Pardo and Valor (2003) addressed the effect of weather on financial markets by analyzing the behavior of market traders. Krämer and Runde (1997), Kamstra, Kramer and Levi (2000), and Tufan and Hamarat (2003) came up with similar results, finding that there is a positive relationship between weather conditions and stock market returns. Studies investigating the link between weather and market irrationality are difficult to find. Based on our research, only one paper has linked these two factors (see Brahmana, Hooy, & Ahmad, 2012b). This paper is a more robust examination of this relationship because it investigates the effect of a financial firm's size and extreme weather conditions.

This paper aims to offer a robust explanation of the Monday effect; a comprehensive explanation is lacking in the literature despite many previous research papers that have suggested that trading behavior is the determinant of this effect (see Abraham & Ikenberry, 1994; Yahyazadehfar, Abounoori, & Shababi, 2006). By considering trading behavior as the source of this irrationality, we have attempted to explain its determinants and propose the notion that weather is the driver of the weekend effect. We believe that the seasonality of weather is the activating event that triggers psychological biases in investors. As a consequence, trading might be influenced by these biases, resulting in the weekend effect. To explain this relationship, we used three theories suggested by Brahmana et al. (2012a): Ellis' ABC (Activating Event, Belief, and Consequence) model, Forgas' Affect Infusion Model, and the Somatic Marker theory.

Ellis' ABC model proposes that stimulating events activate irrational behavior in humans (see Brahmana et al. 2012a; Ellis, 1958). Relating Ellis' ABC model to this research study, the sting of extreme temperature is the stimulus that activates irrationality in investors' decision making processes. At the same time, the somatic marker theory describes that strong threats from the environment create body reactions that reinforce sustained panic (Tvede, 2002). This corresponds to the relationship between temperature and Monday irrationality because the sting of extreme weather affects investors and reinforces sustained panic in the form of irrational decision making. Lastly, Forgas' (1995) affect infusion model (AIM) describes how the external environment (e.g., the temperature anomaly in our research study) affects information processing and creates biased decision making. Elaborating on those theories, temperature affects investors in such a way that investors are stimulated by the sting of the temperature on Mondays. With this stimulant, an investor experiences affective bias and shows weather-induced mood behavior; this is the reason for their random investment decisions on Mondays.

This paper investigates if weather is an essential component of the weekend effect. This study is different from previous studies in three ways. First, our study investigates the weekend effect by analyzing weather patterns to contribute to the current body of knowledge. Second, unlike Saunders (1993), Krämer

and Runde (1997), Pardo and Valor (2003), Hirshleifer and Shumway (2003), Tufan and Hamarat (2004), Goetzmann and Zhu (2005), Cao and Wei (2005), and Dowling and Lucey (2005), this research study was conducted in a tropical country where the temperature level is roughly constant throughout the year. Third, unlike Brahmna et al. (2012b), this research study examined the effect of firm size by investigating 10 portfolio formations ranging from small (P1) to large (P10). Fourth, unlike Dichev and Janes (2003), Goetzmann and Zhu (2005), and Brahmna et al. (2012b), whose research studies did not employ psychological theory to explain their findings, we have used Forgas' Affect Infusion Model (1985) and the Somatic Marker theory to explain our findings. Lastly, the average temperature levels in Malaysia from 3 different weather stations were employed. These differences rationalized the different positions of investors who were spread out all over Malaysia, which has been criticized in previous research studies.

This study aims to answer the following question: Does weather explain investors' Monday irrationality in Malaysia? The remainder of this paper is organized as follows: Section 2 addresses the data and methodology, Section 3 delivers the results with a brief discussion, and Section 4 provides a conclusion to this study.

## 2. Data and Methodology

### 2.1 Data

This research study used the Malaysian stock market index returns as the dependent variable. The data were retrieved from the Thomson Data Stream. Temperatures were obtained on a daily basis from the Malaysian Meteorological Office from January 1, 1999 to March 22, 2010. Our temperature calculations were similar to previous research studies (see Krämer & Runde, 1997; Saunders, 1993) that measured the average maximum and minimum temperatures on the same day. Daily temperature data were recorded from three climate stations in Malaysia (Johor Bahru, Kuala Lumpur, and Penang). Each station reported an average temperature that was calculated from the average daily minimum and maximum temperatures between 9:00 am and 5:00 pm (trading hours). Then, we calculated the mean of these three stations' average temperature results to quantify our temperature data.

### 2.2 Empirical Model

Our baseline DOWA model was adapted from a study by French (1980) and is commonly used in the literature. This model is robust because it avoids the dummy variable trap by introducing an intercept proxy. The model is as follows:

$$R_t = \alpha + \gamma_1 d_{Tue,t} + \gamma_2 d_{Wed,t} + \gamma_3 d_{Thu,t} + \gamma_4 d_{Fri,t} + \omega_t \quad (1)$$

where  $R_t$  is the Bursa Malaysia compounding return series;  $d_{Tue,t}$ ,  $d_{Wed,t}$ ,  $d_{Thu,t}$ , and  $d_{Fri,t}$  are the dummy variables for Tuesday, Wednesday, Thursday, and Friday, respectively. Traditional approaches were used to examine if the weather played a role on the weekend effect by introducing the dummy interaction model. To conclude that temperature affects Monday irrationality, we employed the following model for each day of the week, requiring that a significant coefficient occur in only the Monday model and not on other days' models. The model is given as follows:

$$R_t = \beta_0 + \beta_1 DAY + \beta_2 TEMP + \beta_3 (DAY * TEMP) + \beta_4 DRY + \beta_5 R_{t-1} + \varepsilon_t \quad (2)$$

where  $DAY$  is the day dummy variable;  $TEMP$  is the weather in degrees Celsius;  $DRY$  is the dummy variable for the dry season, where 1 indicates the dry season and 0 indicates the rainy season; and  $R$  is the stock market return. This model was tested for 5 different days of the week by changing the day dummy variable from Monday through Friday.

With regard to the robustness test, we further analyzed our data using 2 innovation models. The first innovation model was the Day-by-Day returns model. This model only tests the relationship between weather and each weekday's returns. To control the equation and increase its goodness of fit, we introduced the random walk model. This model is as follows:

$$R_D = \beta_0 + \beta_1 TEMP_D + \beta_2 DRY + \beta_3 R_{D-1} + \varepsilon_t \quad (3)$$

Our last confirmation model is depicted in Model (4). This model is designed to investigate whether there is a significant relationship between extremely high and low temperature days and day-of-the-week anomalies. First, we employed Model (4) using a threshold of high temperature. We arranged the temperature data from

**Table 1.** Temperature and Returns by Day

		Mean	Max	Min
Monday	Temperature	29.96	41	24.8
	Returns	-0.0530	1.8495	-4.3336
Tuesday	Temperature	28.94	40	14.6
	Returns	0.1223	4.1039	-3.6807
Wednesday	Temperature	28.89	33	14.9
	Returns	0.0125	4.5027	-3.1589
Thursday	Temperature	28.92	40	18.7
	Returns	0.0403	5.7104	-3.9179
Friday	Temperature	28.83	32.5	12.5
	Returns	0.0434	2.5408	-2.1777

the lowest to the highest temperature. The highest 25% of the temperature measurements were given a value of 1, while the remaining measurements were given a value of 0. This dummy variable was multiplied again by a day dummy variable to obtain the series of data that we used in Model (4). *TMON*, *TTUES*, *TWED*, *TTHU*, and *TFRI* are the dummy variables indicating the highest temperature measurements multiplied by the day dummy variables for Monday, Tuesday, Wednesday, Thursday, and Friday, respectively.

We repeated the same procedure with the lowest temperature measurements. We arranged the temperature data from the lowest to the highest temperature. The lowest 25% of the temperature measurements were given a value of 1, while the remaining measurements were given a value of 0. This dummy variable was multiplied again by a day dummy variable. The model is as follows:

$$R_t = \gamma_1 TMON + \gamma_2 TTUE + \gamma_3 TWED + \gamma_4 TTHU + \gamma_5 TFRI + R_{m,t-1} + \varepsilon_t \quad (4)$$

### 2.3 Procedure

This research study conducted several procedures to investigate the relationship between temperature and Monday irrationality. First, we investigated the existence of this irrationality by replicating the procedures used by French (1980). If there was no evidence for this relationship, it would not be necessary to investigate the role of weather. Furthermore, one can argue that Monday irrationality or the Monday effect has dimin-

ished. Instead of merely citing from previous studies, such as Lim and Chia (2010), to prove the existence of Monday irrationality, we have conducted an analysis to show that Monday irrationality does exist in Malaysia. Then, we examined the role of weather on Monday irrationality by introducing a dummy interaction model (Model 2) where the temperature value intersects with the day dummy variable. Lastly, we employed a day-by-day model (Model 3), which is a straightforward method in which we first pooled the data set (temperature and returns) according to the trading days (Monday to Friday) then analyzed the data separately in Model (3).

We analyzed the effect of a financial firm's size in our study. The reason for this analysis was to control the bias in decision making with regards to the size of financial firms (see Baker & Wurgler, 2007; Blume & Stambaugh, 1983; Palamino, 1996; Reinganum, 1983). To mimic this size effect, we constructed size-based portfolios. We ranked and sorted 10 portfolio formations from small to large market value stocks. This procedure replicates Fama-French's (1995) influential studies, where the firm's size was ranked and sorted into a 10% decile formation.

## 3. Results

### 3.1 Descriptive Results

Table 1 shows the descriptive results of our study with three important findings. First, the mean of Monday's returns was negative, indicating a weekend effect. Sec-

**Table 2.** The Result of the Malaysian Stock Market DOWA

Period		Monday	Tuesday	Wednesday	Thursday	Friday
1999-2010	Coefficient	-0.00139	0.00225	0.001849	0.002161	0.002047
	t-Statistic	-2.10892	2.92074	2.306725	2.277263	2.049677
1999-2004	Coefficient	-0.0014	0.00273	0.002136	0.00217	0.001929
	t-Statistic	-2.91198	3.3461	2.974629	2.720946	3.032027
2004-2010	Coefficient	-0.00197	0.00276	0.002478	0.00331	0.004341
	t-Statistic	-2.80834	2.78198	2.704061	2.827546	4.361182

Note: French's (1980) regression model was performed in three sub-periods. The purpose of the sub-period segmentation was to ascertain whether the Monday effect/irrationality disappeared in certain periods or existed throughout the entire time period. The dependent variable is the market return. The independent variable is the dummy variable. Following the day-of-the-week hypothesis, the condition of Monday irrationality exists if the Monday coefficient (the intercept) is negative and statistically significant and the coefficients for other weekdays are positive and statistically significant. The model is as follows:  $R_t = \alpha + \gamma_1 d_{Tue,t} + \gamma_2 d_{Wed,t} + \gamma_3 d_{Thu,t} + \gamma_4 d_{Fri,t} + \omega_t$

ond, the temperature levels on Monday had the broadest spread compared to other days, implying that the temperature levels were dispersed more widely than on other days. Lastly, Monday's temperature mean was higher than that on other days, confirming our hypothesis regarding this weather anomaly.

### 3.2 Monday Irrationality (Monday Effect) in Malaysia

This analysis was designed to prove whether Monday irrationality still exists in Malaysia or if it has disappeared. We replicated a study by French (1980) to investigate the existence of Monday irrationality. Our results showed negative returns on the Monday coefficient (the intercept). Other days, such as Tuesday, Wednesday, Thursday, and Friday, were found to be positively significant. This indicates that the returns on those days were significantly different from Monday, supporting the Monday irrationality hypothesis. This result allowed us to proceed with our study to test if weather was the explanation for the weekend effect.

### 3.3 The Role of Weather on the Weekend Effect

#### 3.3.1 Weather-Monday Irrationality Interaction Model

Table 3 reports the regression estimations for Model 2; overall, the findings support our hypothesis. First, we found supporting evidence for the Monday effect from Model 2's estimates. The day dummy variable ( $\beta_1 DAY$ )

was significant if the model interacted with Monday. The coefficient was negative (-2.4637) and statistically significant at the 5% level. However, when we changed the day dummy variable ( $\beta_1 DAY$ ) proxy to other days of the week (Tuesday through Friday), there was no evidence of a significant relationship between the day dummy variable and the market returns. This implies that Monday irrationality existed for investors in Malaysia from 1999 to 2010. We then tested the relationship between temperature and returns. We found that temperature had an effect on the stock market throughout the weekdays. Regarding the effect of the dry season, we found that there was no significant relationship between the dry season dummy variable and the market returns. This indicates that there was no difference between the dry season and the wet season in influencing investors.

The focus of this study was to investigate whether temperature plays an important role in investors' Monday irrationality. Hence, we tested this relationship by introducing an interactive term between the day dummy variable and temperature ( $\beta_2 DAY * TEMP$ ). First, when the day dummy variable was Monday (i.e., Monday = 1, others = 0) and interacted with temperature, the estimate showed a negative value (-0.0083) that was statistically significant. However, when we changed the day dummy variable in the interactive model (we tested the variable individually from Tuesday through Friday), the results showed no significant relationship between the interactive terms and the market returns. This result surmises that temperature is the driver of

**Table 3.** Dummy Interaction Results

	Day = Monday	Day = Tuesday	Day = Wednesday	Day = Thursday	Day = Friday
INTERCEPT	0.7812 [1.7579] (0.0789)	1.4344 [3.0921] (0.0020)	1.2269 [2.7023] (0.0069)	1.2016 [2.6243] (0.0087)	1.1061 [2.2988] (0.0216)
DAY	-2.4637 [-2.1706] (0.0300)	1.325 [1.3334] (0.1825)	0.4712 [0.4399] (0.6600)	0.3255 [0.3127] (0.7545)	-0.1383 [-0.1501] (0.8807)
TEMP	-0.0025 [-1.9113] (0.0561)	-0.0501 [-3.1073] (0.0019)	-0.0436 [-2.7623] (0.0058)	-0.0423 [-2.6585] (0.0079)	-0.0387 [-2.3164] (0.0206)
DAY*TEMP	-0.0083 [-1.9970] (0.0459)	-0.0429 [-1.2481] (0.2121)	-0.0168 [-0.4527] (0.6508)	-0.0098 [-0.2726] (0.7852)	0.0077 [0.2420] (0.8088)
DRY	0.0203 [0.5227] (0.6012)	0.0157 [0.4040] (0.6862)	0.0159 [0.4093] (0.6823)	0.0159 [0.4083] (0.6831)	0.0156 [0.4020] (0.6877)
RDAYMIN1	0.1395 [7.6448] (0.0000)	0.1392 [7.5922] (0.0000)	0.137 [7.4797] (0.0000)	0.1371 [7.4893] (0.0000)	0.1364 [7.4546] (0.0000)
R <sup>2</sup>	0.058988	0.053307	0.051761	0.051958	0.052766
Adj R <sup>2</sup>	0.057326	0.051634	0.050086	0.050283	0.051092
F-Statistic	17.43468	13.93586	12.9909	13.11116	13.60487

Note: The regressions were performed on each day's data set using White's heteroscedasticity-consistent variances ordinary least square specification. The table shows the coefficient value, [ ] is the T-statistic value, and ( ) is the p-value. The dependent variable is the market return. TEMP is the temperature. DRY is the drought season dummy variable. RDAYMIN1 is the market return of the previous day. We ran the regression five times by changing the threshold of the dummy variable from Monday through Friday. First, we ran the model with the Monday dummy variable (for the Monday model, DAY=1 and others=0 if it is Monday). Then, the model is repeated in the same manner for the other days (e.g., for the Tuesday model, DAY=1 and others=0 if it is Tuesday; for the Wednesday model, DAY=1, others=0 if it is Wednesday; for the Thursday model, DAY=1, others=0 if it is Thursday; for the Friday model, DAY=1, others=0 if it is Friday). The regression model is as follows:  $R_t = \beta_0 + \beta_1 DAY + \beta_2 TEMP + \beta_3 (DAY * TEMP) + \beta_4 DRY + \beta_5 R_{t-1} + \varepsilon_t$

Monday irrationality. Again, the cause of this Monday irrationality might be the higher average temperature on Monday. Note that our plot (see Figure 1) and the previous literature show temperature seasonality on Mondays; these findings are in line with Monday irrationality seen in the stock market. This result is also in line with the study by Brahmana, Hooy, and Ahmad (2012b). Furthermore, the R<sup>2</sup> value of the Monday model is the highest compared with other days, thus confirming this relationship.

To examine the robustness of our analysis, a size-based portfolio was constructed. Portfolio 1 was the smallest-sized portfolio, and Portfolio 10 was the largest-sized portfolio. Model 2 was then re-run to investigate the role of temperature on Monday irrationality based on portfolio size.

The results are depicted in Table 4 and are in line with our previous results shown in Table 3. Monday irrationality is again confirmed, as the Monday dummy variable ( $\beta_1 DAY$ ) contributed negatively and signifi-



**Table 4.** Interaction Model: Firm Size Effect

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
INTERCEPT	0.0461 [0.0272] (0.9783)	0.0532 [0.9138] (0.3609)	0.2571 [-0.665] (0.5056)	0.2107 [0.959343] (0.3375)	0.0345 [0.3446] (0.7304)	0.7026 [1.0696] (0.2849)	0.2591 [0.9041] (0.3660)	0.0274 [1.4261] (0.1540)	0.0678 [1.5622] (0.1184)	1.1181 [0.7634] (0.4453)
DAY	-0.8791 [-3.1839] (0.0015)	-0.6129 [-2.1407] (0.0324)	-0.6824 [-3.840] (0.0001)	-0.7275 [-3.73717] (0.0002)	-0.1078 [-6.6255] (0.0000)	-0.3522 [-3.2890] (0.0010)	-0.4695 [-2.0499] (0.0405)	-0.6137 [-3.0123] (0.0026)	-0.2436 [-2.9595] (0.0031)	-0.2389 [-2.6442] (0.0082)
TEMP	-0.0729 [2.0739] (0.0382)	-0.0934 [-2.4745] (0.0134)	-0.0051 [-2.198] (0.0280)	-0.0711 [-2.9659] (0.0030)	-0.0479 [-2.4196] (0.0156)	-0.2107 [-2.5599] (0.0105)	-0.0614 [-2.6974] (0.0070)	-0.053 [-1.8982] (0.0578)	-0.0901 [-1.3997] (0.1617)	-0.0704 [-0.7866] (0.4316)
DAY*TEMP	0.3059 [3.180641] (0.0015)	0.2085 [2.0904] (0.0367)	0.2341 [3.8771] (0.0001)	0.2525 [3.723868] (0.0002)	0.3708 [6.5459] (0.0000)	1.2802 [3.4321] (0.0006)	0.1553 [1.9463] (0.0517)	0.2192 [3.0912] (0.0020)	0.0874 [1.4410] (0.1497)	0.0831 [0.7855] (0.4322)
DRY	0.3653 [1.6108] (0.1073)	0.3169 [1.3507] (0.1769)	0.2028 [1.389] (0.1648)	0.0047 [0.02949] (0.9765)	0.0963 [1.4416] (0.1495)	0.0844 [1.2603] (0.2077)	0.0126 [0.0883] (0.9297)	0.3099 [1.2424] (0.2142)	0.1466 [0.7789] (0.4361)	0.3009 [1.8047] (0.0712)
RDAYMIN1	0.2069 [3.1297] (0.0018)	0.3055 [1.9663] (0.0494)	0.7208 [4.122] (0.0000)	0.0704 [2.644176] (0.0082)	-1.1615 [-2.6906] (0.0072)	0.8989 [4.5872] (0.0000)	0.201 [6.3813] (0.0000)	0.1252 [4.5582] (0.0000)	-0.1715 [-2.3848] (0.0172)	-0.1051 [-1.6770] (0.0937)
R2	0.03876	0.02877	0.05229	0.05103	0.0161	0.0623	0.0370	0.040	0.0134	0.085
Adj. R2	0.0251	0.01507	0.0386	0.03741	0.0147	0.0487	0.0234	0.026	0.0251	0.051
F-Statistic	2.8369	2.1005	3.8395	3.7459	11.9289	4.5764	2.7139	2.873	0.9818	0.625

Note: We performed a robustness test to examine whether irrationality had a different effect in firms of different sizes. We formed 10 size-based portfolios according to their market capitalization (see Fama and French, 1992 for details). Then, we proceeded by taking the return of each portfolio and treating it as the dependent variable. The regressions were performed using White's heteroscedasticity-consistent variances ordinary least square specification. We reran Model 2, but only with the Monday model (DAY=1 and others=0 if it is Monday). TEMP is the temperature. DRY is the drought season dummy variable. RDAYMIN1 is the Friday returns. The model is as follows:  $R_t = \beta_0 + \beta_1 DAY + \beta_2 TEMP + \beta_3 (DAY * TEMP) + \beta_4 DRY + \beta_5 R_{t-1} + \epsilon_t$ . The table shows the coefficient value, [ ] is the T-statistic value, and ( ) is the p-value.

cantly to portfolio returns. This implies that Monday irrationality does exist regardless of the size of the portfolio. The temperature ( $\beta_2 TEMP$ ) contributed negatively and significantly only in small-sized and medium-sized portfolios, but not in large-sized portfolios. This finding is in line with the estimates of the ( $\beta_3 DAY * TEMP$ ) model, which showed no significant role of temperature interactions on Mondays in large-sized portfolios. Lastly, Table 4 shows that the presence of the dry or wet season had no effect on the influence of temperature on investors. Therefore, we surmise that temperature is the driver of Monday irrationality

and can be used to make predictions about small and medium-sized firms but not large-sized firms.

### 3.3.2 Day-by-Day Model

To make our research more robust, we re-investigated the role of temperature on Monday irrationality by using a different approach. Instead of using only the interactive terms, we employed a day-by-day model, which is formulated in Model 3. A day-by-day regression model (Model 3) indicates that we extracted each day's returns, including temperature, as one unique data set. For instance, we extracted only Monday's returns and Mon-

**Table 5.** Day-by-Day Model Results

	Day = Monday	Day = Tuesday	Day = Wednesday	Day = Thursday	Day = Friday
Intercept	0.0133 [0.0122] (0.9031)	0.0023 [0.00274] (0.9978)	0.0003 [0.0320] (0.9745)	0.0005 [0.0523] (0.9583)	0.0008 [0.0935] (0.9255)
TEMP	-0.0041 [-3.8577] (0.0001)	0.0016 [1.3597] (0.1528)	-0.0007 [-0.7923] (0.4283)	-0.0028 [-0.7945] (0.4269)	-0.0032 [-0.6537] (0.5134)
DRY	0.0724 [1.6225] (0.1048)	0.0442 [1.2859] (0.1986)	0.0815 [2.1814] (0.0292)	0.0501 [1.4084] (0.1591)	0.0144 [0.3957] (0.6923)
RDAYMIN1	0.3437 [15.7930] (0.0000)	-0.0841 [-6.1370] (0.0000)	0.1379 [6.8908] (0.0000)	0.1503 [8.6084] (0.0000)	0.2856 [15.2711] (0.0000)
R2	0.0957	0.0186	0.01834	0.0286	0.0819
Adj. R2	0.0948	0.01762	0.0173	0.0276	0.081
F-Statistic	91.3105	18.4844	18.1942	28.6938	86.8885

Note: The regressions were performed on each day's data set using White's heteroscedasticity-consistent variances ordinary least square specification. The table shows the coefficient value, [ ] is the T-statistic value, and ( ) is the p-value. First, we separated the data according to the day of the week. For the Monday model, we used Monday's temperature and Friday's returns. For the Tuesday Model, we used Tuesday's temperature and Monday's returns. For the Wednesday model, we used Wednesday's temperature and Tuesday's returns. For the Thursday model, we used Thursday's temperature and Wednesday's returns. For the Friday model, we used Friday's temperature and Thursday's returns. We ran the regression model five times by changing the data set according to the days of the week. The dependent variable is the market return. TEMP is the temperature. DRY is the drought season dummy. RDAYMIN1 is the Friday returns. The model is as follows:  $R_D = \beta_0 + \beta_1 TEMP_D + \beta_2 DRY + \beta_3 R_{D-1} + \varepsilon_t$

day's temperatures and then ran it through Model (3). This is what we termed the Monday model. We repeated the same procedure with the other data sets, from Tuesday through Friday. For example, we extracted Wednesday's returns and Wednesday's temperatures, named it the Wednesday model, and then ran it through Model (3). To establish a rigorous conclusion, this robustness test had to meet the following two conditions: (1) the temperature had to significantly impact returns; and (2) the result must only be documented for the Monday data set, not for the other data sets.

Tables 5 and 6 show the results of the day-by-day model in the market and portfolio formation modes. The average of the R<sup>2</sup> value is 9%, which is acceptable for a study that includes a dummy-based model. Furthermore, the F statistic of the model is accepted at the 1% significance level, implying that the model cannot be rejected.

Table 5 reports the estimates of Model 3 where the market returns are the dependent variable. These results confirm the interactive model (Model 2) results, where the temperatures on Mondays contributed negatively and significantly to market returns on Mondays at a 1% significance level. Meanwhile, there was no significant relationship between the temperatures of other weekdays on the market returns of other weekdays, even at the 10% significance level. The coefficient value for Monday was negative (-0.0041). This indicates that if the temperature increases by 1 Celsius unit, market returns might be lowered by 0.4%. Additionally, our results showed that the dry season dummy variable had no effect on the market returns.

These results imply that psychological bias (caused by temperature) has a significant relationship with market performance. The negative coefficient indicates

**Table 6.** Firm Size Effect: Day-by-Day Model

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Intercept	0.9834 [2.0258] (0.0429)	0.015 [0.0719] (0.9427)	0.005 [0.106] (0.915)	2.2403 [1.9594] (0.0502)	2.2452 [1.6684] (0.0954)	0.5243 [1.4587] (0.1448)	0.029 [0.0735] (0.9414)	1.8388 [0.7986] (0.4246)	1.3517 [0.6208] (0.5348)	0.6183 [0.3532] (0.7239)
TEMP	-0.0014 [-1.9999] (0.0456)	-0.0047 [-2.6863] (0.0073)	-0.0009 [-2.085] (0.037)	-0.0812 [-2.0524] (0.0402)	-0.0792 [-1.7001] (0.0892)	-0.3072 [-1.5197] (0.1287)	-0.0051 [-1.3277] (0.1844)	-0.0635 [-0.7976] (0.4252)	-0.0447 [-0.5939] (0.5526)	-0.0216 [-0.3571] (0.7210)
DRY	0.348 [1.0261] (0.3049)	1.6333 [1.9076] (0.0565)	0.06 [0.332] (0.740)	0.386 [2.0153] (0.0440)	0.0822 [0.3648] (0.7153)	0.5468 [0.5585] (0.5765)	0.182 [1.1340] (0.2569)	0.3641 [0.9440] (0.3453)	0.4567 [1.2537] (0.2100)	0.4114 [1.4030] (0.1607)
RDAYMIN1	1.4221 [15.7155] (0.0000)	0.1818 [0.9982] (0.3183)	0.322 [8.369] (0.000)	0.7088 [13.8575] (0.0000)	1.1636 [19.3283] (0.0000)	0.3888 [1.4870] (0.1371)	0.2922 [8.4417] (0.0000)	1.1258 [10.9280] (0.0000)	1.4919 [15.2588] (0.0000)	1.2351 [15.7713] (0.0000)
R2	0.0796	0.0289	0.0256	0.0639	0.1144	0.0016	0.0250	0.0396	0.0744	0.0788
Adj. R2	0.0786	0.0186	0.0246	0.0629	0.1135	0.0006	0.0240	0.0386	0.0735	0.0778
F-Statistic	84.042	28.8197	25.6146	66.4396	125.8266	29.5780	24.5773	40.1405	78.0580	83.2962

Note: We performed a robustness test to examine whether irrationality has a different effect in firms of different sizes. We formed 10 size-based portfolios according to their market capitalization (see Fama and French, 1992 for details). Then, we proceeded by taking the return of each portfolio and treating it as the dependent variable. Note that we considered only the Monday return from each portfolio. The regressions were performed using White's heteroscedasticity-consistent variances ordinary least square specification. We reran Model 3 with only the Monday model (DAY=1 and others=0 if it is Monday). TEMP is the temperature on Mondays. DRY is the drought season dummy. RDAYMIN1 is the Friday returns. The model is as follows:  $R_{D,t} = \beta_0 + \beta_1 TEMP_{D,t} + \beta_2 DRY_t + \beta_3 R_{D,t-1} + \varepsilon_t$ . The table shows the coefficient value, [ ] is the T-statistic value, and ( ) is the p-value.

that when the temperature is higher, the market tends to be bearish. This could be due to increased aggressiveness of investors, causing them to violate their utility function and act irrationally. As a consequence, investors trade following their mood (hedonic utility) instead of their utility function. This is consistent with the studies by Saunders (1993) and Brahmana et al. (2012b), who demonstrated evidence for the relationship between the weather and stock market.

Again, we controlled for the size effect by constructing size-based portfolios and running them through Model 3. Table 6 shows the estimations with portfolio formation returns as the dependent variable. The results were similar to the market return results (Table 5), where there was a temperature effect on Monday irrationality. The role of temperature on Monday irrationality was seen in Portfolios 1 through 5, indicating that the effect of Monday irrational-

ity was seen only in small-sized and medium-sized firms. Large-sized portfolios were not affected by this weather irrationality.

The magnitude of this effect was quite high, as the coefficient values ranged from -0.0014 to -0.0792. This implies that higher temperatures indicated lower returns on Mondays. The dry or wet season was not important, as it was not significant at either the 1% or 5% significance levels in Table 6. This indicates that there was no difference in the temperature effect between the dry and wet seasons.

### 3.3.3 Extreme Weather

Our hypothesis rests on the assumption that because temperatures on Monday are higher, on average, compared to other days, Monday irrationality exists. To strengthen this hypothesis, we conducted another robustness test that examines extreme weather. We built

**Table 7.** The Relationship between Extremely High Temperature Conditions and the Day-of-The-Week Anomaly

Variable	Coefficient of Extremely High	Coefficient of Extremely Low
	Temperature	Temperature
TMON	-0.0927**	0.0564
TTUES	0.0448	0.0117
TWED	0.0256	0.0116*
TTHU	0.0122	0.0135*
TFRI	0.0303	0.0121*
RMIN1	0.1427***	0.1363***

Note: We examined the role of extreme temperature by adopting French's (1980) model. The dependent variable is the market return. The independent variable is the temperature according to day of the week. TMON is Monday's temperature, TTUES is Tuesday's temperature, TWED is Wednesday's temperature, TTHU is Thursday's temperature, TFRI is Friday's temperature, and RMIN1 is the returns of previous day. The model is as follows:  $R_t = \gamma_1 TMON + \gamma_2 TTUE + \gamma_3 TWED + \gamma_4 TTHU + \gamma_5 TFRI + R_{m,t-1} + \varepsilon_t$ . (\*)(\*\*)(\*\*\*) denotes (10%)(5%)(1%) statistical significance, respectively

two other models (model 4 and model 5) by treating extreme temperatures as dummy variables. This was performed by considering the highest and lowest 10% of temperature measurements as the extreme values. On the dates that had extreme temperatures, we assigned a dummy value of 1. This method follows the previous report of Brahmana et al., (2012b), who examined the Indonesian stock market.

Table 7 shows the estimates of Model 4. If the threshold was set at the high temperature measurements, our findings showed that only extreme temperatures on Monday had a significant relationship with market returns. The coefficient was -0.0927, implying that the market returns might decrease by 0.0927 if a high temperature occurred on Monday. Interestingly, high temperature extremes on other days of the week did not significantly contribute to market returns. Considering that temperatures on Monday are higher, on average, than temperatures on other days of the week, these findings confirm our hypothesis that that extreme weather conditions on Monday are the source of this day-of-the-week anomaly. Mood changes generate random decision making processes that can cause anomalies in the market. These results also confirm the similar findings of Forster and Solomon (2003) regarding weather calendar anomalies. Our findings also strengthen the correlation between weather and the week effect reported by

Jaffe and Westerfield (1985); both studies enrich the behavioral finance literature by surmising that there is an effect of weather-induced mood on day-of-the-week anomalies.

We continued to test our hypothesis by changing the threshold from extremely high temperatures to extremely low temperatures. If higher average temperatures on Monday caused Monday irrationality, perhaps extremely low temperatures did not have an effect on market returns.

Table 7 shows that extremely low temperatures influenced investor irrationality only on some weekdays: Wednesday, Thursday, and Friday. Furthermore, these low temperatures influenced the returns at the 10% significance level, a result generally considered to be not significant. In addition, there was no effect on market returns of extremely low temperatures on Monday and Tuesday.

The most convincing explanation for these findings is the environmental psychological approach, a study regarding the role of the environment on human behavior. For instance, McAndrew (1993) noted that a lack of sunlight makes people melancholic and upset. Bell et al., (2003) reported a summer effect, where people feel impatient or angry when the temperature is greater than 84°F. These studies also showed that, unlike hot temperatures, cold temperatures make people upset.

#### 4. Conclusion

Rational behavior, which is the main assumption in conventional finance, has been extensively challenged by behavioral scholars. The inability of conventional finance to explain the existence of Monday irrationality (the Monday effect) is evidence for a failure of the rational behavior assumption. The scholars in behavioral economics have rejected this assumption by introducing the concept of hedonic utility, where the psychology of investors plays an important role in decision making.

This paper examines the relationship between weather conditions and investors' Monday irrationality. The literature has shown that weather conditions (e.g., temperature) can influence investors' moods during trading. We extended this research further by elaborating upon psychology and finance after examining several interesting facts: (1) there is Monday irrationality present in Malaysian stock markets; (2) there is also weather seasonality, which has been documented by Forster and Solomon (2003); and (3) our data analysis shows that the temperature on Mondays is higher, on average, than the temperature on other days of the week. We used these facts as our starting point to further investigate if weather, as a source of mood disorders, has an effect on investor irrationality.

Several of our findings support our hypothesis. First, our results showed that the Monday dummy variable had a significant effect on the model; however, other weekday dummy variables did not. This finding strengthened the evidence for Monday irrationality in the Malaysian stock market, which is in line with prior research studies (see Kok and Wong, 2004; Lim and Chia, 2010). Second, temperature was found to be significant on weekdays, which is in line with prior research studies, such as those published by Saunders (1993), Hirshleifer and Shumway (2003), Pardo and Valor (2003), and Dowling and Lucey (2008). This indicates that temperature had an effect throughout the week, which is representative of the tropical weather patterns in Malaysia. The dry season dummy variable indicated that there was no difference between the dry and wet seasons regarding the behavior of investors. Unlike countries that have four seasons, Malaysia does not have seasonal affective disorders, which occur due to changing seasons.

Lastly, our model has documented the role of weather on the Monday effect by using two models:

the interactive model and the day-by-day model. Our findings are concordant with the literature in psychology. For example, Howarth and Hoffman (1984) stated that weather can affect the emotional state of humans. Basu and Samet (2002), Kovat and Ebi (2006), and Hansen et al. (2008) found that high temperatures can affect mental health. This is why a negative relationship was found between temperatures and returns on Mondays (i.e., the higher the temperature, the lower the returns). In the context of a tropical country, as well as in Malaysia, the literature in psychology also documents the role of temperature on human behavior. For instance, Pakiam and Lim (1984) found a relationship between weather and crime rates. Jain et al. (1992) documented a link between climate and admissions for mood disorder (e.g., mania). Lee, Tsai and Lin (2007) found that a seasonality variation in bipolar disorder does exist and is associated with climate. Furthermore, Van de Vliert et al. (1999) analyzed 136 countries for a relationship between temperature and domestic political violence and found that countries with a mean daytime temperature of approximately 24 degrees Celsius (tropical weather) tend to suffer from more violent political actions compared with colder or warmer countries. This may be due to the level of aggressiveness being different due to warmer temperatures. These findings show that investors may be influenced by temperature. Investors are mentally obstructed by high temperatures, possibly resulting in irrationality.

Because this research study aims to explain this irrationality, one can argue that there is a different level of attention with regards to the size effect (see Blume and Stambaugh, 1983; Meneu & Pardo, 2004; Reinganum, 1983; Ritter, 1988). Hence, we formed size-based portfolios and repeated our models to address this issue. Our results showed that there is size interference on the role of temperature. Small-sized and medium-sized portfolios were found to be affected by temperature; however, large-sized portfolios were not affected. This indicates that small and medium cap formations are influenced by weather on Mondays, but large cap formations are not. This is consistent with the study by Reinganum (1983), who found that small firms experienced seasonality compared to large firms (the size effect anomaly). Blume and Stambaugh (1983) concluded the same result, where there was a small

size effect on the calendar anomaly. Furthermore, Ritter (1988) addressed speculation on low capitalization stocks (small size) as an explanation of the calendar anomaly. One of these explanations is that irrationality and speculation are easier in small- and medium-sized firms compared with large-sized firms. For instance, Palamino (1996) addressed misperception and unpredictable beliefs as the reasons why small firms become the object of irrationality. Baker and Wurgler (2007) found that investors have biased decision making and negative sentiments regarding small-sized firms.

In conclusion, there is evidence that Bursa Malaysia's Monday irrationality is influenced by investors' mood, where the weather is the source of mood fluctuations. This is in agreement with the literature in psychology, where several reports have shown that weather can affect human behavior (see Hansen et al., 2008; Schwarz & Clore, 1983) and can make humans melancholic, upset, or happy. This mood fluctuation is caused by weather acting as an "agent" to a random decision. In economics, this type of behavior is more commonly referred to as irrational behavior.

These findings can be discussed by using the three aforementioned theories (Ellis' ABC model, Forgas' AIM, and the Somatic Marker theory). Under Ellis' ABC model, the relationship is analyzed as follows:

**Activating Event (A):** Weather anomaly on Monday (average temperature is higher on Mondays compared to other trading days)

**Beliefs and Cognition Process (B):** Mood disturbance

Investor A: "I am fed up with my stock's performance. Just sell it."

Or

Investor A: "I feel that it is the time to sell."

*Inferences about the event:* Hedonic Utility

**Consequences (C):** Overweighted on selling side, causing Monday Irrationality

*Feelings:* Depressed, Aggressive, Hedonic, Moody

*Behaviors:* Investor deduced the market and caused Monday Irrationality (day of the week anomaly)

By using Forgas' Affect Infusion Model (AIM), we explain our results in the following manner. The first process in the AIM is "Direct Access," where high temperatures hit investors on Mondays frequently (because there is a weather anomaly). The second stage

is "Motivational Process," a situation where this high temperature has biological effects on the human body through heat. The influence of temperature on human biology leads to irrationality. The third stage is "Heuristic Infusion," where irrationality drives the investor to make a biased decision. The last stage of the AIM is "Substantive Procession," the process of affective bias that bestows the biased decision portrayed in Monday irrationality.

Lastly, the relationship between temperature and Monday irrationality can be explained as a Somatic Marker. In this hypothesis, if a strong threat from external factors exists (in our case, high temperatures), this threat can create a human reaction that reinforces panic or heuristic bias. Weather anomalies (e.g., higher average temperatures on Mondays compared with other days of the week) force the human body to be more heuristically biased in decision making. Hence, Monday irrationality occurred as a consequence of heuristic bias.

Overall, our research study confirms the literature in psychology that shows that temperature is the source of alterations in mood. We used our findings to tackle the problem proposed by Abraham and Ikenberry (1994) showing that trading behavior might be the source of the weekend effect (in our case, Monday irrationality). Extremely high temperatures or higher average temperatures on Mondays played an important role in influencing investors' trading behavior. This research both contributes to theory and has practical implications. The theoretical contribution is the explanation of the market anomaly (Monday irrationality/the Monday Effect) using a psychological approach. This is in line with the paper by Kahneman and Tversky (1979), who reported that irrationality might occur due to the psychological bias of investors. Our research also confirms the results of the study by Brahmana et al. (2012a), which argued that the Monday effect can be explained by using psychological factors such as weather. In terms of practical implications, we refer to investing strategies<sup>1</sup>. Temperature forecasts can be used as indicators of market sentiment or as further signals of the Monday effect. Further research is needed to investigate the relationship between other psychological factors or to investigate these research findings in a quasi-experiment.

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## Endnotes

1. There are several fund managers who run their asset management using the-so-called superstitious fund. Please refer to the news at <http://www.bbc.com/future/story/20120731-bulls-bears-and-black-cats> and <http://www.thejakartapost.com/news/2011/08/08/market-forecast-buy-cloudy-sell-sunny.html>



