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Make hay while the sun shines

Research into the relationship between weather conditions and stock returns

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Abstract

Research suggests that the weather influences our mood, which affects the decision-making process. This could imply that the weather influences stock returns. This paper examines the effects of sun and rain on the stock returns of ten cities from 1995 till 2005. Most importantly, the question is whether these effects differ between countries on near the equator and countries farther away from the equator. The correlations have been estimated and regression analyses have been conducted. The results show that rain and sun can have both a negative as well as a positive effect on stock returns. Rain and sun have a negative effect in countries near the equator, but both negative and positive effects in countries farther away from the equator.

Table of content

1. Introduction

One of the most discussed topics worldwide is the weather. We either complain about it or we enjoy it. The weather does not only influence our conversations, but also our behaviour. It affects the things we do, the clothes we wear and the food we eat. All these changes can also be the product of a change in mood, which suggests that our mood depends on the weather.

According to conventional financial theories, people make decisions based on rational choice and consistent with the Efficient Market Hypothesis. This means that when people participate in financial markets, they should only use the relevant information for decision-making. However, people are not machines and therefore do not always act as the financial theories have predicted. This thesis will investigate such an anomaly, namely if the weather causes regular patterns in the stock markets.

It is relevant to investigate this topic, as the results can give more insight in the human behaviour as well as help improving the existing theories. More practical, traders can use this information when making a strategy, even though the benefits might be negligible.

Evidence shows that sunlight affects the amount of serotonin in our brain. This means that it is related to mood seasonality and seasonal affective disorders (Lambert, Reid, Kaye, Jennings, & Esler, 2002) (Leppämäki, et al., 2003). However, more recent research found contradicting evidence, as it stated that depression and weather conditions did not seem to be associated (Huibers, de Graaf, Peeters, & Arntz, 2010). Thus, the relationship between weather and mood does not seem completely clear and should be further investigated.

As reported by Gerlach, weather anomalies are often found on days with at least one macroeconomic announcement (Gerlach, 2007). Hirshleifer and Shumway have studied the relationship between sunshine and daily stock returns. They concluded that sunshine and daily stock returns were significantly correlated (Hirshleifer & Shumway, 2003). This could mean that sunlight affects the mood of the traders, which subsequently affects the prices on the stock market.

This paper will discuss the following issue:

Do weather conditions have a different effect on the stock returns of nations close to the equator than on the stock returns of nations farther away from the equator?

Individuals living near the equator experience only two seasons, the wet season and the dry season, while inhabitants of countries farther away from the equator experience four seasons. It would be interesting to see if this difference in seasons causes a different effect on the stock returns of those places.

To answer this question, both existing research and empirical evidence will be used as a literature review. This information will be used to describe the behaviour of investors on the stock market and anomalies that could influence this behaviour. Furthermore, new empirical research will be conducted. These anomalies could also influence the data that will be used.

The first section of this thesis will contain the literature review. Some well-known seasonal anomalies, such as the Halloween indicator, will be discussed. Also, the effects of the weather on mood and stock returns, the effects of mood on decision-making and the consequences of Seasonal Affective Disorder will be discussed. Furthermore, hypotheses and some important definitions will be given in the last paragraph of this chapter.

In the next chapter, I will describe the data that are used to test the hypotheses. These consists of stock market and weather variables data of ten countries, within the period 1995-2005.

Chapter four will subsequently illustrate the methodology used to run the tests. Both the correlation between the weather and stock returns as well as a regression analysis will be conducted. The results of these tests will be given in chapter five.

Finally, these results will be interpreted in the discussion and the research question will be answered in the conclusion.

2. Literature review

Both the relationship between weather and mood, and the relationship between weather and stock returns have been the subject of previous research. These findings will be discussed in this chapter.

First, some seasonal effects in stock returns will be discussed. These anomalies are not necessarily related to the weather of a specific day, but can also be related to a specific season.

In the second section the effects of the weather on mood will be reviewed, followed by the third paragraph that discusses the effects of mood on decision-making.

Next, research into the effects of the weather on stock market returns will be reviewed.

The fifth paragraph is used to describe Seasonal Affective Disorder (SAD). This is a type of depression that is caused by less hours of daylight. Evidence shows that SAD effects exist on the stock market.

In the last paragraph hypotheses are given that will be tested. Also, some definitions will be given that are important for the data selection.

2.1 Seasonal effects in stock returns

As stated in the introduction, people do not behave as conventional financial theories expect them to behave. Investors can be affected by environmental factors (such as the weather), which can result in irrational behaviour on the stock market.

The first example of a seasonal anomaly is the 'Halloween indicator', also known as the market wisdom 'Sell in May and go away'. According to this phenomenon, people should sell their shares in May (before the summer starts), as stock returns are higher during November to April than during the remainder of the year (Van der Sar, 2015). Bouman and Jacobsen found that this effect is present in stock market returns. Moreover, they found that the effect is stronger in countries with a long summer vacation tradition, but they could not explain the seasonal anomaly completely (Bouman & Jacobsen, 2002).

Another study shows that local media coverage is strongly related to the probability and magnitude of local trading. The weather can influence the media and thereby the probability and magnitude of trading. For example, a blizzard could prevent investors from receiving the newspaper, which results in a lack of information on the stock market (Engelberg & Parsons, 2011). However, most people follow the news online and therefore the effect of extreme weather on media coverage will be smaller.

2.2 Effects of the weather on mood

It is well-acknowledged that the weather affects the life of human-beings, both the physical as the mental condition. Sunshine causes the serotonin level in our bodies to increase (Lambert, Reid, Kaye, Jennings, & Esler, 2002). As serotonin is a natural mood stabilizer, sunshine gives our mood a boost. This means that only the actual sunshine itself has an impact on our mood, not the forecast of good weather.

Cunningham stated that sunny and clear days improve our mood (Cunningham, 1979). Others found that the weather had a substantial impact on the mood of the subjects. Especially humidity, temperature and hours of sunshine had the biggest impact on mood (Howarth & Hoffman, 1984). De Montigny et al. also suggested that several weather components, such as air temperature and direct solar radiation, had a significant effect on place-based human behaviour (de Monitgny, Ling, & Zacharias, 2011). Place-based behaviour means that people living in the same place show the same behaviour to some extent.

The weather can influence investor decision-making by ‘mood misattribution’. This means that some transitory factors, such as the weather, can influence decisions that should not be related to these factors (Lucey & Dowling, 2005). For example, sunny weather can affect the mood of investors, which makes them more optimistic. This makes them more willing to enter into long positions and eventually causes higher returns (Symeonidis, Daskalakis, & Markellos, 2010).

2.3 Effects of mood on decision-making

As stated in the previous paragraph, the weather can affect our mood. It is reasonable to believe that our mood influences decision-making. After all, having a good mood makes people more optimistic. Wright and Bower showed that mood may directly affect a judgement of the uncertainty of a future event (Wright & Bower, 1992). Thus, mood has the biggest impact on decision-making when there is a lack of sufficient information (Clore, Schwarz, & Conway, 1994). Also, people tend to notice negative information better when they are in a bad mood, while positive information seems to be more available when individuals are in a good mood (Forgas & Bower, 1987). This is called the mood congruency effect.

If an individual is in a good mood, he will use more simplifying heuristics to make a decision, while an individual with a bad mood will make more use of analytic skills (Bless, Schwarz, & Kemmelmeier, 1996) (Isen, 2008).

However, being in a good mood does not necessarily mean that individuals make irrational decisions. People in good moods will simplify complicated information effectively, which makes decision-making easier and faster (Hirshleifer & Shumway, 2003). Also, people in good moods tend to be less short-sighted and are more open to the opinions of others (Isen, 2008).

Both the assessment of risk as the assessment of future prospects are affected by emotions (Johnson & Tversky, 1983). This is called the affect heuristic, which means that people make decisions based upon feelings (Slovic, Finucane, Peters, & MacGregor, 2007). People often believe that emotions are a consequence of the environment. This can explain the problem of mood misattribution (see para. 2.2).

2.4 Effects of the weather on stock market returns

The previous paragraphs show that the weather influences our mood, which subsequently affects the process of decision-making. It seems reasonable that the weather affects the decisions individuals make on the stock market and therefore affects the stock returns.

Saunders investigated the correlation between cloud coverage and stock returns on the New York Stock Exchange. He found that the correlation was negative, which means that stock returns tend to be negative on cloudy days and higher on days with less cloudiness (Saunders, 1993). In addition, Hirshleifer and Shumway supported the results of Saunders by finding a negative correlation between cloud coverage and stock returns in 26 international stock markets. Moreover, they found that sunshine is significantly related to stock returns (Hirshleifer & Shumway, 2003). This implies that sunshine and cloudiness have the opposite effect on stock returns.

Other weather factors have been studied as well. For example, Keef and Roush concluded that wind has a significant effect on stock returns in New Zealand (Keef & Roush, 2002).

Cao and Wei used psychological evidence that showed that low temperature can cause aggression while high temperatures can cause both aggression as apathy. Aggression could result in risk-seeking behaviour, while apathy could result in risk-averse behaviour. Substantiated with empirical research, they concluded that the correlation between temperature and stock returns is significantly negative (Cao & Wei, 2005).

2.5 Seasonal Affective Disorder

Seasonal Affective Disorder (SAD) is a seasonal depression that is caused by less hours of daylight (the mild form is also known as 'winter blues'). Even though Huibers et al. (2010) show that the weather is not associated with the mood of SAD patients, others find a relation between seasonal variation in sunlight and depression (Cohen, et al., 1992) (Rosenthal, 1998).

Kamstra et al. (2003) suggested that the seasonal variation in hours of sunlight causes seasonal variation in equity returns. They also argued that depression leads to higher risk aversion. The research was carried out in nine countries and includes both countries of the northern as the southern hemisphere. The effects of SAD were the strongest on the Swedish stock market, which is the furthest away from the equator, while the effects were relatively low in Australia, which is closer to the equator. The number of hours of daylight were more constant at the equator, which could explain the difference in SAD effects. The results were also consistent with the seasons, as the results in the southern hemisphere were six months out of phase.

Other research shows that people who suffer from SAD demonstrate more risk-averse behaviour that varied across the season. They significantly stronger preferred safe choices during the winter months than people who did not suffer from SAD, while their preferences were the same during the summer months (Kramer & Weber, 2012).

2.6 Hypotheses

Based on the evidence given in this chapter, four hypotheses have been made. An answer to the research question can be given by accepting or rejecting these hypotheses.

The first hypothesis concerns the relationship between sunshine and stock returns:

H_1: On sunny days, the stock returns will be higher.

Sunshine causes the level of serotonin in our body to increase, which makes us feel better. Subsequently, being in a good mood makes people more optimistic. This could imply that investors behave more optimistic on the stock market, which causes higher stock returns. Research of Hirshleifer and Shumway (2003) shows that sunshine is strongly correlated with stock returns.

The second hypothesis investigates the relationship between rain and stock returns:

H_2: On rainy days, the stock returns will be lower.

Whereas a combination of sunshine and rain is possible, it is not very common. This means that in general, rain implies bad weather, especially in countries that do not endure extremely dry periods. Combined with the first hypothesis, this hypothesis tests whether good weather causes high stock returns and bad weather causes low stock returns. It is necessary to test both hypotheses, as accepting (rejecting) one hypothesis does not automatically mean that the other hypothesis can be accepted (rejected) as well.

The third hypothesis focusses on countries farther away from the equator:

H_3: In countries farther away from the equator, sunshine will have a positive reaction on the stock market.

As the weather in nations farther away from the equator can fluctuate through the year, people experience several weather conditions. The weather can be noticeably different throughout the seasons, as the population has to deal with snow, rain, storms, heatwaves and frigid conditions. This makes sunny days more noteworthy, especially when the hours of daylight decrease during the winter.

Finally, the fourth hypothesis concerns the relationship between stock returns and the weather in countries near the equator:

H_4: The effect of rain on the stock market in countries near the equator will not differ from the effect in countries farther away from the equator.

Near the equator, the hours of daylight remain nearly the same and there is little temperature fluctuation throughout the year. As a result, countries near the equator do not have the four typical seasons. Instead, people living in this area experience two seasons: the wet season and the dry season. As these people are used to big amounts of rainfall, their reaction will be little. Meanwhile, people living farther away from the equator face the effects of rainfall throughout the year. The result of these weather conditions is that the effect of rain on the stock market will not differ between the these countries.

In order to test these hypotheses some definitions have to be given.

First, there has been made a division between countries farther away from the equator and countries near the equator. Residents of the first group of countries have to deal with four different seasons, which means that the weather conditions fluctuate.

The climate of nations that lie close to the equator is not divided into four distinctive seasons. However, they do face a dry and a wet season. As a consequence, the temperature is lower during the wet season, but the deviation in temperature is never as big as the deviation in countries farther away from the equator (*App. 1*).

3. Data

In order to analyse the correlation between stock returns and the weather, both data about stock returns and weather conditions have been gathered. These data consist of input of ten countries from January 1995 to December 2005. As the stock markets are closed during the weekends, only data from weekdays are retrieved.
The countries that are chosen are: the Netherlands, Sweden, the United States of America, Canada, Japan, South Africa, Australia, Brazil, Singapore and Malaysia. These countries are chosen for two reasons. First, the stock markets of these countries are either important for its continent or these countries play another important economic role. Second, these countries are chosen for their position on the world. Singapore and Malaysia lie near the equator, while the other nations lie either on the northern or the southern hemisphere. Brazil, South Africa and Australia lie on the southern hemisphere and approximately on the same latitude. The difference between the equator and Tokyo is roughly the same as the distance between the countries on the southern hemisphere and the equator, but lies on the northern hemisphere. Canada, the United States, the Netherlands and Sweden lie also on the northern hemisphere, but farther away from the equator than Tokyo.

As the weather can differ within a country, a city is chosen to be the main subject of the data collection. These cities are either the capital city or an important financial city of the nation (*App. 1*).

The values for the Skewness, Kurtosis and Jarque-Bera tests show that all data follow a non-normal distribution (*App. 4*).

3.1 Stock market returns

The daily index returns are collected from DataStream. This database contains financial information about equities, indices, bonds and more. For all cities except Amsterdam, the market equity index of that country that has been calculated by DataStream is used. For Amsterdam, the AEX (Amsterdam Exchange Index) has been used. The Total Return Index of these equity indices have been retrieved and will be used as measure for the stock returns.

The reason that only for Amsterdam the 'official' exchange index has been used, is because bigger nations have several stock exchanges and DataStream did not contain the Total Return Index for (the biggest) national stock exchange of all countries during 1995 to 2005.

The Total Return Index has the currency that is used in the country of that specific stock return (*App. 2*). However, the currency itself is not of interest as the (cor)relation between weather and stock returns will be tested and the stock returns of different countries will not be compared.

3.2 Environmental factors

The weather data are collected from the *National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR)* (GlobalWeather, 2017). This CFSR contains information about weather factors from 1979 to 2014. More specific, these data consist of information about temperature (ºC), precipitation (mm), wind (m/s), relative humidity (fraction) and solar (MJ/m^2). As the hypotheses are focussed on sunshine and rain, the information about precipitation and solar will be the most relevant.

The weather dataset does not contain information about May 1996 and January 1999 for Tokyo and January 1999 is missing for Singapore and Kuala Lumpur as well. This means that the stock market returns of these months of these cities will not be used.

Solar radiation is the amount of energy of the sun that reaches the earth. That is why sun radiation is measured as the amount of Mega Joule per square meter (MJ/m^2). One hour of sun in the Netherlands contains about 3,6 MJ/m^2 of solar radiation. I assume that on a sunny day, the sun will shine 4 to 5 full hours. This means that in total 14,4 to 18 MJ/m^2 of solar radiation reaches the earth (Velds, Van der Hoeven, Koopstra, Raaff, & Slob, 1992). That is why I will qualify a day as a sunny day if the amount of solar radiation of that day is 15 MJ/m^2 or higher. However, the highest amount of solar radiation that has been measured during the sample period is 30,14 MJ/m^2, which means that the sun can be stronger on some sunny days than on others (*App. 4.1*). There are some limitations to this generalisation. For instance, the sun is most likely stronger in Johannesburg than in Amsterdam. Also, days are longer in the summer than in the winter, which means that the amount of sunshine could be spread over more hours or the sun could only shine for half a day, while that day would still be qualified as a sunny day. Due to the scope of this paper, the differences between the lengths of the day and the difference in the strength of the sun are not taken into account.

When using this qualification, there are a couple of things that stand out the most. First, the average amount of sunny days in countries on the northern hemisphere varies between 108 and 163 days per year. In countries near the equator, the average amount of sunny days varies between 318 and 323 days per year. In countries on the southern hemisphere, the amount of sunny days varies between 199 and 331 days per year. Second, Johannesburg has the highest percentage of sunny days per year (90,67%), whereas Amsterdam has the lowest percentage (29,62%). The average amount of solar radiation in Johannesburg is 22,36 MJ/m^2 and 10,38 MJ/m^2 in Amsterdam, which could explain the substantial difference in the percentage of sunny days (*App. 4.1 & 4.6*). While the difference between the highest and lowest value is quite high, the difference between the sunniest city (New York; 44,40%) on the northern hemisphere and the least sunny city on the southern hemisphere (Sydney; 54,50%) is not that big (*App. 3*).

A dummy variable will be used to test whether sunshine affects the stock returns. If a day is qualified as a sunny day, the dummy variable will be SUN=1. If it is not a sunny day, the dummy variable will be SUN=0.

Precipitation is the amount of rain that falls per day in millimetres. According to the *Koninklijk Nederland Meteorologisch Instituut* (Royal Dutch Meteorological Institute; KNMI) a day is qualified as a ‘wet day’ if there falls at least 10 millimetres of rain. The Netherlands only have 22 ‘wet days’ per year (KNMI, 2017). This amount of rain means that it is pouring rain most of the day or that there are some short but severe storms. However, a day full of drizzle feels like a rainy day, while the actual amount of rain will not be that big. That is why I will qualify a rainy day as a day where the amount of precipitation is 3 mm or higher. This generalisation has the same limitations as the generalisation of the amount of sunlight. In a country near the equator, where it rains most of the days, 3 mm would be a very little amount of rain. However, this paper does not investigate the difference between the level of rainfall. Therefore, this assumption is made.

The percentage of rainy days is the highest in the countries that are the nearest to the equator (Singapore; 60,22%). This seems reasonable, as it rains quite often near the equator. The maximum amount of precipitation that has fallen in one day in Singapore is 261,52 mm (*App. 4.7*). The lowest percentage of rainy days is that of Johannesburg (6,17%). This seems fair, as the average amount of rainfall is 0,72 mm per day (*App. 4.6*). Thus, Johannesburg has both the highest amount of sunny days as the lowest amount of rainy days. The amount of rainy days on the northern hemisphere becomes bigger if a country lies closer to the equator. There are 77 rainy days per year in Stockholm, while Tokyo has 115 rainy days per year (*App. 4*).

A dummy variable will be used to test whether rain affects the stock returns. If a day is qualified as a rainy day, the dummy variable will be RAIN=1. If it is not a rainy day, the dummy variable will be RAIN=0.

4. Methodology

In order to test the hypotheses, the correlation between weather conditions and stock returns will be estimated and a regression analysis will be conducted. A 5% significance level will be used for all tests, except the unit root tests. A 1% significance level will be used for the unit root tests, because the result of these tests will have a critical influence on the regression analysis (*see para. 4.2*).

4.1 Correlation

The correlation between two variables measures the degree of linear association between them. This means that these two variables are related in a symmetrical way. For example, if the variables y and x are correlated, changes in x could cause changes in y, but it could also mean that changes in y cause changes in x (Brooks, 2014).

When estimating the correlation between the weather and stock returns, some different conclusions can be drawn. Weather conditions are independent variables and therefore, are not affected by the stock returns. Thus, if the weather and stock returns are correlated, it is most likely that changes in weather conditions will cause changes in stock returns. However, this cannot be said with certainty, as there could be other variables that affect both the weather and the stock returns, and therefore the correlation between these variables.

Also, the correlation between the stock returns of the different cities will be estimated. Due to the globalisation, major events in one country often do not only effect the stock market of that specific country, but also the stock markets of other nations.

4.2 Unit Root Test

Before conducting a regression analysis, it is important to test whether the variables are stationary. A time series variable is considered stationary, if the mean and auto-covariance do not change over time. If the data are non-stationary, the effects of for example a stock market event will be infinite, which means that the effect will not become smaller over time (Brooks, 2014). Therefore, the weather and stock return time series have to be stationary if they are used in a regression analysis.

To test for the stationarity of the weather series and the stock returns series, a unit root test is used. This test is called the Augmented Dickey-Fuller (ADF) test. If a series is stationary, the null hypothesis that the series has a unit root has to be rejected.

For all tests, the null hypothesis that there exists a unit root is rejected at a 1% significance level (*App. 5*). This means that all variables are stationary and therefore can be used for a regression analysis.

4.3 Regression model

Since the data are stationary, they can be used to make an OLS regression model. In regression, the dependent variable is supposed to be 'stochastic' (random), whereas the independent variables are 'non-stochastic' (fixed). In the relationship between weather variables and stock returns, stock returns are the dependent variables and weather conditions the independent variables.

The regression model is expressed as below:

$$STOCK\ RETURNS_t = \alpha_0 + \alpha_1 STOCK\ RETURNS_{t-1} + \alpha_2 RAIN_t + \alpha_3 SUN_t + \varepsilon_t$$

As discussed in the data section, SUN and RAIN are set as dummy variables. Also, the lagged value of the stock returns is used, because reactions on the stock market may take longer than one day to work through. A lagged value of the weather variables is not used, as the weather during one day will only affect mood of that day (Lambert, Reid, Kaye, Jennings, & Esler, 2002).

5. Results

First, the results of the correlation tests will be discussed. The second paragraph will be used to review the results of the regression analysis. All tests are carried out per city, except for the correlation between cities.

5.1 The correlation between stock returns of all cities

Before estimating the correlation between the stock returns and weather conditions of a specific city, the correlation between the stock returns of all cities is assessed (*App. 7).* This correlation does not give (a part of) the answer to the research question, but can be used to define a limitation to this analysis (*see the conclusion*).
There are a couple of things that stand out.

First, most stock returns are significantly correlated. Only the stock returns of Sao Paulo and Tokyo, Sydney and Tokyo, and Kuala Lumpur and Stockholm are not significantly correlated. Thus, there cannot be concluded that there is a linear association between these stock returns.

Furthermore, it is interesting to see that most stock returns are positively correlated, except for the stock returns of Johannesburg and Tokyo, Sydney and Tokyo, Kuala Lumpur and Amsterdam, and New York and Kuala Lumpur. This means these stock returns show opposite reactions. For example, when the stock returns of Johannesburg increase, the stock returns of Tokyo will decrease. However, it must be noted that these negative correlations are quite low (except for the correlation between Amsterdam and Kuala Lumpur) and therefore, the effect will be miniscule.

5.2 The correlation between stock returns and weather conditions per city

Subsequently, the correlations between stock returns and weather conditions are estimated per city (*App. 8*). Also, the correlation between rain and sun are tested. For all cities, the correlation between rain and sun are significant and negative. This seems quite logical, because if it rains, it is less likely that the sun shines, and vice versa.

However, the correlation between stock returns and rain and/or sun does not follow such a regular pattern across the different cities (*App. 8 & 9)*. Most correlations are not significant and therefore will not be reviewed.

The correlation between stock returns and rain is positive for Amsterdam and Stockholm, but negative for Tokyo, Johannesburg and Sao Paulo (*App. 9*). This means that this correlation is negative for countries below the equator (Johannesburg and Sao Paulo), but also for Tokyo, which lies on the northern hemisphere. Thus, the stock returns of these cities will be lower if it rains. Meanwhile, stock returns and rainy days are positively correlated for Amsterdam and Stockholm. These cities lie on the northern hemisphere and not far apart from each other. This implies that the stock returns will be higher on rainy days.

Sun and stock returns are positively correlated for Tokyo, Johannesburg and Sydney, but negatively correlated for Kuala Lumpur. On sunny days the stock returns of Tokyo, Johannesburg and Sydney will be higher, while the stock returns of Kuala Lumpur will be lower (*App. 9*).

Some conclusions can be drawn from these results.

First of all, the stock returns of Tokyo and Johannesburg are both negatively correlated with rain, but positively correlated with sun. Johannesburg is the city with the largest number sunny days and the lowest number of rainy days, while Tokyo is somewhere in the middle when it comes to the amount of rainy and sunny days. These results are in line with the information found in the literature review, as these studies suggested that sunshine is positively correlated with stock returns. As Johannesburg is the sunniest city, it would be most plausible that a positive correlation is found.

Also, the negative correlation between the stock returns of Sao Paulo and rain, and the positive correlation between the stock returns of Sydney and sun are in line with what was expected.

However, some results deviate from the conclusions drawn in the theoretical framework. Rain and stock returns are positively correlated for Amsterdam and Stockholm, even though the expectation was that they would be negatively correlated. Likewise, the results of Kuala Lumpur differ from the expectation, as stock returns and sun are negatively correlated.

5.3 Regression analysis

Regression analyses have been conducted for all cities to see whether rain and sun affect the stock returns. Also, the lagged value of the stock returns is used as an independent variable. The results show that the effect of the lagged value is significant for all cities and the coefficient is roughly 1,00 (*App. 10*). This means that the lagged value directly affects the stock returns and the stock returns would remain approximately the same, ceteris paribus.

The coefficients of the weather conditions are more relevant. However, nearly all coefficients are not significant. Therefore, it is not possible to use these results for accepting or rejecting the hypothesis, but it is possible to analyse the signs of these coefficients. The coefficient of sun is only positive for Stockholm, Singapore, Sao Paulo and Sydney (*App. 11*). It was expected that sunshine would have a positive effect on stock returns, but it seems that this does not apply for all cities. Rain has a negative coefficient for most cities, except for Sao Paulo and Sydney. It was expected that this coefficient would be negative. The distance between the equator and Sao Paulo is approximately the same as the distance between the equator and Sydney, but another relationship between these cities cannot be found (*App. 1*).

Only two coefficients are significant and can be used. The coefficient of sun for Toronto is -1,60 (*App 10*). This means that the stock returns decrease by 1,60 Canadian dollars on sunny days compared to their value on non-sunny days. Furthermore, the coefficient of rain for Kuala Lumpur is -0,76, which implies that the stock returns are 0,76 Malaysian Ringgit less on rainy days than they are on non-rainy days (*App 10*).

6. Conclusion

This paper has discussed the effects of rain and sun on stock returns. Psychological evidence shows that the weather influences our mood, especially because sunshine affects the level of serotonin in the human body. Being in a good mood tends to make people more optimistic. This could influence the decision-making process and therefore the behaviour of investors on the stock market. The weather could influence the decision-making process as well by mood misattribution. Previous research confirms the relationship between weather condition and stock returns.

The relationship between the weather conditions and the stock returns of ten cities have been examined by estimating the correlation and conducting a regression analysis. The results of these tests can be used to accept or reject the hypotheses.

The first hypothesis is '*on sunny days, the stock returns will be higher'.* Testing for the correlation between sun and stock returns showed that the stock returns of Tokyo, Johannesburg and Sydney were positively correlated with sunshine, but the stock returns of Kuala Lumpur and sun were negatively correlated. Also, the regression coefficient of sun was negative for the stock returns of Toronto. This means that there is not enough evidence to support this hypothesis.

Next, the hypothesis that '*on rainy days, the stock returns will be lower'* has been tested. The stock returns of Amsterdam and Stockholm are positively correlated with sun, while the stock returns of Toronto, Tokyo and Sao Paulo have a negative correlation with rain. Furthermore, rain has a negative effect on the stock returns of Kuala Lumpur. Even though stock returns will be lower in most cities, this evidence is not sufficient to support this hypothesis

The third hypothesis focusses on the difference between cities farther away from the equator and cities near the equator: '*H_3: 'in countries farther away from the equator, sunshine will have a positive reaction on the stock market'*. This statement is true for the stock returns of Tokyo, Johannesburg and Sydney. However, sunshine has negative effect on the stock returns of Toronto. Thus, not enough evidence is found to support this hypothesis.

Finally, the hypothesis that *'the effect of rain on the stock market in countries near the equator will not differ from the effect in countries farther away from the* *equator'* is examined. Rain has a negative effect on the stock returns of Kuala Lumpur, which lies near the equator. This cannot be said for all cities farther away from the equator. Rain is negatively correlated with the stock returns of Tokyo, Johannesburg and Sao Paulo, but positively correlated with the stock returns of Amsterdam and Stockholm. Because of the results of Amsterdam and Stockholm, the evidence cannot support this hypothesis.

Subsequently, the research question has to be answered:

Do weather conditions have a different effect on the stock returns of nations close to the equator than on the stock returns of nations farther away from the equator?

The effects of rain on the stock market do differ between countries on the northern hemisphere and countries near the equator. Rain will cause lower stock returns in countries near the equator, but both negative and positive returns in cities that do not lie close to the equator. The same conclusion can be drawn for the effects of sunshine, as these results are negative for countries near the equator, but both negative and positive in countries that lie farther away from the equator.

This research has some limitations. First of all, weather data of one specific place can be estimated quite easily, but it is more difficult to assess the stock returns of one specific place. The weather will not differ that much in cities across countries like the Netherlands, but this cannot be said for nations like the United States or Australia. However, stock returns can be bought across the whole country. As a consequence, the effect of the weather could be less relevant or more relevant. This makes it difficult to examine the true effects of the weather, as investors are exposed to different weather conditions.

Secondly, most stock returns are significantly correlated with the stock returns of other countries, which means that they affect each other. This could mean that the weather conditions in one country have an indirect effect on the stock returns of other countries. Due to the scope of this thesis, these effects are not considered. Also, there are many other factors that affect the stock market, such as macro-economic variables, politics and company information. These variables could be more important than the weather. Therefore, further research could take (macro-)economic and other weather variables in account.

Finally, sunshine is based on the amount of solar radiation. However, a high amount of solar radiation does not necessarily mean that people will be see the sun shine on that day. It could be that clouds cover the sun. It would be recommended to use cloudiness as a variable in follow-up studies. Moreover, the differences between the lengths of the day nor the strength of the sun or the amount of rain are taken into account, while this could affect the expectations and therefore the behaviour of the individuals. It would be best to take these differences into account when investigating this topic further.

In conclusion, the effects of weather conditions do differ between countries, but these differences could not specifically be found when comparing countries near the equator and countries farther away from the equator. Thus, the climate differences and weather experiences of investors could be less important after all.

7. Bibliography

Bless, H., Schwarz, N., & Kemmelmeier, M. (1996). Mood and stereotyping: Affective states and the use of general knowledge structures. *European Review of Social Psychology, 7*(1), 63-93.

Bouman, S., & Jacobsen, B. (2002). The Halloween indicator, sell in May and go away: Another puzzle. *American Economic Review, 92*(5), 1618-1635.

Brooks, C. (2014). Introductory Econometrics for Finance. Cambridge: Cambridge University Press.

Cao, M., & Wei, J. (2005). Stock market returns: A note on temperature anomaly. *Journal of Banking & Finance, 29*(6), 1559-1573.

Clore, G., Schwarz, N., & Conway, M. (1994). Affective causes and consequences of social information processing. In R. Wyer Jr, & T. Srull, *Handbook of Social Cognition* (2e edition ed., Vol. I, pp. 323-418). New York: Psychology Press.

Cohen, R., Gross, M., Nordahl, T., Semple, W., Oren, D., & Rosenthal, N. (1992). Preliminary data on the metabolic brain pattern of patients with winter seasonal affective disorder. *Archives of General Psychiatry, 49*(7), 545-552.

Cunningham, M. (1979). Weather, mood, and helping behavior: Quasi experiments with the sunshine samaritan. *Journal of Personality and Social Psychology, 37*(11), 1947-1956.

de Freitas, C. (2014). Weather and place-based human behavior: recreational preferences and sensitivity. *International Journal of Biometeorology, 59*(1), 55-63.

de Monitgny, L., Ling, R., & Zacharias, J. (2011). The effects of weather on walking rates in nine cities. *Environment and Behavior, 44*(6), 821-840.

Engelberg, J., & Parsons, C. (2011). The causal impact of media in financial markets. *The journal of finance, 66*(1), 67-97.

Forgas, J., & Bower, G. (1987). Mood effects on person-perception judgments. *Journal of Personality and Social Psychology, 53*(1), 53-60.

Gerlach, J. (2007). Macroeconomic news and stock market calendar and weather anomalies. *The Journal Of Financial Research, 30*(2), 283-300.

GlobalWeather. (2017). *NCEP Climate Forecast System Reanalysis (CFRS)*. Retrieved June 17, 2017, from Global Weather Data for SWAT: https://globalweather.tamu.edu

Hirshleifer, D., & Shumway, T. (2003). Good Day Sunshine: Stock Returns and the Weather. *The Journal Of Finance, 58*(3), 1009-1032.

Howarth, E., & Hoffman, M. (1984). A multidimensional approach to the relationship between mood and weather. *British Journal of Psychology, 75*(1), 15-23.

Huibers, M., de Graaf, L., Peeters, F., & Arntz, A. (2010). Does the weather make us sad? Meteorological determinants of mood and depression in the general population. . *Psychiatry Research, 180*, 143-146.

Isen, A. (2008). Some ways in which positive affect influences decision-making and problem solving. In M. Lewis, J. Haviland-Jones, & L. Feldman Barrett, *Handbook of emotions* (3e edition ed., pp. 548-573). New York: The Guilford Press.

Johnson, E., & Tversky, A. (1983). Affect, generalization, and the perception of risk. *Journal of Personality and Social Psychology, 45*(1), 20-31.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 263-291.

Kamstra, M., Kramer, L., & Levi, M. (2003). Winter Blues: A SAD Stock Market Cycle. *American Economic Review, 93*(1), 324-343.

Keef, S., & Roush, M. (2002). The weather and stock returns in New Zealand. *Quarterly Journal of Business and Economics, 41*(1/2), 61-79.

KNMI. (2017). *Uitleg over regenintensiteit*. Retrieved June 20, 2017, from Koninklijk Nederlands Meteorologisch Instituut: https://www.knmi.nl/kennis-en-datacentrum/uitleg/regenintensiteit

Kramer, L., & Weber, J. (2012). This is your portfolio on winter: seasonal affective disorder and risk aversion in financial decision making. *Social Psychological and Personality Science, 3*(2), 193-199.

Lambert, G., Reid, C., Kaye, D., Jennings, G., & Esler, M. (2002). Effect of sunlight and season on serotonin turnover in the brain. *Lancet, 360*, 1840-1842.

Leppämäki, S., Partonen, T., Vakkuri, O., Lönnqvist, J., Partinen, M., & Laudon, M. (2003). Effect of controlled-release melatonin on sleep quality, mood, and quality of life in subjects with seasonal or weather-associated changes in mood and behaviour. *European Neuropsychopharmacology, 13*(3), 137-145.

Lucey, B., & Dowling, M. (2005). The role of feelings in investor decision-making. *Journal of economic surveys, 19*(2), 211-237.

Rosenthal, N. (1998). Winter Blues: Seasonal Affective Disorder: What it is and how to overcome it. London: Guilford Press.

Saunders, E. (1993). Stock prices and Wall Street weather. *The American Economic Review, 83*(5), 1337-1345.

Slovic, P., Finucane, M., Peters, E., & MacGregor, D. (2007). The affect heuristic. *European Journal of Operational Research, 177*(3), 1333-1352.

Symeonidis, L., Daskalakis, G., & Markellos, R. (2010). Does the weather affect stock market volatility? . *Finance Research Letters, 7*(4), 214-223.

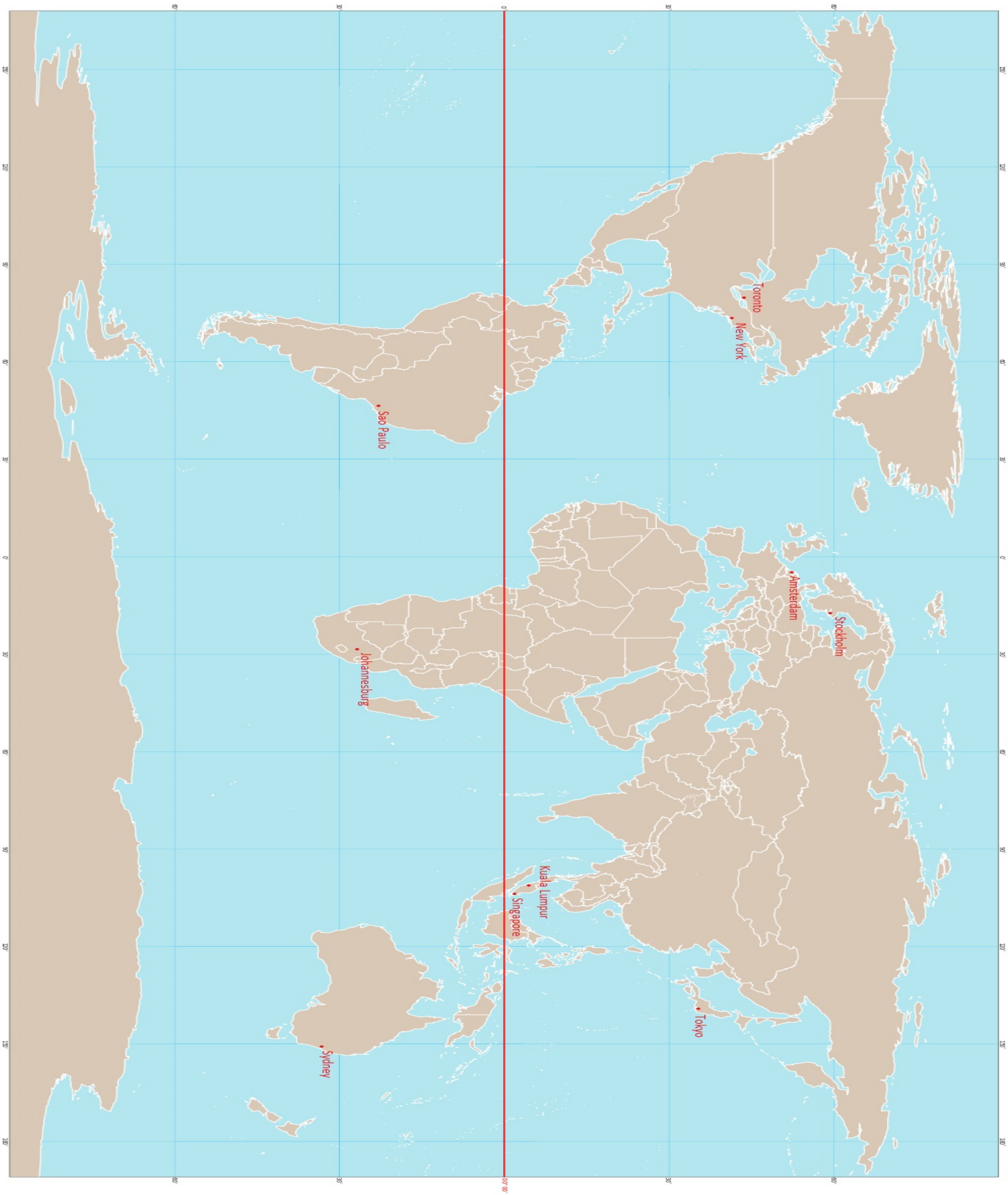
Van der Sar, N. (2015). *Stock pricing and corporate events.* Erasmus School of Economics, Department of Finance. Rotterdam: Erasmus School of Economics.

Velds, C., Van der Hoeven, P., Koopstra, J., Raaff, W., & Slob, W. (1992). Zonnestraling in Nederland - KNMI. Baarn: Thieme.

Wright, W., & Bower, G. (1992). Mood effects on subjective probability assessment. *Organizational Behavior and Human Decision Processes, 52*(2), 276-291.

8. Appendix

App. 1: World map with cities and equator



App. 2: Currencies of the countries

Countries	Currencies
The Netherlands (Amsterdam)	Euro (E)
Sweden (Stockholm)	Swedish Krona (SK)
United States of America (New York)	American Dollar (U$)
Canada (Toronto)	Canadian Dollar (C$)
Japan (Tokyo)	Japanese Yen (Y)
South Africa (Johannesburg)	South African Rand (R)
Singapore (Singapore)	Singaporean Dollar (S$)
Brazil (São Paulo)	Brazilian Real (C)
Australia (Sydney)	Australian Dollar (A$)
Malaysia (Kuala Lumpur)	Malaysian Ringgit (M$)

App. 3: Sunny Days

City	Total amount of sunny days from 1995-2005	Percentage sunny days	Average amount of sunny days per year
Total days in dataset = 4018			
Amsterdam	1190	29,62%	108
Stockholm	1234	30,71%	112
New York	1784	44,40%	162
Toronto	1770	44,05%	161
Tokyo	1763	44,55%	163
Johannesburg	3643	90,67%	331
Singapore	3523	88,36%	323
São Paulo	2540	63,22%	231
Sydney	2190	54,50%	199
Kuala Lumpur	3474	87,13%	318

App. 4: Rainy days

City	Total amount of rainy days from 1995-2005	Percentage rainy days	Average amount of rainy days per year
Total days in dataset = 4018			
Amsterdam	1156	28,77%	105
Stockholm	845	21,03%	77
New York	1000	24,89%	91
Toronto	966	24,04%	88
Tokyo	1245	31,46%	115
Johannesburg	248	6,17%	23
Singapore	2401	60,22%	220
São Paulo	1592	39,62%	145
Sydney	701	17,45%	64
Kuala Lumpur	2100	52,67%	192

App. 5: Summary Statistics

5.1 Amsterdam

	Stock returns	Rain	Sun
Observations	2870	2870	2870
Mean	4457,920	2,712593	10,38556
Median	4350,345	0,999070	7,727793
Maximum	7370,960	42,18406	30,13931
Minimum	1708,320	0,000000	0,143663
Std. Dev.	1479,395	4,208626	8,513563
Skewness	-0,061825	2,769602	0,658936
Kurtosis	2,190685	13,72283	2,177778
Jarque-Bera	80,15428	17418,74	288,5351

5.2 Stockholm

	Stock returns	Rain	Sun
Observations	2870	2870	2870
Mean	2644,744	2,025687	9,980240
Median	2619,885	0,727844	6,885818
Maximum	5657,400	40,29404	30,31188
Minimum	933,1500	0,000000	0,069638
Std. Dev.	1031,117	3,351074	8,969383
Skewness	0,380680	3,343298	0,640797
Kurtosis	2,757636	20,26931	2,086857
Jarque-Bera	70,34324	41009,88	296,1256

5.3 New York

	Stock returns	Rain	Sun
Observations	2870	2870	2870
Mean	2358,219	3,549691	14,38888
Median	2490,015	0,247192	13,16813
Maximum	3538,430	182,2460	31,25548
Minimum	913,1400	0,000000	0,270281
Std. Dev.	669,0841	8,537641	8,582846
Skewness	-0,501208	6,618651	0,197603
Kurtosis	2,219390	89,47908	1,862622
Jarque-Bera	193,0302	915273,9	173,3741

5.4 Toronto

	Stock returns	Rain	Sun
Observations	2870	2870	2870
Mean	1969,940	2,811651	14,10891
Median	1937,715	0,508547	12,79080
Maximum	3572,240	74,13536	31,10135
Minimum	781,9400	0,000000	0,495843
Std. Dev.	665,7458	5,568817	8,647611
Skewness	0,126171	3,999942	0,272128
Kurtosis	2,413736	27,82424	1,744703
Jarque-Bera	48,71615	81345,47	223,8582

5.5 Tokyo

	Stock returns	Rain	Sun
Observations	2828	2828	2828
Mean	540,7669	4,523768	14,83461
Median	530,8150	0,673771	13,62189
Maximum	788,0100	127,7401	31,55457
Minimum	342,9200	0,000000	0,483919
Std. Dev.	92,60378	10,15651	8,158730
Skewness	0,331309	5,406356	0,118403
Kurtosis	2,874079	46,28190	1,948191
Jarque-Bera	53,60471	234516,3	136,9670

5.6 Johannesburg

	Stock returns	Rain	Sun
Observations	2870	2870	2870
Mean	18196.02	0.728904	22.36603
Median	16476.04	0.000000	21.84545
Maximum	47930.35	79.55474	36.31884
Minimum	7220.320	0.000000	0.974081
Std. Dev.	8409.330	3.713949	6.584751
Skewness	1.178412	11.91494	-0.122594
Kurtosis	4.130284	197.2949	2.713266
Jarque-Bera	817,0125	4582240	17,02077

5.7 Singapore

	Stock returns	Rain	Sun
Observations	2849	2849	2849
Mean	546,6938	6,592473	22,09276
Median	538,3000	4,154203	24,31068
Maximum	801,2800	261,5192	28,41305
Minimum	279,8300	0,000000	0,450787
Std. Dev.	104,9380	12,51246	5,640275
Skewness	0,194298	10,09760	-1,768650
Kurtosis	2,814562	152,4504	5,813888
Jarque-Bera	22,00791	2699816	2425,266

5.8 Sao Paulo

	Stock returns	Rain	Sun
Observations	2870	2870	2870
Mean	334.7632	5.337083	16.98781
Median	312.0000	1.434231	17.38674
Maximum	962.4400	79.32992	32.98481
Minimum	86.24000	0.000000	0.669094
Std. Dev.	199.9354	8.795298	8.397060
Skewness	1.225753	2.968590	-0.174580
Kurtosis	3.772330	15.61686	2.093865
Jarque-Bera	790,0119	23251,21	112,7663

5.9 Sydney

	Stock returns	Rain	Sun
Observations	2870	2870	2870
Mean	3212.918	2.251319	17.24579
Median	3363.035	0.112438	16.17579
Maximum	5968.690	125.4519	33.74771
Minimum	1455.360	0.000000	0.735187
Std. Dev.	1028.692	6.591365	8.445836
Skewness	0.384269	7.503769	0.156108
Kurtosis	2.775680	91.55623	2.022822
Jarque-Bera	76,64929	964730,3	125,8442

5.10 Kuala Lumpur

	Stock returns	Rain	Sun
Observations	2849	2849	2849
Mean	776.1843	6.672762	21.27637
Median	769.4200	3.292466	23.27456
Maximum	1091.250	150.3720	28.10370
Minimum	251.6700	0.000000	0.819225
Std. Dev.	167.5213	11.57976	5.649202
Skewness	-0.375877	5.583958	-1.666997
Kurtosis	2.628179	47.26358	5.353130
Jarque-Bera	83,49769	247386,6	1976,819

App. 6: Unit Root tests

H_0: variable has a unit root.

Test critical value: -3,432439 (1% significance level)

6.1 Amsterdam

ADF test statistic	t-Statistic
Stock returns	-53,19607
Rain	-23,09906
Sun	-23,11270

6.2 Stockholm

ADF test statistic	t-Statistic
Stock returns	-53,15482
Rain	-25,42458
Sun	-30,09098

6.3 New York

ADF test statistic	t-Statistic
Stock returns	-52,68985
Rain	-24,96119
Sun	-28,48000

6.4 Toronto

ADF test statistic	t-Statistic
Stock returns	-50,13037
Rain	-22,93504
Sun	-30,57544

6.5 Tokyo

ADF test statistic	t-Statistic
Stock returns	-49,19278
Rain	-20,24090
Sun	-27,80684

6.6 Johannesburg

ADF test statistic	t-Statistic
Stock returns	-47,47858
Rain	-22,89630
Sun	-22,09061

6.7 Singapore

ADF test statistic	t-Statistic
Stock returns	-49,43230
Rain	-18,62295
Sun	-23,30656

6.8 Sao Paulo

ADF test statistic	t-Statistic
Stock returns	-47,26771
Rain	-28,79996
Sun	-26,75909

6.9 Sydney

ADF test statistic	t-Statistic
Stock returns	-53,14518
Rain	-25,62750
Sun	-24,90506

6.10 Kuala Lumpur

ADF test statistic	t-Statistic
Stock returns	-33,62461
Rain	-21,85929
Sun	-22,22475

App. 7: Correlation between cities

Correlation *Probability*	Amsterdam	Stockholm	New York	Toronto	Tokyo	Johannesburg	Singapore	Sao Paulo	Sydney	Kuala Lumpu
Amsterdam	1,000000 ----									
Stockholm	0,883689 *0,0000*	1,000000 ----								
New York	0,881300 *0,0000*	0,939318 *0,0000*	1,000000 ----							
Toronto	0,641307 *0,0000*	0,847020 *0,0000*	0,877380 *0,0000*	1,000000 ----						
Tokyo	0,337241 *0,0000*	0,430804 *0,0000*	0,261842 *0,0000*	0,113604 *0,0000*	1,000000 ----					
Johannesburg	0,270898 *0,0000*	0,539743 *0,0000*	0,594858 *0,0000*	0,879483 *0,0000*	-0,060265 *0,0012*	1,000000 ----				
Singapore	0,184846 *0,0000*	0,492016 *0,0000*	0,435446 *0,0000*	0,564944 *0,0000*	0,595007 *0,0000*	0,585232 *0,0000*	1,000000 ----			
Sao Paulo	0,254028 *0,0000*	0,566380 *0,0000*	0,602723 *0,0000*	0,886389 *0,0000*	0,019328 *0,3006*	0,973691 *0,0000*	0,655259 *0,0000*	1,000000 ----		
Sydney	0,505450 *0,0000*	0,709580 *0,0000*	0,789781 *0,0000*	0,959201 *0,0000*	-0,025768 *0,1676*	0,946780 *0,0000*	0,552628 *0,0000*	0,931714 *0,0000*	1,000000 ----	
Kuala Lumpur	-0,314144 *0,0000*	0,026583 *0,1545*	-0,071673 *0,0001*	0,190492 *0,0000*	0,380134 *0,0000*	0,374853 *0,0000*	0,750923 *0,0000*	0,444674 *0,0000*	0,211678 *0,0000*	1,0000 ----

App. 8: Correlation per city

8.1 Amsterdam

Correlation ***Probability***	**Stock returns**	**Rain**	**Sun**
Stock returns	1,000000 ----		
Rain	0,081526 *0,0000*	1,000000 ----	
Sun	-0,005164 *0,7821*	-0,286788 *0,0000*	1,000000 ----

8.2 Stockholm

Correlation *Probability*	Stock returns	Rain	Sun
Stock returns	1,000000 ----		
Rain	0,050532 *0,0068*	1,000000 ----	
Sun	-0,003251 *0,8618*	-0,194303 *0,0000*	1,000000 ----

8.3 New York

Correlation *Probability*	Stock returns	Rain	Sun
Stock returns	1,000000 ----		
Rain	-0,014368 *0,4416*	1,000000 ----	
Sun	0,010183 *0,5855*	-0,340822 *0,0000*	1,000000 ----

8.4 Toronto

Correlation *Probability*	Stock returns	Rain	Sun
Stock returns	1,000000 ----		
Rain	0,006944 *0,7100*	1,000000 ----	
Sun	-0,005620 *0,7634*	-0,264287 *0,0000*	1,000000 ----

8.5 Tokyo

Correlation ***Probability***	**Stock returns**	**Rain**	**Sun**
Stock returns	1,000000 ----		
Rain	-0,041726 *0,0265*	1,000000 ----	
Sun	0,075379 *0,0001*	-0,345620 *0,0000*	1,000000 ----

8.6 Johannesburg

Correlation ***Probability***	**Stock returns**	**Rain**	**Sun**
Stock returns	1,000000 ----		
Rain	-0,053785 *0,0039*	1,000000 ----	
Sun	0,057708 *0,0020*	-0,258741 *0,0000*	1,000000 ----

8.7 Singapore

Correlation ***Probability***	**Stock returns**	**Rain**	**Sun**
Stock returns	1,000000 ----		
Rain	-0,012338 *0,5104*	1,000000 ----	
Sun	0,000771 *0,9672*	-0,346263 *0,0000*	1,000000 ----

8.8 Sao Paulo

Correlation *Probability*	Stock returns	Rain	Sun
Stock returns	1,000000 ----		
Rain	-0,065259 *0,0005*	1,000000 ----	
Sun	-0,000642 *0,9726*	-0,166621 *0,0000*	1,000000 ----

8.9 Sydney

Correlation *Probability*	Stock returns	Rain	Sun
Stock returns	1,000000 ----		
Rain	-0,027301 *0,1437*	1,000000 ----	
Sun	0,069919 *0,0002*	-0,316111 *0,0000*	1,000000 ----

8.10 Kuala Lumpur

Correlation *Probability*	Stock returns	Rain	Sun
Stock returns	1,000000 ----		
Rain	-0,008086 *0,6662*	1,000000 ----	
Sun	-0,039024 *0,0373*	-0,403371 *0,0000*	1,000000 ----

App. 9: Summary of the correlation matrices

Stock returns	Rain	Sun
Amsterdam	Significantly positive	Non-significantly negative
Stockholm	Significantly positive	Non-significantly negative
New York	Non-significantly negative	Non-significantly positive
Toronto	Non-significantly positive	Non-significantly negative
Tokyo	Significantly negative	Significantly positive
Johannesburg	Significantly negative	Significantly positive
Singapore	Non-significantly negative	Non-significantly positive
Sao Paulo	Significantly negative	Non-significantly negative
Sydney	Non-significantly negative	Significantly positive
Kuala Lumpur	Non-significantly negative	Significantly negative

App. 10: Regression analysis per city with Stock returns as the dependent variable and lagged stock returns (-1), rain and sun as independent variable

10.1 Amsterdam

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	7,817576	3,830864	2,040683	*0,0414*
Lagged stock returns (-1)	0,998697	0,000796	1255,059	*0,0000*
Rain	-2,450802	2,683733	-0,913206	*0,3612*
Sun	-0,040763	2,626204	-0,015522	*0,9876*

10.2 Stockholm

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	3,986833	2,363101	1,687119	*0,0917*
Lagged stock returns (-1)	0,999198	0,000798	1251,672	*0,0000*
Rain	-3,190004	2,043371	-1,561147	*0,1186*
Sun	0,004652	1,799280	0,002586	*0,9979*

10.3 New York

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	4,272693	1,961727	2,178027	*0,0295*
Lagged stock returns (-1)	0,998674	0,000755	1322,721	*0,0000*
Rain	-0,350410	1,206958	-0,290324	*0,7716*
Sun	-0,543747	1,053334	-0,516215	*0,6057*

10.4 Toronto

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	1,632685	1,202849	1,357349	*0,1748*
Lagged stock returns (-1)	1,000062	0,000540	1850,890	*0,0000*
Rain	-0,340990	0,850164	-0,401088	*0,6884*
Sun	-1,602563	0,736722	-2,175263	*0,0297*

10.5 Tokyo

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	0,950508	0,733324	1,296164	*0,1950*
Lagged stock returns (-1)	0,998518	0,001313	760,2680	*0,0000*
Rain	-0,240690	0,269524	-0,893018	*0,3719*
Sun	-0,028395	0,251105	-0,113081	*0,9100*

10.6 Johannesburg

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	-13,78409	15,47597	-0,890677	*0,3732*
Lagged stock returns (-1)	1,001586	0,000438	2284,435	*0,0000*
Rain	-9,525701	16,65395	-0,571978	*0,5674*
Sun	-0,980294	13,73717	-0,071361	*0,9431*

10.7 Singapore

	Coefficient	Std. Error	t-Statistic	*Probability*
C	0,373376	0,695485	0,536857	*0,5914*
Lagged stock returns (-1)	0,999335	0,001078	926,8451	*0,0000*
Rain	-0,332943	0,231345	-1,439160	*0,1502*
Sun	0,325225	0,354669	0,916981	*0,3592*

10.8 Sao Paulo

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	-0,313258	0,230216	-1,360715	*0,1737*
Lagged stock returns (-1)	1,001262	0,000440	2275,478	*0,0000*
Rain	0,168446	0,183349	0,918716	*0,3583*
Sun	0,172026	0,186455	0,922615	*0,3563*

10.9 Sydney

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	-0,437874	1,551311	-0,282261	*0,7778*
Lagged stock returns (-1)	1,000490	0,000431	2319,065	*0,0000*
Rain	0,773975	1,225103	0,631763	*0,5276*
Sun	0,525178	0,920621	0,570461	*0,5684*

10.10 Kuala Lumpur

Variable	Coefficient	Std. Error	t-Statistic	*Probability*
C	1,695603	1,017945	1,665712	*0,0959*
Lagged stock returns (-1)	0,998689	0,001067	936,1418	*0,0000*
Rain	-0,761514	0,360212	-2,114074	*0,0346*
Sun	-0,217586	0,545501	-0,398874	*0,6900*

App. 11: summary of the signs of the regression coefficients

City	Sun	Rain
Amsterdam	-	-
Stockholm	+	-
New York	-	-
Toronto	-	-
Tokyo	-	-
Johannesburg	-	-
Singapore	+	-
Sao Paulo	+	+
Sydney	+	+
Kuala Lumpur	-	-