ERASMUS UNIVERSITEIT ROTTERDAM

Weather Effects on the Amsterdam Stock Exchange

Simeon Vasilev

428627

Supervisor: Prof. Mintra Dwarkasing

International Bachelor of Science in Economics and Business Economics

Erasmus School of Economics

Erasmus University Rotterdam

August 2019

Abstract

This paper examines the relationship between the weather in the Netherlands and the returns on three indices of the Amsterdam Euronext stock exchange: AEX, AMX, and AScX. The research uses daily data from March 3rd, 2015 to May 9th, 2019, and incorporates normality tests, correlation analyses, OLS regressions, and a GARCH model. Overall, the largest AEX index did not demonstrate significant weather effects even after controlling for other factors such as macroeconomic environment, market sentiment, and foreign weather. The AMX and AScX indices exhibit relatively weak weather effects. AMX is significantly and negatively correlated to the mean windspeed in the Netherlands, and AScX has a significant positive correlation with the mean sea level pressure in the Netherlands. Nevertheless, new research can be done about weather variable selection and further explanatory variable selection.

Preface

I would like to express my gratitude to Professor Mintra Dwarkasing for the educational guidance throughout the thesis process and for the expertise and understanding.

Furthermore, I would like to thank my parents for their wise advice and empathy.

1. Introduction

Extensive studies in the field of psychology have implied that weather is significantly associated with a person's mood and emotional situation (Howarth and Hoffman, 1984). This proposition has been theoretically extended in the field of behavioral finance, to examine the relationship between weather-induced mood and investor decision-making. It is postulated that sunny and warm weather makes investors more optimistic about market prospects, while the opposite holds when it is cloudy and rainy. Hence, investors are more susceptible to buy stocks when the weather is good and sell them when the weather is bad (Loewenstein et al., 2001).

There is existing research on weather effects on various geographical locations, including different weather variables and stock indices. Nevertheless, current research in behavioral finance has not extensively and specifically examined how potential weather effects are moderated by firm size, indicated by the market capitalization. The prevailing opinion is that the share prices of large firms are more efficient, due to the greater institutional involvement (Badrinath et al., 1995). Thus, a paper can contribute to existing research by extending the scope of this field of interest and specifically inspecting how the potential weather effect is moderated by firm size. Additionally, current literature has not explicitly indicated how weather effects are affected by market sentiment, the tone of the market dictated by investor perceptions and security prices (Bodurtha et al., 1995), and how foreign weather affects the domestic stock market.

Furthermore, there barely exist any studies that examine the relationship between weather variables and stock market returns in the Netherlands, more specifically in the Amsterdam Stock Exchange, one of the first incarnations of what one could today call a stock market. Dutch-listed companies, such as Royal Dutch Shell, ING Group, Unilever, and Heineken are major players on the global market and deserve to be examined. Consequently, a study can contribute to the existing literature by inspecting a different market (Netherlands). Supposing investor irrationality is found in the Dutch stock market, investors can be made aware of this bias, anticipate and hence eliminate the anomaly. Finally, the inspected recent time period of this paper covers the years from 2005 to 2019 and can thus provide a modern overview of the subject.

The purpose of the research is to scrutinize the relationship between several weather indicators and the returns of three indices on the Amsterdam Euronext stock exchange. The three indices are namely: the AEX index (large-cap), the AMX index (mid-cap), and the AScX index (small cap). The paper incorporates proxies for both Dutch and foreign weather (New York, London, Hong Kong) as not all investors on the Amsterdam stock exchange are located in the Netherlands. It further performs the analysis on a daily frequency. Furthermore, the work aims to test whether the higher or lower capitalization fraction of the Dutch stock market is more efficient, after controlling for calendar (seasonality) effects, and domestic and global macroeconomic conditions. The research further inspects the relationship between weather and stock returns in the context of domestic market sentiment. It incorporates a select number of statistical tools, such as normality tests, correlation analysis, OLS regressions, and a GARCH model. Therefore, the following research question is formulated:

What is the relationship between weather and equity returns on the Amsterdam stock exchange?

The structure of this paper is as follows: in the next section, it presents a review of the existing literature, which forms the theoretical framework and builds up to the research hypotheses of this study. Subsequently, the motivation behind the used dataset will be explained, consisting of various weather variables, three Dutch stock market indices, and different control variables. This is followed by the methodology that models the studied relationship. The consequent section presents the results of the statistical models. Based on these results, the conclusions and implications of the study are indicated. Finally, the limitations of this study and recommendations for future research are presented.

2. Literature review

2.1 Market efficiency

In classical finance, an agent that is active in financial markets is known as 'homo economicus' (Mill, 1848). This individual is rational, since it listens to its preferences and makes decisions aimed at maximizing its own satisfaction, which is affected upon receiving new relevant information (Stigler, 1986).

Malkiel and Fama (1970) utilize the market efficiency theory to explain stock price alterations, indicating that prices in the market completely manifest all available information. Information is available to all agents and quickly implemented in the stock price. Thus, rational agents identify the short-term profit opportunity in the case of mispricing, which causes a correction of the market price. Thus, according to the efficient market hypothesis (EMH), an agent cannot profit from historical information and earn excess risk-adjusted average returns, as historical information is fully reflected in the current prices. Essentially, equity prices follow a random walk, meaning that they have no pattern and cannot be forecasted based on past information (Fama, 1998).

Nevertheless, there seem to exist anomalies that cannot be justified by the efficient market hypothesis such as calendar effects. (Barone, 1990).

2.2 Mood and decision making in psychology

One can define mood as the temporary conscious state of mind or feeling, which is distinct from the concept of emotion (Beedie et al., 2005). While both concepts are associated with feelings, mood is less specific to, and not as focused on, the source of the feeling, contrasted with emotion. The impact of emotion is usually limited to the setting from which the feeling was initiated, yet mood impacts on settings other than those which originated the feeling. Thus, mood is also less intense, but more enduring than emotion (Harding and He, 2016).

Multiple studies in the field of psychology examine the relationship between an individual's mood and its decision making. Forgas (1995) introduces the Affect Infusion Model, which suggests that individuals in positive mood are more optimistic in their decision making than those in a negative mood, as they project their current good mood on the future. Those in a positive mood are inclined to recall positive experiences, overweight positive elements of the decision setting and underestimate the likely negative consequences of any decision. Thus, experiencing positive mood in the present leads people to think positively regarding future events, which can generate overconfidence (Nofsigner, 2005). Furthermore, as individuals in a good mood are expected to evaluate the environment more favorably, they behave more proactively. Schwarz (2002) confirms those implications, specifying that negative mood directs attention to the negative elements of the decision setting, and stimulates an increase of attention when processing information, thus suggesting a more detailed analytical thinking. Subsequently, negative mood can relate to conservatism, pessimism, and risk-aversion. Additionally, good mood can produce an increase in risk perception (Johnson and Tversky, 1983).

Conversely, the Mood Maintenance Model implies that a positive mood will result in greater caution and more risk aversion compared to a negative mood, as individuals in a positive mood wish to maintain their positive state and avoid risky behavior that may cause a negative mood state. Those in a negative mood state, on the other hand, wish to move into a more positive state and are prepared to engage in riskier behavior in the hope of receiving some benefit that makes an improvement in mood more likely (Isen and Patrick, 1983; Isen et al., 1988). Nevertheless, most research supports the implications of the Affect Infusion Model (Grable and Roszkowski, 2008)

2.3 Investor mood and equity returns

Conversely to the EMH, equity prices may not only be affected by new information, but also by investor mood (Bollen et al., 2011). Investors have on disposal billions of pieces of information online but cannot process all this information and update their beliefs accordingly (Barber and Odean, 2001). Shu (2010) implies that stock prices are positively correlated with investor mood. Cohen-Charash et al. (2013) finds that investor mood on the previous trading day can forecast the opening price of the NASDAQ on the next day. Thus, a pleasant mood at the previous trading day can lead to higher opening prices on the next one.

As mentioned above, mood is also associated with the amount of risk an individual is willing to take. Hirshleifer (2001) indicates that in a financial context, this can cause market mispricing, as investors can wrongly percept and tolerate risk. It is possible that short-term changes in mood may impact on both investors' risk aversion and their forecasts of future cash flows.

In a financial market's context, investors in a positive mood are expected to search for, recall and process positive aspects of a company's performance such that they make higher predictions of the firm's future cash flows and earnings. Conversely, those in a negative mood make lower predictions of future earnings and cash flows.

2.4 Weather and mood

Multiple research sources inspect the association between weather-induced mood and stock returns, presenting controversial and often contradicting findings. The seminal paper on the relationship is Saunders (1993), which in the context of New York weather and returns on NYSE indices, implied a strong negative relationship between cloud cover and stock returns. Then, Hirshleifer and Shumway (2003) repeated Saunders' research using data on stock indices of 26 countries and confirmed a positive correlation between sunshine and stock returns. Dowling and Lucey (2005) analyzed the Irish stock market and concluded that a "rain' variable is also significantly and negatively associated with equity returns. Using Taiwanese stock market data, Chang et al. (2006) affirm a significant relationship between temperature, cloud cover, and stock returns.

Floros (2011) reaffirms the temperature effect in Portugal, finding a statistically significant relationship between daily stock prices of the PSI20 index and temperature from 1995 to 2007. Cao and Wei (2005) inspects the association between temperature and stock market returns utilizing nine stock market indices located in eight different countries, and finding a temperature anomaly, as stock market returns and daily temperature are negatively correlated. In addition, Howarth and Hoffman (1984) claim that of the whole weather effects, the effects of humidity, hours of sunshine and temperature on mood are the most significant. Thus, based on past literature, this research utilizes mean temperature as its main indicator variable.

Conversely, a critical view on Saunders (1993) is conveyed by Trombley (1997), which reassessed and rebutted its findings, signifying that the relationship between stock returns and Wall Street weather is insignificant. Krämer and Runde (1997), in the context of the German stock index (DAX) examined cloud cover, humidity, atmospheric pressure and rainfall, finding no significant relationships. Analogous results were affirmed in Spain (Pardo and Valor, 2003), New Zealand (Keef and Roush, 2003), and Turkey (Tufan and Hamarat, 2006).

3. Theoretical framework

As discussed above, domestic weather can serve as a mood proxy for investors located in the Netherlands and may thus influence equity returns. Thus, the following first research sub-question is formulated:

Q1: What is the relationship between Dutch domestic weather and stock returns on the Amsterdam stock exchange?

Nevertheless, it is paramount to acknowledge that investors on the Amsterdam stock exchange may not be all located in the Netherlands and that Dutch weather cannot dictate foreign investors' mood. To establish more comprehensive research, it may prove beneficial to examine foreign capital providers.

The IMF Coordinated Portfolio Investment Survey (CPIS) gathers and reports information on the flows and types of portfolio investment securities (e.g. debt instruments, equity) for a specific economy (IMF, 2019). According to it, the majority of the inflow of equity and investment fund shares for the Netherlands derives from the United States, the United Kingdom, and Hong Kong, descending. Furthermore, according to the Global Financial Centres Index (GFCI), as of April 2019, the cities of New York City and London establish the top two financial centers in the world (Long Finance, 2019). Therefore, this paper analyzes the relationship between weather in those three cities and Dutch stock returns, presenting an answer to the second sub-question of this research:

Q2: What is the relationship between foreign weather and stock returns on the Amsterdam stock exchange?

Baker and Wurgler (2006) imply that stocks of low capitalization, relatively young, high volatility, and growth companies are more inefficient based on the EMH and are sensitive to investor mood and market sentiment. Additionally, Fama and French (1996) regards a firm's market capitalization as measures of fundamental riskiness of a stock in the context of the Three-factor-model. Based on this model, stocks of smaller firms must earn higher average returns as they are fundamentally riskier as measured by their higher exposure to size factors. Conversely, large stocks earn lower returns because they are safer.

Furthermore, share prices of large firms are supposed to be more efficient, compared to that of small firms for several reasons. Badrinath et al. (1995) claims that the size of a company may be a proxy for the magnitude of the information available to investors. Another reason for larger companies being more efficient is greater institutional involvement. Thus, one may question how potential weather effects are being moderated by index capitalization, forming the following third research sub-question:

Q3: How is the relationship between Dutch weather and stock returns on the Amsterdam stock exchange moderated by firm capitalization?

While investor mood reflects the temporary mental state of the individual investor, market sentiment is the overall attitude of investors toward a particular security, financial market or the economy as a whole. Thus, market sentiment is the feeling or tone of the market, revealed through the investor activity and price movement of the securities traded in that market (Eichengreen and Mody, 1998). In general, investor sentiment can be viewed as simply optimism or pessimism regarding the equity market.

As financial markets incorporate irrationality (e.g. emotion, optimism, pessimism), market sentiment differs from the fundamental value concept under the EMH. Furthermore, similar to investor mood, one can expect sentiment to have a stronger relationship with small companies, as through not paying dividends, many small stocks' fundamentals remain currently uncertain and therefore subject to speculation (Pontiff, 1996). Additionally, the higher degree of idiosyncratic risk and thus volatility of smaller stocks may lead to second-guessing by the investors and subsequently relying on market sentiment (Shleifer and Vishny, 1997). Thus, it can prove important to differentiate between investor mood and market sentiment, so that the magnitude and degree of the potential weather effect is correctly specified. Thus, the fourth research sub-question is contrived:

Q4: How does the relationship between Dutch weather and stock returns on the Amsterdam stock exchange change when including a measure of market sentiment?

4. Data

The research incorporates various explanatory, control, and response variables at a daily frequency. This section presents those variables divided by the categories of domestic weather, foreign weather, stock market returns, market sentiment, and control variables.

4.1. Domestic weather

The weather data for the Netherlands was collected from the Royal Netherlands Meteorological Institute. Seven domestic weather proxies are incorporated into the analysis. First, daily mean windspeed, representing the average wind speed (in 0.1 m/s), for a 24-hour period. The second variable is daily mean temperature measured in degrees Fahrenheit, while daily mean sea level pressure represents the 24-hour average air pressure reduced to sea level (in 0.1 hPa) calculated from 24-hour values. 3629 daily observations were collected from March 3rd, 2015, to May 9th, 2019.

Table 1.1 (see *Appendix*) provides summary descriptive summary statistics for the Dutch weather data. All three variables demonstrate a relatively symmetrical distribution, as the data show absolute skewness values of below one. Most of the variables have a rather tailed distribution based on the kurtosis values, which range between 2.5 and 4.2 for daily data. Table 1.2. (see *Appendix*) illustrates the correlations between the Dutch weather variables, which can be deemed not too high as the highest coefficient is 0.362. Thus, one can eliminate the threat of multicollinearity when the domestic weather variables are regressed against the Euronext stock market returns.

4.2. Stock market returns

For its dependent variable, the paper first uses data on the closing prices of the three indices (AEX, AMX, AScX) transformed to returns as the natural logarithm of the ratio of the closing price on 't' to that on 't-1'. The data is limited by the AScX index, which commences on March 2nd, 2005, thus the time period is from March 3rd, 2015, until May 9th, 2019. After holidays and other closures are considered, there are 3629 observations available for analysis. As the Amsterdam Stock Exchange is closed during the weekend, the percentage change on Monday is calculated by comparing its value to the closing value on the previous Friday. The historical financial data is retrieved from Datastream.

Table 1.3 (see *Appendix)* provides summary descriptive summary statistics for the relevant Euronext stock return data. Comparable to the Dutch weather variables, all three stock market return variables demonstrate a relatively symmetrical distribution. All three indices have a tailed distribution based on the high kurtosis values, where 8.217 is the minimum value. Furthermore, the stock returns of the AEX, AMX, and AScX are highly correlated on with values ranging from 0.763 to 0.848 (Table 1.4, see *Appendix*).

4.3. Foreign weather

Daily data on the weather in London and New York was obtained from the National Climatic Data Center (NNDC) of the United States. Three common variables for all three locations were inspected: average wind speed (in 0.1 m/s), daily mean temperature measured in degrees Fahrenheit, and mean visibility (.1 km). The time period was from March 3rd, 2015, until May 9th, 2019.

4.4. Market sentiment

Market sentiment was incorporated by factoring the AEX Volatility Price Index, which was converted from absolute values to daily percentage change. The trading volumes of the AEX, AMX, and AScX indices were utilized as a further sentiment proxy. The trading volume variables were further transformed from absolute values to daily percentage changes, to account for trends. The time period was from March 3rd, 2015, until May 9th, 2019.

4.5. Macroeconomic control variables

Macroeconomic control variables were obtained from various sources. The 3-month EURIBOR / EONIA spread was utilized as an interest rate proxy and obtained from European Money Markets Institute. Furthermore, the term spread of the 10-year Dutch bond yield and the 2-year Dutch bond yield was gathered from Datastream. Lastly, the prices of the MSCI World Index were obtained from Datastream, which were further converted to natural logarithmic returns based on the natural logarithm of the ratio of the closing price on day t to that on t-1. v

5. Methodology

5.1.1 OLS

The paper first employs ordinary least squares (OLS) regression with White heteroskedasticity-consistent standard errors due to the found non-normality in the Euronext stock return and Dutch weather data in the previous section. Performed regressions are analyzed via the Ramsey RESET test, which inspects if non-linear combinations of the fitted values describe the response variable. Collinearity between the explanatory variables is inspected by the variance inflation factors (VIF) of the regression, which represent the proportion of the variance in a multiple-term regression model to that of the variance of a single-term regression model (Witten et al., 2013).

First, to answer the first and third research questions, the returns of each of the three Euronext indices are regressed against the Dutch weather variables. The model controls for macroeconomic conditions by incorporating control variables for the 3-month EURIBOR / EONIA spread, the term spread of the 10-year Dutch bond yield and the 2-year Dutch bond yield, and the returns of the MSCI World Index. Thus, the following equations are formed:

$$\begin{aligned} ReturnAEX_t = b_0 + \ & b_1 * MeanWindspeedNL + b_2 * MeanTemperatureNL + b_3 \\ & * MeanSeaLevelPressureNL + b_4 * MSCIWorldReturn + b_5 \\ & * Month3EURIBOREONIASpread + \ b_6 * DutchBondYieldSpread + \ \varepsilon_t \end{aligned}$$

$$\begin{aligned} ReturnAMX_t = b_0 + \ & b_1 * MeanWindspeedNL + b_2 * MeanTemperatureNL + b_3 \\ & * MeanSeaLevelPressureNL + b_4 * MSCIWorldReturn + b_5 \\ & * Month3EURIBOREONIASpread + \ b_6 * DutchBondYieldSpread + \ \varepsilon_t \end{aligned}$$

$$\begin{aligned} ReturnAScX_t = b_{01} + \ & b_1 * MeanWindspeedNL + b_2 * MeanTemperatureNL + b_3 \\ & * MeanSeaLevelPressureNL + b_4 * MSCIWorldReturn + b_5 \\ & * Month3EURIBOREONIASpread + \ b_6 * DutchBondYieldSpread + \ \varepsilon_t \end{aligned}$$

Consequently, the returns of the AEX, AMX, and AScX indices are regressed against the foreign weather (London and New York) variables.

$$ReturnAEX_t = b_{01} + \ b_1 * MeanWindspeedLDN + b_2 * MeanTemperatureLDN + b_3 * MeanVisibilityLDN + b_4 * MeanWindspeedNY + b_5 * MeanTemperatureNY + \ b_6 * MeanVisibilityNY + b_7 * MSCIWorldReturn + b_8 * Month3EURIBOREONIASpread + \ b_9 * DutchBondYieldSpread + \varepsilon_t$$

$$ReturnAMX_t = b_{01} + \ b_1 * MeanWindspeedLDN + b_2 * MeanTemperatureLDN + b_3 * MeanVisibilityLDN + b_4 * MeanWindspeedNY + b_5 * MeanTemperatureNY + \ b_6 * MeanVisibilityNY + b_7 * MSCIWorldReturn + b_8 * Month3EURIBOREONIASpread + \ b_9 * DutchBondYieldSpread + \ \varepsilon_t$$

$$ReturnAScX_t = b_{01} + \ b_1 * MeanWindspeedLDN + b_2 * MeanTemperatureLDN + b_3 * MeanVisibilityLDN + b_4 * MeanWindspeedNY + b_5 * MeanTemperatureNY + \ b_6 * MeanVisibilityNY + b_7 * MSCIWorldReturn + b_8 * Month3EURIBOREONIASpread + \ b_9 * DutchBondYieldSpread + \ \varepsilon_t$$

Consequently, both the domestic and foreign weather variables additional to the control variables are regressed against the index return. Furthermore, the returns of the AEX, AMX, and AScX indices are regressed against the market sentiment proxies, in specific the daily trading volume of each of the three indices and the daily percentage change of the AEX Volatility Price Index.

$$ReturnAEX_t = b_{01} + \ b_1 * VolumeAEXPercChange + b_2 * VolumeAMXPercChange + b_3 * VolumeAScXPercChange + b_6 * AEXVolatilityIndexPercChange + b_7 * MSCIWorldReturn + b_8 * Month3EURIBOREONIASpread + \ b_9 * DutchBondYieldSpread + \ \varepsilon_t$$

$$ReturnAMX_t = b_{01} + b_1 * VolumeAEXPercChange + b_2 * VolumeAMXPercChange + b_3 * VolumeAScXPercChange + b_6 * AEXVolatilityIndexPercChange + b_7 * MSCIWorldReturn + b_8 * Month3EURIBOREONIASpread + b_9 * DutchBondYieldSpread + \varepsilon_t$$

$$ReturnAScX_t = b_{01} + b_1 * VolumeAEXPercChange + b_2 * VolumeAMXPercChange + b_3 * VolumeAScXPercChange + b_6 * AEXVolatilityIndexPercChange + b_7 * MSCIWorldReturn + b_8 * Month3EURIBOREONIASpread + b_9 * DutchBondYieldSpread + \varepsilon_t$$

Consequently, both the domestic weather variables and sentiment proxies additional to the control variables are regressed against the index return. Lastly, all the previously specified explanatory variables are aggregated into the following model:

$$ReturnAEX_t = b_0 + b_1 * MeanWindspeedNL + b_2 * MeanTemperatureNL + b_3 * MeanSeaLevelPressureNL + b_4 * MSCIWorldReturn + b_5 * Month3EURIBOREONIASpread + b_6 * DutchBondYieldSpread + \varepsilon_t + b_7 * MeanWindspeedLDN + b_8 * MeanTemperatureLDN + b_9 * MeanVisibilityLDN + b_{10} * MeanWindspeedNY + b_{11} * MeanTemperatureNY + b_{12} * MeanVisibilityNY + b_{13} * VolumeAEXPercChange + b_{14} * VolumeAMXPercChange + b_{15} * VolumeAScXPercChange + b_{16} * AEXVolatilityIndexPercChange + \varepsilon_t$$

5.1.2 GARCH (1,1)

The previous segment details the performance of an ordinary least squares (OLS) regression with White heteroskedasticity-consistent standard errors, to account for heteroskedasticity where the residuals in a regression model do not possess a constant variance. Nevertheless, an OLS regression can neglect the variance of the error terms themselves. Thus, this paper explores the Generalized autoregressive conditional heteroskedasticity model, which. A GARCH (1,1) is utilized, meaning one autoregressive lag and one lag included in the moving average portion of the variable.

The GARCH (1,1) models the variance of the return on date ‘t’ as a weighted average of a constant, yesterday’s return, and yesterday’s squared error. Thus, the GARCH (1,1) model is derived in the following manner:

$ReturnAMX_t = \mu_t + \varphi * ReturnAMX_{t-1} + + \varepsilon_t$ (1)

$h_t = \varphi + \alpha * h_{t-1} * \varepsilon_{t-1}^2 + \beta * h_{t-1}$ (2)

As stationarity is required for the use of time series in regression analysis, the research firstly performs a Phillips–Perron test for unit roots. The null hypothesis of the test is that the time series contains a unit root, and the alternative hypothesis is that the time series is stationary.

6. Results

This section illustrates and manifests the results of the statistical analyses described in the previous section. It follows the methodology structure described above.

6.1.1 OLS

Table 1.5 (see below) illustrates the regression of the Dutch weather variables on the return of the AEX index including the macroeconomic control variables. Only the coefficient for the return on the MSCI World Index ('MSCIWorldReturn') is significant at the 10% level, with a P-value of 0.000. The rest of the coefficients are all insignificant.

Table 1.5: Regression of Dutch weather variables and macroeconomic control variables on AEX index returns

				Number of observations =	3629	
				F (3, 3625) =	194.81	
				Prob > F	0.0000	
				R-squared	0.5387	
				Root MSE	.86273	
ReturnAEX	**Coefficient**	**Robust Std. Error**	**t**	**P>|t|**	**[95% Conf. Interval]**	
MeanWindspeedNL	-.0017182	.0012489	-1.38	0.169	-.0041669	.0007304
MeanTemperatureNL	-.0017279	.0012938	-1.34	0.182	-.0042645	.0008087
MeanSeaLevelPressureNL	-.0000844	.0018213	-0.05	0.963	-.0036553	.0034865
MSCIWorldReturn	.9676596	.0288155	33.58	0.000	.9111634	1.024156
Month3EURIBOREONIASpread	-.0997455	.0935356	-1.07	0.286	-.2831331	.0836422
DutchBondYieldSpread |	.0063135	0205837	0.31	0.759	-.0340433	.0466704
constant	.2416566	1.884705	0.13	0.898	-3.453531	3.936845

Furthermore, the Ramsey RESET test demonstrates a P-value of 0.095 (lower than the significance level of 10%), thus it rejects the hypothesis of no omitted variables in the previous regression (see Table 1.6, *Appendix*). The mean-variance inflation factor (VIF) is 1.07, thus there is no threat of multicollinearity (see Table 1.7, *Appendix*).

Regarding the AMX index, two of the three weather variables prove significant. Windspeed is significant at the 10% significance level with a P-value of 0.069 complemented by temperature with a P-value of 0.003 (see Table 1.8, *Appendix*). Similarly to the AEX index, sea level pressure is insignificant. Furthermore, the Ramsey RESET test demonstrates a P-value of 0.0008, thus rejecting the null hypothesis of no omitted variables (see Table 1.9, *Appendix*). Concerning the AScX index, temperature proves to be significant along with the control variables for the 3-month EURIBOR-EONIA spread and the MSCI World Return (see Table 2.1, *Appendix*). Nevertheless, the Ramsey

RESET still showed a P-value of 0.000, hence rejecting the null hypothesis of no omitted variables (see Table 2.2, *Appendix*).

The regression of the foreign (London and New York) weather variables on the AEX return demonstrates significance solely for the return of the MSCI World index (P-value of 0.000) and the mean temperature in London with P-value of 0.079, significant under a 10% level (see Table 2.3 below). The Ramsey RESET test demonstrated a significant coefficient of 0.011, thus rejecting the null hypothesis of no omitted variables (see Table 2.3, *Appendix*). The VIF test showed an average VIF of 1.25, consequently indicating a lack of multicollinearity (see Table 2.4, *Appendix*).

Table 2.3: Regression of foreign weather variables and macroeconomic control variables on AEX index returns

```
Linear regression                                      Number of obs =     3629
                                                       F(  9,  3619) =   134.33
                                                       Prob > F      =   0.0000
                                                       R-squared     =   0.5391
                                                       Root MSE      =   .86272
```

ReturnAEX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedLDN	-.0008695	.000768	-1.13	0.258	-.0023753	.0006363
MeanTemperatureLDN	-.0027344	.0015545	-1.76	0.079	-.0057822	.0003134
MeanVisibilityLDN	-.0035722	.004928	-0.72	0.469	-.0132341	.0060896
MeanWindspeedNY	-.0006523	.0008989	-0.73	0.468	-.0024147	.0011102
MeanTemperatureNY	.0006531	.0010923	0.60	0.550	-.0014884	.0027947
MeanVisibilityNY	-.0058459	.0058259	-1.00	0.316	-.0172683	.0055765
MSCIWorldReturn	.9680169	.0288371	33.57	0.000	.9114784	1.024555
Month3EURIBOREONIASpread	-.1068527	.0933219	-1.14	0.252	-.2898215	.076116
DutchBondYieldSpread	.0084661	.0210287	0.40	0.687	-.0327632	.0496954
_cons	.3124262	.1290535	2.42	0.016	.0594013	.5654511

Regarding the AMX index, the mean London temperature again proved significant but at the significance level of 5% instead of 10% compared to the AEX index with P-value of 0.010 (see Table 2.5, *Appendix*). The mean visibility in London also proved significant with a P-value of 0.033. Again, the return of the MSCI World Index is highly correlated with the return of the AMX index, signifying. The Ramsey RESET test rejected the null hypothesis with a P-value of 0.0011 (see Table 2.6, *Appendix*). For the AScX index, windspeed and temperature in London prove significant at the 5% and 10% significance levels, respectively. Furthermore, temperature and visibility in New York have P-values of 0.033 and 0.043, thus AScX is the sole index where New York weather variables are significant (see Table 2.7, *Appendix*). The Ramsey RESET test indicates a P-value of 0.000, thus again rejecting the null hypothesis of no omitted variables (see Table 2.8, *Appendix*).

Table 2.9 (see below) demonstrates the OLS regression of the explanatory foreign weather variables in addition to the Dutch weather variables controlled by the macroeconomic parameters. Only the return of the MSCI World index proves significant with a P-value of 0.000 and a very high coefficient of .968. Table 3.1 (see *Appendix*) demonstrates the Ramsay RESET test and specifies that the null hypothesis of no omitted variables cannot be rejected. Furthermore, the mean VIF is 1.5 according to Table 3.2 (see *Appendix*).

Table 2.9: Regression of domestic weather and foreign weather variables and macroeconomic control variables on AEX index return

```
Linear regression                                     Number of obs =    3629
                                                      F( 12,  3616) =  101.60
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.5392
                                                      Root MSE      =  .86298
```

ReturnAEX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedNL	-.0012292	.0014392	-0.85	0.393	-.0040508	.0015925
MeanTemperatureNL	-.0003378	.0021293	-0.16	0.874	-.0045125	.0038369
MeanSeaLevelPressureNL	-.000085	.0018125	-0.05	0.963	-.0036387	.0034687
MeanWindspeedLDN	-.0003819	.0009121	-0.42	0.675	-.0021702	.0014063
MeanTemperatureLDN	-.0027396	.0020031	-1.37	0.171	-.0066669	.0011876
MeanVisibilityLDN	-.00325	.0049236	-0.66	0.509	-.0129033	.0064033
MeanWindspeedNY	-.0006537	.0009002	-0.73	0.468	-.0024186	.0011113
MeanTemperatureNY	.0006437	.0011777	0.55	0.585	-.0016654	.0029528
MeanVisibilityNY	-.0057247	.0058054	-0.99	0.324	-.0171068	.0056575
MSCIWorldReturn	.9678651	.028822	33.58	0.000	.9113561	1.024374
Month3EURIBOREONIASpread	-.1036069	.0943141	-1.10	0.272	-.288521	.0813071
DutchBondYieldSpread	.008456	.0210746	0.40	0.688	-.0328634	.0497754
_cons	.4314262	1.871299	0.23	0.818	-3.237481	4.100333

Nevertheless, for the AMX index, the mean windspeed and mean visibility in London is significant at the 10% level with P-values of 0.064 and 0.057, respectively (see Table 3.3, *Appendix*). The return of the MSCI World also highly and significantly correlates with the return of the AMX index. Concerning AScX, the mean temperature and mean visibility in New York are significant at the 10% level, both having P-values of 0.055. For AScX, the 3-month EURIBOR-EONIA spread is also significant and has a negative correlation with the return of AMX (see Table 3.4, *Appendix*).

The regression of the controlled market sentiment variables on the AEX index resulted in three significant at the 10% level variables, namely the percentage change of the traded AEX volume, the percentage change of the AEX Volatility Index, and the return of the MSCI World Index. Perhaps natural, the traded AEX volume and the AEX Volatility are significantly correlated to the returns of the AEX index. Table (see *Appendix*) indicated a Ramsey RESET P-value of 0.000, thus rejecting the null hypothesis of no omitted variables. Furthermore, the mean VIF for the explanatory variables is 1.300 (see *Appendix*).

Table 1.5: Regression of market sentiment variables and macroeconomic control variables on AEX index returns

```
Linear regression                                    Number of obs =    3629
                                                     F(  7,  3621) =  194.38
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.6222
                                                     Root MSE      =  .78082
```

ReturnAEX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
VolumeAEXPercChange	-.0734602	.0431331	-1.70	0.089	-.1580279	.0111074
VolumeAMXPercChange	.0190954	.0348928	0.55	0.584	-.0493162	.0875069
VolumeAScXPercChange	.0014292	.0147278	0.10	0.923	-.0274463	.0303047
AEXVolatilityIndexPercChange	-5.62199	1.486498	-3.78	0.000	-8.536447	-2.707534
MSCIWorldReturn	.7699946	.0606914	12.69	0.000	.6510018	.8889873
Month3EURIBOREONIASpread	-.1275887	.0877521	-1.45	0.146	-.2996371	.0444597
DutchBondYieldSpread	.0098776	.0183325	0.54	0.590	-.0260655	.0458207
_cons	.033351	.0273771	1.22	0.223	-.020325	.0870271

Regarding the AMX index, the (percentage change of the) AEX Volatility Index and the return on the MSCI World Index both having P-values of 0.000. This is consistent with the regression results for the return of the AEX index. The Ramsey RESET test rejects the null hypothesis of no omitted variables with P=0.000. Concerning AScX, both the percentage changes in the traded AEX volume and that of AScX are significant at the 5% level, as well as the 3-month EURIBOR-EONIA spread and the return of the MSCI World index. Nevertheless, the Ramsey RESET test again rejects the hypothesis of no omitted variables.

Lastly, all the explanatory variables are added in one OLS regression model for the three Euronext indices. For AEX, only the percentage change of the AEX volume, the AEX volatility, and the return of the MSCI World index proved significant at the 10% level.

Table 1.5: Regression of domestic weather, foreign weather, market sentiment and macroeconomic control variables on AEX index returns

```
Linear regression                                      Number of obs =     3629
                                                       F( 16,  3612) =    87.03
                                                       Prob > F      =   0.0000
                                                       R-squared     =   0.6229
                                                       Root MSE      =   .78109
```

ReturnAEX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedNL	-.0007993	.0012552	-0.64	0.524	-.0032603	.0016616
MeanTemperatureNL	-.0012424	.0016787	-0.74	0.459	-.0045338	.002049
MeanSeaLevelPressureNL	.0005293	.0016356	0.32	0.746	-.0026774	.003736
MeanWindspeedLDN	-.000461	.0007263	-0.63	0.526	-.001885	.0009631
MeanTemperatureLDN	-.0014352	.0016565	-0.87	0.386	-.0046829	.0018126
MeanVisibilityLDN	-.0024644	.0042428	-0.58	0.561	-.0107829	.005854
MeanWindspeedNY	-.0001669	.0007868	-0.21	0.832	-.0017095	.0013757
MeanTemperatureNY	.0007898	.0010053	0.79	0.432	-.0011812	.0027608
MeanVisibilityNY	-.0034973	.0050497	-0.69	0.489	-.0133979	.0064032
VolumeAEXPercChange	-.0755732	.0431191	-1.75	0.080	-.1601134	.0089671
VolumeAMXPercChange	.0196688	.0349584	0.56	0.574	-.0488713	.0882089
VolumeAScXPercChange	.0023491	.0146818	0.16	0.873	-.0264362	.0311345
AEXVolatilityIndexPercChange	-5.614073	1.490619	-3.77	0.000	-8.536612	-2.691535
MSCIWorldReturn	.77007	.0608551	12.65	0.000	.6507561	.8893839
Month3EURIBOREONIASpread	-.1313608	.0887949	-1.48	0.139	-.3054539	.0427324
DutchBondYieldSpread	.0098811	.0187173	0.53	0.598	-.0268164	.0465787
_cons	-.2729347	1.688765	-0.16	0.872	-3.583964	3.038094

Regarding AMX, the mean windspeed in the Netherlands is significant at the 10% level with a P-value of 0.065. As presumed in the theoretical framework, windspeed can correlate negatively with the stock market returns. Furthermore, the mean visibility in London is negatively significant with regards to AMX returns (P-value of 0.046). Concerning AScX, the mean sea level pressure in the Netherlands is positively significant with a P-value of 0.064. The mean temperature and visibility in New York have a significant negative correlation with the AScX returns.

6.1.2 GARCH (1,1)

Table (see 4.1, see *Appendix*) demonstrates the result of the Phillips–Perron test for unit roots AEX stock returns. As p = 0.000, one can reject the null hypothesis that the variable contains a unit root. The same holds for the returns of the AMX and AScX stock indices where the Phillips-Perron test further demonstrates a significance value of zero (Tables 4.2 and 4.3, see *Appendix*).

Table 4.4 (see below) demonstrates the results of the GARCH (1,1) model for the AEX index. The estimate of the lagged value of the error term is 0.238 and the coefficient of the lagged variance is 0.853.

Furthermore, the P-values are all significant at every significance level. Thus, AEX volatility can be estimated based on historical data.

Table 4.4: GARCH (1,1) regression on AEX stock returns

		OPG				
ReturnAEX	**Coefficient**	**Std. Error**	**z**	**P>|z|**	**[95% Conf. Interval]**	
ReturnAEX						
_const	.0507768	.0168525	3.01	0.003	.0177464	.0838071
ARCH						
arch						
L1.	.2378068	.020131	11.81	0.000	.1983507	.2772629
garch						
L1.	.8528886	.047073	18.12	0.000	.7606272	.94515
const	-.166482	.0508318	-3.28	0.001	-.2661105	-.0668535

The same holds for the AMX index, where the lagged value of the error term is estimated at .275 and the coefficient of the lagged variance is 0.751. Both lagged values are significant and subsequently for AMX current volatility can be derived from previous volatility that perseveres over time (Table 4.5, see below).

Table 4.5: GARCH (1,1) regression on AMX stock returns

		OPG				
ReturnAMX	**Coefficient**	**Std. Error**	**z**	**P>|z|**	**[95% Conf. Interval]**	
ReturnAMX						
_const	.0536338	.0180096	2.98	0.003	.0183357	.0889319
ARCH						
arch						
L1.	.2745787	.0222617	12.33	0.000	.2309465	.3182109
garch						
L1.	.750749	.0415858	18.05	0.000	.6692424	.8322557
const	-.0574865	.0429975	-1.34	0.181	-.14176	.026787

Table 4.6 (see below) indicates that the AScX index demonstrates similar results, where the lagged value of the error term is estimated at .256 and the coefficient of the lagged variance is 0.751. Both lagged values are significant and subsequently for AMX current volatility can be derived from previous volatility that perseveres over time.

Table 4.6: GARCH (1,1) regression on AScX stock returns

		OPG				
ReturnAScX	**Coefficient**	**Std. Error**	**z**	**P>|z|**	**[95% Conf. Interval]**	
ReturnAScX						
_const	.0613368	.0139326	4.40	0.000	.0340294	.0886442
ARCH						
arch						
L1.	.2559052	.0233702	10.95	0.000	.2101005	.3017099
garch						
L1.	.7286979	.7286979	15.07	0.000	.6339016	.8234941
const						

7. Conclusion

7.1. Discussion

By analyzing the statistical results, one can derive an answer to the research question and its related sub-questions mentioned in the beginning of the paper.

The first sub-question of this research is: *What is the relationship between Dutch domestic weather and stock returns on the Amsterdam stock exchange?* Overall, the results section demonstrated both predictable and unpredictable findings compared to past literature. The common opinion is that the share prices of large firms are more efficient, due to the greater institutional involvement (Badrinath et al., 1995). This was proven correct as the AEX index did not experience a significant correlation with the Dutch weather variables even after controlling for other factors (e.g. global and local macroeconomic environment). The AMX and AScX indices exhibit weather effects in several regression models. AMX is significantly and negatively correlated to the mean windspeed in the Netherlands as presumed in the theoretical framework. AScX has a significant positive correlation with the mean sea level pressure in the Netherlands.

The second sub-question of this research is: *What is the relationship between foreign weather and stock returns on the Amsterdam stock exchange?* The AEX index exhibited no weather effects with regards to foreign weather, most likely due to its large size and the grand amount of trading volume. Nevertheless, AMX was significantly and negatively correlated with the mean visibility in London. This may be due to relatively short distance between London and Amsterdam, or to the fact that AMX is heavily traded on the London Stock Exchange. The mean temperature and visibility in New York have a significant negative correlation with the AScX returns. This may be due to the fact that there is a significant number of investors located in New York that deal with the AScX index.

The third sub-question is *How is the relationship between Dutch weather and stock returns on the Amsterdam stock exchange moderated by firm capitalization?* In general, the AEX index did not experience any significant weather effects contrastingly to the AMX and AScX, which are mentioned in the answer to the first sub-question in this section. Even then, the AScX index did not experience relatively stronger weather effects than the AMX index.

The fourth sub-question is *How does the relationship between Dutch weather and stock returns on the Amsterdam stock exchange change when including a measure of market sentiment?* Overall, the most significantly correlated measures of market sentiment proved to be the return of the MSCI World Index, the percentage change in the AEX Volatility price, and the percentage change in the traded AEX volume. In general, the relationship between Dutch weather and stock returns was not significantly influenced by the current measures of market sentiment.

7.2. Recommendations for future research

A suggestion for further research is to include different measures of market sentiment such as sentiment analysis and to systematically extract and utilize subjective information. This can bring modernity to the research and strengthen its statistical foundation

Secondly, one may wish to look at more weather variables such as sunshine duration, precipitation amount, and evapotranspiration, which may prove to be better proxies than the variables used in this research.

Thirdly, researchers may wish to explore the weather effects in further regions and countries with different climatic conditions.

References

Andreou, E., Ghysels, E., & Kourtellos, A. (2013). Should macroeconomic forecasters use daily financial data and how?. *Journal of Business & Economic Statistics, 31*(2), 240-251.

Badrinath, S., Kale, J., & Noe, T. (1995). Of shepherds, sheep, and the cross-autocorrelations in equity returns. *The Review of Financial Studies, 8*(2), 401-430.

Baker, M., & Wurgler, J. (2006). Investor sentiment and the cross-section of stock returns. *The Journal of Finance, 61*(4), 1645-1680.

Barber, B., & Odean, T. (2001). The internet and the investor. *Journal of Economic Perspectives, 15*(1), 41-54.

Barberis, N., & Thaler, R. (2003). A survey of behavioral finance. *Handbook of the Economics of Finance*, 1, 1053-1128.

Barone, E. (1990). The Italian stock market: efficiency and calendar anomalies. *Journal of Banking and Finance, 14*(2), 483-510.

Beedie, C., Terry, P., & Lane, A. (2005). Distinctions between emotion and mood. *Cognition and Emotion*, 19(6), 847-878.

Bollen, J., Mao, H., & Zeng, X. (2011). Twitter mood predicts the stock market. *Journal of Computational Science, 2*(1), 1-8.

Boudreaux, D. (1995). The monthly effect in international stock markets: evidence and implications. *Journal of Financial and Strategic Decisions*, *8*(1), 15-20.

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

Chang, T., Nieh, C., Yang, M., & Yang, T. (2006). Are stock market returns related to the weather effects? Empirical evidence from Taiwan. *Physica A, 364*, 343-354.

Cohen-Charash, Y., Scherbaum, C., Kammeyer-Mueller, J., & Staw, B. (2013). Mood and the market: can press reports of investors' mood predict stock prices? *PloS one, 8*(8), 12-43.

Dowling, M., & Lucey, B. (2005). Weather, biorhythms, beliefs and stock returns – some preliminary Irish evidence. *International Review of Financial Analysis, 14*, 337- 355.

Eichengreen, B., & Mody, A. (1998). *What explains changing spreads on emerging-market debt: fundamentals or market sentiment?* (NBER working paper series, working paper 6408). Cambridge, MA: National Bureau of Economic Research.

Fama, E. (1998). Market efficiency, long-term returns, and behavioral finance. *Journal of Financial Economics, 49*(3), 283-306.

Floros, C. (2011). On the relationship between weather and stock market returns. *Studies in Economics and Finance, 28*(1), 5-13.

Forgas, J. (1995). Mood and judgment: the affect infusion model (AIM). *Psychological Bulletin, 117*(1), 39.

French, K. (1980). Stock returns and the weekend effect. *Journal of Financial Economics, 8*(1), 55-69.

Grable, J., & Roszkowski, M. (2008). The influence of mood on the willingness to take financial risks. *Journal of Risk Research, 11*(7), 905-923.

Harding, N., & He, W. (2016). Investor mood and the determinants of stock prices: an experimental analysis. *Accounting and Finance, 56*(2), 445-478

Hirshleifer, D. (2001). Investor psychology and asset pricing. *The Journal of Finance, 56*(4), 1533-1597.

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*, 15-23.

IMF Data (2019, May 6). *Coordinated Portfolio Investment Survey (CBIS)*. Retrieved from http://data.imf.org/?sk=B981B4E3-4E58-467E-9B90-9DE0C3367363

Isen, A., & Patrick, R. (1983). The effect of positive feelings on risk taking: when the chips are down. *Organizational Behavior and Human Performance, 31*(2), 194-202.

Isen, A., Nygren, T., & Ashby, F. (1988). Influence of positive affect on the subjective utility of gains and losses: it is just not worth the risk. *Journal of Personality and Social Psychology, 55*(5), 710.

Jacobsen, B., & Marquering, W. (2008). Is it the weather?. *Journal of Banking & Finance*, *32*(4), 526-54

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An introduction to statistical learning, 112* (18). New York: Springer.

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

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

Krämer, W., & Runde. R. (1997). Stocks and the weather: an exercise in data mining or yet another capital market anomaly? *Empirical Economics, 22*: 637-641.

Loewenstein, G., Elke, U., Weber, C., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin, 127*, 267-286.

Long Finance (2019, March). The Global Financial Centres Index 25. Retrieved from http://www.longfinance.net/Publications/GFCI25.pdf

Malkiel, B., & Fama, E. (1970). Efficient capital markets: a review of theory and empirical work. *The Journal of Finance*, *25*(2), 383-417.

Mill, J. (1848). *Principles of political economy with some of their applications to social philosophy*. London, England: John W. Parker

Nofsinger, J. (2005). Social mood and financial economics. *The Journal of Behavioral Finance, 6*(3), 144-160.

Pardo, A., & Valor, E. (2003). Spanish stock returns: where is the weather effect? *European Financial Management*, *9*(1), 117-126.

Pontiff, J. (2006). Costly arbitrage and the myth of idiosyncratic risk. *Journal of Accounting and Economics, 42*(2), 35-52.

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

Schwarz, N. (2002). Situated cognition and the wisdom of feelings: cognitive tuning. *The wisdom in feelings*, 1, 144-166

Shleifer, A., & Vishny, R. (1997). The limits of arbitrage. *The Journal of Finance, 52*(1), 35-55.

Shu, H. C., & Hung, M. W. (2009). Effect of wind on stock market returns: evidence from European markets. *Applied Financial Economics*, *19*(11), 893-904.

Stigler, S. (1986). *Laplace's 1774 memoir on inverse probability*. *Statistical Science*, *1*(3), 359-363.

Trombley, M. (1997). Stock prices and Wall Street weather: Additional evidence. *Quarterly Journal of Business and Economics*, *36*, 11–21.

Tufan, E., & Hamarat, B. (2006). Do investors being affected by the weather conditions: an evidence from Istanbul Stock Exchange. *The ISE Review (Journal of Istanbul Stock Exchange)*, *31*, 33-43.

Appendix

Table 1.1: Descriptive statistics summary for weather variables in the Netherlands

Variable	Observations	Mean	St. Dev	Min	Max	Skewness	Kurtosis
MeanWindspeedNL	3629	33.80738	13.71109	9	99	.992617	4.237634
MeanTemperatureNL	3629	51.43097	11.30583	16.7	85.46	-.1904049	2.518852
MeanSeaLevelPressureNL	3629	1015.429	9.628307	973.2	1044.5	-.3305137	3.515641

Table 1.2: Correlation matrix for weather variables in the Netherlands

	Variables		
	MeanWindspeedNL	MeanTemperatureNL	MeanSeaLevelPressureNL
MeanWindspeedNL	1.0000		
MeanTemperatureNL	-0.1157	1.0000	
MeanSeaLevelPressureNL	-0.3619	-0.0373	1.0000

Table 1.3: Descriptive statistics summary for stock returns on the Amsterdam stock exchange

Variable	Observations	Mean	St. Dev	Min	Max	Skewness	Kurtosis
ReturnAEX	3629	.0104399	1.269197	-9.590334	10.02827	-.2136069	12.16269
ReturnAMX	3629	.01452	1.284053	-9.981594	7.970579	-.5353429	8.21743
ReturnAScX	3629	.0214657	.9962473	-8.224369	7.535051	-.6732936	8.886253

Table 1.4: Correlation matrix for stock returns on the Amsterdam stock exchange

	Variables		
	ReturnAEX	ReturnAMX	ReturnAScX
ReturnAEX	1.0000		
ReturnAMX	0.8478	1.0000	
ReturnAScX	0.7628	0.8163	1.0000

Table 1.6: Ramsey RESET test - regression of Dutch weather variables and macroeconomic control variables on AEX index returns

Ramsey RESET test using powers of the fitted values of ReturnAEX	
Ho: model has no omitted variables	
F (3, 3619) =	3.82
Prob > F =	0.0095

Table 1.7: Variance inflation factors - regression of Dutch weather variables and macroeconomic control variables on AEX index returns

Variable	**VIF**
	1.17
MeanWindspeedNL	1.16
MeanSeaLevelPressureNL	1.03
MeanTemperatureNL	1.03
DutchBondYieldSpread	1.03
Month3EURIBOREONIASpread	1.02
MSCI World Return	1.0
Mean VIF	1.07

Table 1.8: Regression of Dutch weather variables and macroeconomic control variables on AMX index returns

```
Linear regression                                   Number of obs =    3629
                                                    F(  6,  3622) =  195.90
                                                    Prob > F      =  0.0000
                                                    R-squared     =  0.4521
                                                    Root MSE      =  .95128
```

ReturnAMX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedNL	-.0024407	.0013432	-1.82	0.069	-.0050742	.0001928
MeanTemperatureNL	-.0040528	.0013472	-3.01	0.003	-.0066942	-.0014115
MeanSeaLevelPressureNL	.0017618	.0018668	0.94	0.345	-.0018982	.0054219
MSCIWorldReturn	.893144	.0262345	34.04	0.000	.8417082	.9445797
Month3EURIBOREONIASpread	-.1497261	.087317	-1.71	0.086	-.3209214	.0214692
DutchBondYieldSpread	.0179503	.0237925	0.75	0.451	-.0286977	.0645983
_cons	-1.484858	1.921599	-0.77	0.440	-5.252382	2.282667

Table 1.9: Ramsey RESET test - regression of Dutch weather variables and macroeconomic control variables on AMX index returns

Ramsey RESET test using powers of the fitted values of ReturnAMX

Ho: model has no omitted variables

F(3, 3619) = 5.62

Prob > F = 0.0008

Table 2.1: Regression of Dutch weather variables and macroeconomic control variables on AScX index returns

Linear regression

Number of obs	=	3629
F(6, 3622)	=	126.94
Prob > F	=	0.0000
R-squared	=	0.3617
Root MSE	=	.79657

ReturnAScX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedNL	-.0011178	.0011202	-1.00	0.318	-.003314	.0010784
MeanTemperatureNL	-.0042038	.0011712	-3.59	0.000	-.0065	-.0019075
MeanSeaLevelPressureNL	.0021949	.0015177	1.45	0.148	-.0007807	.0051706
MSCIWorldReturn	.6139363	.0225282	27.25	0.000	.569767	.6581055
Month3EURIBOREONIASpread	-.2461315	.0744967	-3.30	0.001	-.3921911	-.1000719
DutchBondYieldSpread	.0107854	.0201812	0.53	0.593	-.0287822	.0503531
_cons	-1.914443	1.562187	-1.23	0.220	-4.977296	1.14841

Table 2.2: Ramsey RESET test - regression of Dutch weather variables and macroeconomic control variables on AScX index returns

Ramsey RESET test using powers of the fitted values of ReturnAScX

Ho: model has no omitted variables

F(3, 3619) = 9.38

Prob > F = 0.0000

Table 2.3: Ramsey RESET test - regression of foreign weather variables and macroeconomic control variables on AEX index returns

Ramsey RESET test using powers of the fitted values of ReturnAEX

Ho: model has no omitted variables

F(3, 3616) = 3.70

Prob > F = 0.0113

Table 2.4: Variance inflation factors - regression foreign weather variables and macroeconomic control variables on AEX index returns

Variable	VIF	1/VIF
MeanTemper~Y	1.90	0.525984
MeanTemper~N	1.78	0.560930
MeanVisibi~N	1.17	0.852605
MeanWindsp~Y	1.13	0.883378
MeanWindsp~N	1.12	0.889964
Month3EURI~d	1.08	0.926676
DutchBondY~d	1.08	0.928470
MeanVisibi~Y	1.01	0.989777
MSCIWorldR~n	1.00	0.996875
Mean VIF	1.25	

Table 2.5: Regression of foreign weather variables and macroeconomic control variables on AMX index returns

Linear regression

Number of obs	=	3629
F(9, 3619)	=	132.99
Prob > F	=	0.0000
R-squared	=	0.4524
Root MSE	=	.9514

ReturnAMX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedLDN	-.0002958	.0008548	-0.35	0.729	-.0019717	.0013801
MeanTemperatureLDN	-.0047622	.0018408	-2.59	0.010	-.0083712	-.0011531
MeanVisibilityLDN	-.0117914	.0055269	-2.13	0.033	-.0226276	-.0009551
MeanWindspeedNY	-.0013669	.0009661	-1.41	0.157	-.0032609	.0005272
MeanTemperatureNY	.0006175	.0012404	0.50	0.619	-.0018144	.0030494
MeanVisibilityNY	-.0034967	.0063573	-0.55	0.582	-.015961	.0089677
MSCIWorldReturn	.8930305	.0262057	34.08	0.000	.8416511	.9444099
Month3EURIBOREONIASpread	-.1407281	.0874788	-1.61	0.108	-.3122408	.0307845
DutchBondYieldSpread	.027661	.0241223	1.15	0.252	-.0196337	.0749558
_cons	.4774204	.1412134	3.38	0.001	.2005547	.7542861

Table 2.6: Ramsey RESET test - regression of foreign weather variables and macroeconomic control variables on AMX index returns

Ramsey RESET test using powers of the fitted values of ReturnAMX
Ho: model has no omitted variables
F(3, 3616) = 5.39
Prob > F = 0.0011

Table 2.7: Regression of foreign weather variables and macroeconomic control variables on AScX index returns

```
Linear regression                                      Number of obs =    3629
                                                       F(  9,  3619) =   87.03
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.3635
                                                       Root MSE      =  .79582
```

ReturnAScX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedLDN	-.0016679	.0007312	-2.28	0.023	-.0031014	-.0002343
MeanTemperatureLDN	-.0025958	.0015572	-1.67	0.096	-.0056489	.0004574
MeanVisibilityLDN	.001383	.0043538	0.32	0.751	-.0071531	.009919
MeanWindspeedNY	-.0011649	.0008031	-1.45	0.147	-.0027395	.0004098
MeanTemperatureNY	-.0021614	.0010119	-2.14	0.033	-.0041453	-.0001775
MeanVisibilityNY	-.0111262	.005498	-2.02	0.043	-.0219056	-.0003467
MSCIWorldReturn	.6144628	.022506	27.30	0.000	.570337	.6585886
Month3EURIBOREONIASpread	-.2588262	.0744722	-3.48	0.001	-.4048379	-.1128145
DutchBondYieldSpread	.0061667	.0204512	0.30	0.763	-.0339302	.0462637
_cons	.6079472	.1226151	4.96	0.000	.3675456	.8483489

Table 2.8: Ramsey RESET test - regression of foreign weather variables and macroeconomic control variables on AScX index returns

Ramsey RESET test using powers of the fitted values of ReturnAScX

Ho: model has no omitted variables

F(3, 3616) = 8.82

Prob > F = 0.0000

Table 3.1: Ramsey RESET test - regression of market sentiment variables and macroeconomic control variables on AEX index returns

Ramsey RESET test using powers of the fitted values of ReturnAEX

Ho: model has no omitted variables

F(3, 3616) = 119.71

Prob > F = 0.0000

Table 3.2: Variance inflation factors - regression of market sentiment variables and macroeconomic control variables on AEX index returns

Variable	VIF	1/VIF
VolumeAEXP~e	1.71	0.583107
VolumeAMXP~e	1.71	0.585382
MSCIWorldR~n	1.27	0.786053
AEXVolatil~e	1.27	0.788572
VolumeAScX~e	1.06	0.944659
Month3EURI~d	1.02	0.978402
DutchBondY~d	1.02	0.978912
Mean VIF	1.30	

Table 3.3: Regression of market sentiment variables and macroeconomic control variables on AMX index returns

Linear regression

Number of obs = 3629
F(7, 3621) = 203.80
Prob > F = 0.0000
R-squared = 0.5268
Root MSE = .88411

ReturnAMX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
VolumeAEXPercChange	-.1900272	.0587181	-3.24	0.001	-.305151	-.0749033
VolumeAMXPercChange	.112763	.0635682	1.77	0.076	-.01187	.2373961
VolumeAScXPercChange	.0291369	.0176716	1.65	0.099	-.0055104	.0637843
AEXVolatilityIndexPercChange	-5.340722	1.412403	-3.78	0.000	-8.109906	-2.571538
MSCIWorldReturn	.7034082	.0560427	12.55	0.000	.5935298	.8132866
Month3EURIBOREONIASpread	-.1711027	.0804532	-2.13	0.034	-.3288409	-.0133646
DutchBondYieldSpread	.0213921	.0219337	0.98	0.329	-.0216114	.0643957
_cons	.0338303	.0315778	1.07	0.284	-.0280817	.0957423

Table 3.4: Regression of market sentiment variables and macroeconomic control variables on AScX index returns

```
Linear regression                                      Number of obs =    3629
                                                       F(  7,  3621) =  125.80
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.4311
                                                       Root MSE      =  .75216
```

ReturnAScX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
VolumeAEXPercChange	-.1387155	.0427871	-3.24	0.001	-.2226048	-.0548263
VolumeAMXPercChange	.0146936	.0359639	0.41	0.683	-.0558179	.0852051
VolumeAScXPercChange	.0701666	.0278284	2.52	0.012	.0156056	.1247275
AEXVolatilityIndexPercChange	-3.927036	.9688148	-4.05	0.000	-5.826513	-2.027559
MSCIWorldReturn	.4761704	.0414396	11.49	0.000	.394923	.5574177
Month3EURIBOREONIASpread	-.2566406	.071184	-3.61	0.000	-.3962053	-.1170758
DutchBondYieldSpread	.0132192	.0189414	0.70	0.485	-.0239177	.0503562
_cons	.0728623	.0275776	2.64	0.008	.0187931	.1269315

Table 3.6: Ramsey RESET test - regression of market sentiment variables and macroeconomic control variables on AEX index returns

Ramsey RESET test using powers of the fitted values of ReturnAEX

Ho: model has no omitted variables

F(3, 3616) = 70.40

Prob > F = 0.0000

Table 3.7: Regression of domestic weather, foreign weather, market sentiment, and macroeconomic control variables on AMX index returns

```
Linear regression                                      Number of obs =    3629
                                                       F( 16,  3612) =   91.76
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5301
                                                       Root MSE      =  .88213
```

ReturnAMX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedNL	-.0025417	.0013752	-1.85	0.065	-.0052379	.0001545
MeanTemperatureNL	-.0028928	.0019302	-1.50	0.134	-.0066772	.0008916
MeanSeaLevelPressureNL	.0026603	.0017335	1.53	0.125	-.0007385	.0060591
MeanWindspeedLDN	.0011324	.0008448	1.34	0.180	-.0005239	.0027887
MeanTemperatureLDN	-.0032047	.0020434	-1.57	0.117	-.007211	.0008016
MeanVisibilityLDN	-.0098876	.0049495	-2.00	0.046	-.0195918	-.0001835
MeanWindspeedNY	-.0008319	.0008733	-0.95	0.341	-.0025441	.0008802
MeanTemperatureNY	.0011445	.0011877	0.96	0.335	-.0011842	.0034732
MeanVisibilityNY	-.0001971	.0057533	-0.03	0.973	-.0114772	.011083
VolumeAEXPercChange	-.1947552	.0584794	-3.33	0.001	-.3094112	-.0800992
VolumeAMXPercChange	.1133595	.0629318	1.80	0.072	-.0100259	.2367449
VolumeAScXPercChange	.0312683	.0176564	1.77	0.077	-.0033491	.0658858
AEXVolatilityIndexPercChange	-5.325929	1.418868	-3.75	0.000	-8.107791	-2.544068
MSCIWorldReturn	.7026632	.0562037	12.50	0.000	.5924691	.8128573
Month3EURIBOREONIASpread	-.1563205	.0813326	-1.92	0.055	-.3157829	.0031419
DutchBondYieldSpread	.0276574	.0223915	1.24	0.217	-.0162438	.0715587
_cons	-2.235664	1.790208	-1.25	0.212	-5.745583	1.274255

Table 3.8: Regression of domestic weather, foreign weather, market sentiment, and macroeconomic control variables on AScX index returns

```
Linear regression                                   Number of obs =     3629
                                                    F( 16,  3612) =    57.87
                                                    Prob > F      =   0.0000
                                                    R-squared     =   0.4361
                                                    Root MSE      =   .74976
```

ReturnAScX	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
MeanWindspeedNL	-.0005478	.0011998	-0.46	0.648	-.0029001	.0018045
MeanTemperatureNL	-.0009256	.0018017	-0.51	0.607	-.004458	.0026068
MeanSeaLevelPressureNL	.0026328	.0014233	1.85	0.064	-.0001577	.0054233
MeanWindspeedLDN	-.0010578	.0007553	-1.40	0.161	-.0025386	.0004231
MeanTemperatureLDN	-.0020979	.0017976	-1.17	0.243	-.0056223	.0014266
MeanVisibilityLDN	.0023828	.0039948	0.60	0.551	-.0054494	.010215
MeanWindspeedNY	-.00076	.0007467	-1.02	0.309	-.002224	.0007041
MeanTemperatureNY	-.0019079	.0010063	-1.90	0.058	-.0038808	.000065
MeanVisibilityNY	-.0087073	.0051414	-1.69	0.090	-.0187877	.0013731
VolumeAEXPercChange	-.1399335	.0423484	-3.30	0.001	-.2229626	-.0569043
VolumeAMXPercChange	.0134135	.0359348	0.37	0.709	-.0570411	.083868
VolumeAScXPercChange	.0714497	.0271991	2.63	0.009	.0181225	.1247768
AEXVolatilityIndexPercChange	-3.914899	.9738666	-4.02	0.000	-5.824282	-2.005516
MSCIWorldReturn	.4763761	.0415912	11.45	0.000	.3948315	.5579208
Month3EURIBOREONIASpread	-.2713049	.0719937	-3.77	0.000	-.4124573	-.1301525
DutchBondYieldSpread	.0056395	.0193339	0.29	0.771	-.032267	.043546
_cons	-2.115817	1.471526	-1.44	0.151	-5.000921	.7692869

Table 4.1: Phillips–Perron test for unit root in the AEX index returns

Phillips–Perron test for unit root

Number of observations = 2871

Newey-West lags 8

	Test statistic	Interpolated Dickey-Fuller 1% Critical value	5% Critical value	10% Critical value
z (rho)	-2914.977	-29.500	-21.800	-18.300
z (t)	-56.232	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

ReturnAEX	Coefficient	Std. Error	t	P>|t|	[95% Conf.	Interval]
ReturnAEX						
L1.	.0115316	.0175299	0.66	0.511	-.0228408	.045904
_trend	.0000171	.0000151	1.13	0.257	-.0000125	.0000467
constant	-.0379344	.0450702	-0.84	0.400	-.1263077	.0504389

Table 4.2: Phillips–Perron test for unit root in the AMX index returns

Phillips–Perron test for unit root

Number of observations = 2871

Newey-West lags 8

Interpolated Dickey-Fuller

	Test statistic	1% Critical value	5% Critical value	10% Critical value
z (rho)	-2814.996	-29.500	-21.800	-18.300
z (t)	-54.243	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

ReturnAMX	**Coefficient**	**Std. Error**	**t**	**P>|t|**	**[95% Conf. Interval]**	
ReturnAMX						
L1.	.0513425	.0174512	2.94	0.003	.0171244	.0855607
_trend	-3.05e-06	.0000154	-0.20	0.843	-.0000333	.0000272
constant	.019466	.0460094	0.42	0.672	-.0707485	.109681

Table 4.3: Phillips–Perron test for unit root in the AScX index returns

Phillips–Perron test for unit root

Number of observations = 2871

Newey-West lags 8

Interpolated Dickey-Fuller

	Test statistic	1% Critical value	5% Critical value	10% Critical value
z (rho)	-2768.862	-29.500	-21.800	-18.300
z (t)	-52.415	-3.960	-3.410	-3.120

MacKinnon approximate p-value for Z(t) = 0.0000

ReturnAScX	**Coefficient**	**Std. Error**	**t**	**P>|t|**	**[95% Conf. Interval]**	
ReturnAScX						
L1.	.0952167	.017233	5.53	0.000	.0614263	.129007
_trend	7.24e-06	.0000118	0.61	0.540	-.0000159	.0000304
constant	-.0090619	.0352483	-0.26	0.797	-.0781765	.0600527