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COVID-19 effects on the Amsterdam Stock Exchange

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Abstract

This research quantifies and scrutinizes the relationship between the coronavirus-caused cases and deaths and the returns on the three major indices of the Amsterdam Euronext stock exchange, namely the AEX, the AMX, and the AScX. The research uses daily data from 31 December 2019 until 28 July 2020, and subsumes correlation analyses, normality tests, ordinary least-squares (OLS) regressions, and a generalized autoregressive conditional heteroskedasticity (GARCH) model. Fundamentally, overall, there is no statistically significant relationship between Dutch, European, and global COVID-19 cases and deaths, and returns on the three indices. Nevertheless, domestic (Dutch) coronavirus and cases and deaths were significantly correlated with the volatility of the three indices, where size effects were present. The volatility of the smallest companies, represented by the AScX index, had the highest correlation with the domestic COVID-19 cases and deaths, followed by the mid-cap ones (AMX index), and lastly the large-cap ones (AEX index). No size effects materialized regarding Dutch equity returns. All three indices exhibit persistent volatility clustering as demonstrated by GARCH (1,1) models.

Table of Contents

1. Introduction

The coronavirus (COVID-19) outbreak was first identified in China in December 2019 and has arisen to a global pandemic causing major social disruptions, a stock market crash and subsequently a recession. News about the quickly evolving virus has raised health concerns and fears amongst people. Equities were the first one to suffer as stock markets plummeted and volatility rocketed. A CNBC article from 16th March pointed out a huge sell-off Monday with the Dow Jones Industrial Average index posting its worst day since the "Black Monday" market crash in 1987 and the Standard & Poor's (S&P) 500 index hitting its lowest level since the 2008 financial crisis (Li, 2020).

The financial crisis caused by the coronavirus further presented a liquidity issue for firms of both small and medium capitalization, as investors deemed them as riskier and thus avoidable investments. The stock market was severely affected during this health crisis with it being the main daily trading driver and volatility reaching or surpassing the levels of the great depression, the great recession, or Black Monday in 1987 (Baker et al., 2020) Furthermore, the CBOE Volatility Index (VIX), which doubled in March, surged to a record high surpassing the peak level from the 2008 financial crisis. Baker et al. (2020) find that despite the low mortality rate compared to other past pandemics, there is no other infectious disease outbreak that experienced such daily stock market swings as COVID-19.

Growing literature investigating the effects of COVID-19 new cases and deaths on stock markets is currently being developed. Onali (2020) and Yousef (2020) find evidence for a positive impact between COVID-19 developments in some of the most affected countries and the conditional heteroscedasticity of Dow Jones, S&P 500 and Nasdaq indices returns. The results of Yilmazkuday (2020) suggest negative effects of U.S. daily COVID-19 cases on the price of the S&P 500 index, mostly observed in March 2020. However, as most of the conducted research inspects U.S. stock markets, this paper can contribute to existing literature by extending the scope of COVID-19 developments on equities in the Kingdom of the Netherlands.

What is more, neither of the current literature accounts for the virus impact on differently sized companies. As prices of small firms are less efficient due to lower involvement by investor and thus lower liquidity, they are expected to be more volatile. On average, firms with smaller possess higher growth potential than companies with large market capitalization. Nevertheless, they, on average, possess more risk and lower liquidity (Fama and French, 1992). As the coronavirus caused investors to become more risk-averse, it would be beneficial to examine how the returns and volatility of small- and medium-capitalized companies was affected.

Therefore, this paper examines the relationship between COVID-19 developments and the returns and volatility of differently capitalized companies. Moreover, previous literature incorporates in their analysis new cases and deaths from the most affected countries during the pandemic outbreak, namely China, Italy, U.S.A., and more. Whereas, this study will inspect the relationship between Dutch stock markets on the Euronext Amsterdam stock exchange and COVID-19 cases and deaths from a regional to a more global level, namely from the Netherlands, Europe (excluding the Netherlands), and Worldwide (excluding the Netherlands). The inspected time period will be conditional on the first confirmed case for each region.

As asset prices reflect investors' expectations about future payoffs, they can be a useful indicator in assessing the potential pandemic costs (Gormsen and Koijen, 2020). A fundamentally economically relevant topic for investors and policymakers is how COVID-19 developments have influenced stock markets during the ongoing pandemic. This study aims at investigating the relationship between COVID-19 new cases and deaths and the returns and volatility of three Dutch indices listed on the Amsterdam Stock Exchange. The three indices present high- to low-capitalized Dutch companies. The first index is the AEX presenting large-cap companies, the AMX index for mid-cap, and the AScX index for small-cap companies. Therefore, after controlling for market sentiment and several macroeconomic factors, this paper is able to account for capitalization differences in the studied relationship. Furthermore, the statistical analysis will incorporate correlation analyses, multiple ordinary least-squares (OLS) regressions, and a generalized autoregressive conditional heteroskedasticity (GARCH) model. Thus, the formulated main research question is:

What is the relationship between COVID-19 cases and deaths and the returns and volatility on the Amsterdam Stock Exchange?

This paper will address the research question by the following structure: the next section will present the relevant existing literature used to set up the research sub-questions in the theoretical framework section. Next, the theoretical framework will explain, formalize, and declare the relevant sub-questions of this research. Then, the data collection process will be explained and the variables applicability in the methodology section. Describing the model selection consisting of new cases and deaths, the three Dutch stock market indices and the relevant investor sentiment and macroeconomic control variables. Subsequently, in the results section the studied relationship will be presented by the formed statistical analysis. A discussion of the results will be carried on and a consequent conclusion will be presented in the final section, followed by the study limitations and recommendations for future research.

2. Literature Review

2.1 COVID-19 as a black swan event

Historically, there have been a variety of pandemics, seismic events, and climatic events that come as a surprise to people, resulting in a large impact on the status quo. According to Taleb's (2007) Black Swan theory, such events are characterized as unexpected, very unlikely events that might have extremely negative consequences for society and for the global economy. Despite the random nature of such events, Platje et al. (2020) discuss that those events are indeed possible to be predicted. Nonetheless, small probability events with potentially high impacts are often ignored or downplayed by people until really feeling and experiencing such a situation.

The coronavirus pandemic is a great example of a Black Swan event as it unexpectedly spread worldwide, causing global social and economic disruption. On the authority of the World Health Organization (WHO), the coronavirus outburst was first recognized in December 2019 in Wuhan, China, however, according to Ford (2020) COVID-19 threats appear to be known in November 2019. Insufficient preventative measures taken by authorities and the vast initial underestimation of the virus lead to a soar in the number of confirmed Covid-19 cases and a gradual shift of the outbreak center from China to Europe and the USA. People's behavior drastically changed due to the virus misinformation and rising fears. It was not until the final week of February, when stock markets replied to the increased global awareness of the virus and experienced the worst week since the 2008 financial crisis (Smith, 2020).

In addition, regardless of the economic damage, countries implemented quarantines and social restrictions to fight the spread. This global lockdown resulted in a collapse of industries and increase in unemployment rates leading to a stock market crash and subsequently, a recession. The International Monetary Fund (IMF) projected that it is going to be the "worst recession since the Great Depression, and far worse than the Global Financial Crisis" (Gopinath, 2020).

2.2 COVID-19 as a catalyst for the stock market crash – a timeline

The initial signs for a global recession came with the global stock market crash when equities plummeted and entered into a correction in the week from 24th to 28th February 2020. Fears over China's imposed measures put major U.S. indices to a weekly drop of 10% (Bayly, 2020) and made safe-haven assets, such as government bonds and gold, a preferred investment choice. Due to a decreased travel demand and the Russia–Saudi Arabia oil price war, global stocks experienced severe contractions the week from 9th to 12th March 2020. On Black Monday, 9th March, oil prices went down by 22% (Defterios, 2020), the major bourses declined sharply and the European Stoxx 600 was down 20% of its year high (Smith and Ellyatt, 2020).

Stocks plummeted once again on "Black Thursday", 12th March 2020, as Imbert and Franck (2020) reported that major stock markets suffered from its lowest one-day percentage drop since the 1987 market crash. The day after, on 13th March 2020, stocks rebounded from the COVID-19 collapse as most European and American stock markets closed, posting the biggest rally since 2008 (Imbert et al., 2020). However, the following Monday, March 16th 2020, markets were again down, reacting to proposed travel restrictions. Intensifying fears and the high uncertainty over the virus, brought the VIX (the 30-day implied volatility of S&P 500 index) to a record high, surpassing the peak of the 2008 financial crisis (Li, 2020).

March was volatile and global stocks experienced a huge downturn, however, due to monetary and fiscal stimulus measures from central banks and governments and news for potential vaccines, markets have seen a recovery since than (Smith, 2020). Figure 1.1 (see below) illustrates the development of the price (in euro) of three relevant and examined Dutch indices (AEX, AMX and AScX indices) from 2 January 2020 to 2 July 2020.

Figure 1.1: The price development of the three examined Dutch indices (the AEX, AMX, and AScX) from 2 January 2020 until 2 July 2020 (numbers in euro);Index price is demonstrated on the vertical y-axis, time period is shown on the horizontal x-axis.

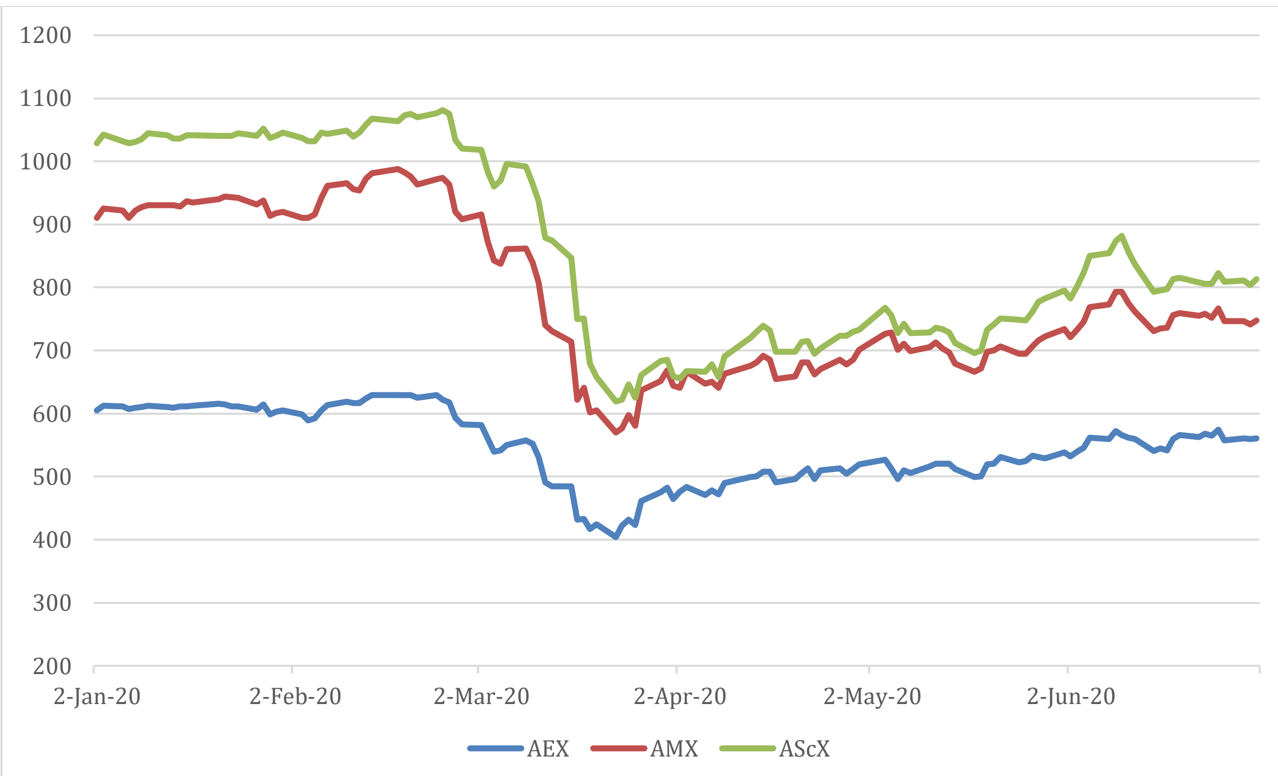

Figure 1.2 (see Appendix) demonstrates the price (in euro) development of the S&P 500 index, where one can observe a similar pattern in March, demonstrated by a significant price decrease. Thus, one can argue that the stock market behavior has adopted a relatively global pattern, instead of a purely domestic one.

2.3 The impact of COVID-19 on the stock market returns and volatility

Small but quickly growing literature inspects the impact of COVID-19 on stock markets. Baker et al. (2020) find evidence and potential explanations for the unprecedented stock market reaction to the pandemic, stating that no other infectious disease had so vigorous effects in the past.

Largely compared to the Spanish Flu from 1918 that killed over 56 million people (Marck, 2020), COVID-19 experiences a way lower mortality rate, yet it has seen "an extremely high frequency of large daily stock market moves in response to news about COVID-19 and policy adoption as drivers of the stock market" (Baker et al., 2020). For the U.S.A., the stock volatility in March surged to levels last seen in October 1987 and during the 2008 financial crisis (Kawa, 2020).

Yilmazkuday (2020) also observed a growing impact on U.S. stock markets during March. In his study investigating the effects of COVID-19 cases on the S&P 500, he shows that a 1.00% increase in cumulative daily COVID-19 cases results in a 0.01% cumulative reduction in the S&P 500 index. The analysis was achieved by a structural vector autoregression (VAR) model, using the spread between 10-year treasury and the federal funds rate as a proxy for global economic activity. Yilmazkuday (2020) also concluded more pronounced negative effects during March. In the study of Onali (2020), the research allowed for changes in trading volume, volatility expectations and day-of-the-week effects, where the impact of COVID-19 cases and deaths on the S&P 500 and Dow Jones Industrial Average indices was inspected. The results of the study suggest that changes in the number of cases and deaths in the U.S.A. and other seriously affected countries does not impact the two indices returns. An exception is China's numbers of reported new cases, which result in a significant influence on U.S. stock market returns. In terms of the COVID-19 relationship on the conditional heteroscedasticity, Onali (2020) found enough evidence to conclude a positive impact for some of the inspected countries. Furthermore,

Yousef (2020) also inspects COVID-19 impact on stock market volatility for the three major U.S. indices, in specific the S&P 500, the NASDAQ, and the Dow Jones Industrial Average. By analyzing the standard deviation of the returns and the conditional variance using GARCH models, the paper concludes that daily new cases and their growth rate have a significant positive impact on U.S. stock market volatility. Fundamentally, the COVID-19 crisis has made the U.S. stock market more volatile.

2.4 The impact of COVID-19 on stock market liquidity and on differently capitalized companies

Historical research such as Fama and French (1992) has indicated that there exists a risk premium where companies of small capitalization, on average, exhibit abnormally high returns compared to firms of larger capitalization (i.e. the size effect). Thus, size is a significant and strong return factor in the seminal paper of Fama and French (1992), which demonstrates a three-factor empirical asset pricing model. Kim and Burnie (2002) examine and scrutinize the relationship between the size effect and the economic cycle by utilizing data on U.S. equity returns from 1976 until 1995. The findings indicate and conclude that small-cap equities, on average, outperform large-cap stocks during economic highs. Nonetheless, there is no relevant evidence that this relationship holds during economic downturns. Furthermore, Kim and Burnie (2002) demonstrate that small equities possess more vulnerability to negative shocks due to their relatively high financial leverage (i.e. the ratio of total debt over total stockholder's equity).

A further theoretical framework is that of Gabaix (2012), where he represents the equity size premium as a compensation for the risk that the security will nullify its fundamental value. In addition, equity of smaller capitalization has higher exposure to economic and financial downturns as their cashflows are more sensitive to the specific business cycle (Koijen et al., 2017). On a similar note, this is congruent with the results of Zhang (2005), where the author examines the countercyclical price of risk, which is relatively costly in deteriorated days. Subsequently and essentially, small companies are especially riskier during economic and financial downturns. The concept of a countercyclical size risk premium is further researched and confirmed in Gomes et al. (2003).

3. Theoretical framework

The past literature suggests a definite and significant impact of the COVID-19 developments on the return and volatility of equities. This paper will further analyze and dig into into the Dutch stock market and its relationship with the coronavirus. Therefore, the first sub-question is:

Q1: What is the relationship between Dutch COVID-19 cases and deaths, and equity stock returns and volatility on the Amsterdam stock exchange?

During the pandemic outbreak, drivers of the stock market were panicking responses to news related to the spread of the quickly evolving coronavirus and the measures taken by authorities. What is more, the virus was first identified in China and later in Europe (firstly in Italy) and then in the Netherlands. One may question whether the COVID-19 developments of other countries have influenced the Dutch stock market. Thus, this paper will account for the COVID-19 effects from different regions and the following sub-question is formulated:

Q2: What is the relationship between European and global (excluding Dutch) COVID-19 cases and deaths, and equity stock returns and volatility on the Amsterdam stock exchange?

The last section of the Literature Review (2.4) presented literature regarding the variance of the effect of an economic downturn on companies of different capitalization. Smaller firms are often less efficient and are, on average, riskier during economic and financial downturns while possessing a countercyclical size risk premium. Nevertheless, it may be beneficial to assess whether Subsequently, the third and final sub-question of this research is the following below:

Q3: How is the relationship between Dutch, European, and global COVID-19 cases and deaths, and equity stock returns and volatility on the Amsterdam stock exchange influenced by firm size (measured by index market capitalization)?

4. Data

All of the various explanatory, control, and response variables were used at a daily frequency. The examined time period was from 31 December 2019 until 28 July 2020. This section presents those variables divided by the categories of COVID-19 epidemiological data, Dutch stock market return data differentiated by index capitalization, macroeconomic control variables, and market sentiment control variables.

4.1. COVID-19 epidemiological data

The COVID-19 data regards both the number of new cases and new deaths in the Netherlands, Europe (excluding the Netherlands), and worldwide (excluding the Netherlands) and was extracted from the Our World in Data database (Our World in Data, 2020). The first global COVID-19 case is recorded on 31 December 2019, while the first Dutch one is from 27 February 2020. These two variables are utilized to formulate the cumulative number of total cases and total deaths in all three geographical regions examined. Furthermore, the natural logarithmic growth rate of both new cases and new deaths was formulated for the three distinct regions.

Table 2.1: Correlation coefficients of Dutch epidemiological variables regarding COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total)

Variable	Daily new cases	Daily new cases growth	Total cases	Daily new deaths	Daily new deaths growth	Total deaths
Daily new cases	1.000					
Daily new cases growth	0.108	1.000				
Total cases	-0.557	-0.144	1.000			
Daily new deaths	0.843	0.080	-0.412	1.000		
Daily new deaths growth	0.025	0.161	-0.138	0.177	1.000	
Total deaths	-0.597	-0.142	0.996	-0.442	-0.137	1.000

Based on the correlation coefficients above, it would be appropriate to use the daily new cases and total deaths in a multiple linear regression against Dutch stock returns, as multicollinearity (common with correlation of above 0.800) will be avoided. Multicollinearity may be present when regressing both daily new cases and daily new deaths, as well as total cases and total deaths, as independent variables.

Tables 2.2 and 2.3 (see Appendix) indicate the correlation coefficients of the same 6 epidemiological variables for Europe (excluding the Netherlands) and worldwide (excluding the Netherlands), which exhibit similar patterns to the Dutch data. Table 2.4 (see below) presents summary statistics regarding the six Dutch epidemiological variables (daily new, daily natural logarithmic growth rate, cumulative/total for both cases and deaths).

Table 2.4: Summary statistics for the six Dutch epidemiological variables constructed

Variable	Observations	Mean	St. dev	Minimum	Maximum	Skewness	Kurtosis
Daily new cases	147	228	312	0	1224	1.640	4.489
Daily new cases growth	104	0.050	0.420	-0.955	1.792	0.788	5.633
Total cases	147	24348	22298	0	53151	0.004	1.167
Daily new deaths	147	26.946	48.454	0	234	2.137	6.885
Daily new deaths growth	98	-0.007	0.810	-1.872	1.610	-0.251	2.410
Total deaths	147	2937	2779	0	6141	0.036	1.132

Of the six variables, all but the daily new cases and daily new deaths, demonstrate a relatively symmetrical distribution, as the data show absolute skewness values of below one. Both daily new cases and daily new deaths are relatively skewed with values of 1.640 and 2.137, respectively. All of the variables except total cases and total deaths possess a rather tailed distribution based on the kurtosis values, which range between 2.410 for daily new deaths growth and 5.633 for daily new cases growth. The number of observations for the daily new deaths growth is the least at 98, as the natural logarithmic growth rate cannot be computed when there were no deaths the day before. Overall, there were 147 observations for new cases and deaths.

Tables 2.5 and 2.6 (see Appendix) demonstrate summary statistics regarding the six epidemiological variables (daily new, daily natural logarithmic growth rate, cumulative/total for both cases and deaths) for Europe and worldwide (excluding the Netherlands). One can observe very similar conclusions and patterns in terms of skewness and kurtosis, nevertheless, naturally higher mean values and number of observations (as the first global COVID-19 case/death is before the European one, which itself is before the Dutch one).

Tables 2.7 and 2.8 (see Appendix) denote the Skewness and kurtosis test for normality described by D'Agostino, Belanger, and D'Agostino (1990) with the empirical correction developed by Royston (1991) and the Shapiro-Wilk W test for normality for each of the six Dutch epidemiological variables. Based on the former Skewness and kurtosis test, one can reject the hypothesis that the daily new cases, daily new cases growth, and daily new deaths are normally distributed as the test P-values are zero. Nevertheless, one can argue that the total deaths are normally distributed. The latter Shapiro-Wilk test indicates that we can reject the hypothesis that all the variables except daily new deaths growth are normally distributed as the test P-values are zero.

Tables 2.9 and 3.0 (see Appendix) perform the Skewness and kurtosis test for normality and the Shapiro-Wilk test for the six European (excluding the Netherlands) COVID-19 variables and Tables 3.1 and 3.2 (see Appendix) regard the same ones but for the global (excluding the Netherlands) region. One can see very similar data patterns in terms of skewness, kurtosis, and non-normality as with the Dutch data.

4.2. Dutch stock market return data differentiated by market capitalization

For its examined dependent variable, this research exploits data on the closing prices of the three main indices on the Dutch (Amsterdam) stock exchange, namely the AEX, AMX (Amsterdam Midkapindex), and AScX (Amsterdam Small Cap-Index). The AEX index comprises a maximum of 25 of the most frequently traded securities on the Euronext Amsterdam stock exchange, while the AMX index composes the 25 funds that trade on the exchange and that rank 26-50 in size (Euronext, 2020). The AScX index comprises twentyfive funds that trade on the Euronext Amsterdam exchange and that are ranked from 51 to 75 in terms of size (Euronext, 2020). The closing daily prices are transformed to returns as the natural logarithm of the ratio of the closing price on ‘t’ to that of the previous trading day ‘t-1’. Logarithmic returns are utilized as they, on average, decrease the time series variation, consequently facilitating the model fit. After weekends and holidays are considered, there are 146 observations for daily returns, derived from 147 price observations. 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 Euronext website (Euronext, 2020) provides the historical index price and return data.

Table 3.3 (see below) provides summary descriptive summary statistics for the relevant stock return data on the AEX, AMX, and AScX indices. Comparable to the Dutch COVID-19 data, all three stock market return variables demonstrate a relatively symmetrical distribution with a slight left skew (due to the negative values). Nevertheless, the absolute values of the skewness are below 1.500, thus indicating a good degree of symmetry. In addition, all three indices have a tailed distribution based on the high kurtosis values, where 8.840 is the minimum value. Subsequently, one can confirm the existence of a relatively high number of outliers, even after using a logarithmic scale. It is interesting to note that, the absolute value of the minimum return for the time period of all three indices was significantly larger than the absolute value of the maximum return. Thus, the COVID-19 period is one of extreme loss, rather than extreme gain.

Table 3.3: Summary statistics for the natural logarithmic returns of the three Dutch indices (AEX, AMX, AScX)

Variable	Observations	Mean	St. dev	Minimum	Maximum	Skewness	Kurtosis
AEX	146	-0.0004	0.0219	-0.1138	0.0859	-1.0107	9.1804
AMX	146	-0.0011	0.0246	-0.1390	0.0916	-1.4056	10.7059
AScX	146	-0.0015	0.0237	-0.1221	0.0564	-1.4877	8.8394

Furthermore, the stock returns of the AEX, AMX, and AScX are all highly correlated with each other, with values ranging from 0.842 to 0.915 (Table 3.4, see below). This can present a multicollinearity problem when the returns of two of the three indices are used as explanatory variables, to explain the returns of the third index, as each index is highly correlated with any 2 others.

Table 3.4: Correlation coefficients of the daily natural logarithmic returns of the three Dutch indices (AEX, AMX, AScX)

Variable	AEX	AMX	AScX
AEX	1.000		
AMX	0.915	1.000	
AScX	0.842	0.910	1.000

Tables 3.5 and 3.6 (see Appendix) demonstrate the Skewness and kurtosis test for and the Shapiro-Wilk W test for normality the three Dutch indices (AEX, AMX, AScX). In both tests, one can reject the hypothesis that the three variables are normally distributed as all six (three per two tests) respective test P-values are zero.

4.3. Market sentiment indicator and macroeconomic control variables

Market sentiment was incorporated by factoring the AEX Volatility Price Index (AIX), which was converted from absolute values to daily percentage change. This variable represents the market's expectation of 30-day forward-looking volatility and is derived from the price of the AEX index options, subsequently indicating a measure of market risk and investors' sentiments. Lastly, the daily change of the trading volume of all three indices examined (AEX, AMX, and AScX) were utilized as market sentiment proxies as it is a significant measure of liquidity. Increase in the AEX Volatility Price Index can explain the percentage increase in trading volume in a high AIX period, nevertheless, this is further analyzed and explored (So and Lei, 2011). A growth in trading volume and thus liquidity indicates an upsurge in investor sentiment (Baker and Stein, 2004)

There are two macroeconomic control variables that are represented. First, the daily 3-month EURIBOR / EONIA spread constitutes an interest rate determinant and obtained from European Money Markets Institute (European Money Markets Institute, 2020). The Euro Interbank Offered Rate (EURIBOR) and the Euro Overnight Index Average (EONIA) are critically important interest rate benchmarks for the eurozone and are crucial demonstrants of liquidity hoarding behavior, credit risk, central bank interventions (Osorio, 2017). Additionally, the yield spread of the 10-year Dutch bond yield and the 2-year Dutch bond yield obtained from Datastream was utilized as a fundamental indicator of real economy activity (Mody and Taylor, 2003). Finally, the prices of the MSCI World Index were obtained from the MSCI database (MSCI, 2020), which were transformed to natural logarithmic returns based on the natural logarithm of the ratio of the closing price on a trading that to that of the previous trading day.

5. Methodology

5.1. The relationship between COVID-19 and Dutch stock returns

Firstly, an ordinary least-squares (OLS) regression is performed, where the number of COVID-19 new cases and total (i.e. cumulative) deaths in the Netherlands is regressed independently on the stock returns of the three indices (AEX, AMX, AScX). The model includes dummy variables for weekday (ranging from 1 to 5 as there are no weekend trading days) to account for day-of-the-week effects. This is represented in the following three equations for each of the Dutch equity indices:

$$ReturnIndex = constant + b_1 * NewDutchCases + b_2 * TotalDutchDeaths + b_3 * Weekday + \varepsilon$$

Secondly, the research examines the relationship between the European and global (excluding the Netherlands) COVID-19 cases and deaths on the three Dutch stock indices, with the following model that also includes dummy variables for weekday:

$$ReturnSectorIndex = constant + b_1 * NewEUCases + b_2 * TotalEUDeaths + b_3 * NewGlobalCasesGrowth + b_4 * NewGlobalDeathsGrowth + b_5 * Weekday + \varepsilon$$

A third model includes as explanatory variables, the COVID-19 cases and deaths of all three regions on the Dutch equity returns, in the following manner:

$$ReturnIndex = constant + b_1 * NewDutchCases + b_2 * TotalDutchDeaths + b_3 * NewEUCasesGrowth + b_4 * TotalEUDeathsGrowth + b_5 * NewGlobalCasesGrowth + b_6 * NewGlobalDeathsGrowth + b_7 * Weekday + \varepsilon$$

Subsequently, the regression model includes the control variables for investor sentiment, namely the daily percentage change of the AIX index and the daily percentage change of the trading volume of the examined index, producing the equation below. Furthermore, the three control explanatory macroeconomic variables are added as independent variables, namely the 3-month EURIBOR / EONIA spread, the yield spread of the 10-year Dutch bond yield and the 2-year Dutch bond yield, and the logarithmic returns of the MSCI World Index. The following equation is produced:

$$ReturnIndex = constant + b_1 * NewDutchCases + b_2 * TotalDutchDeaths + b_3 * NewEUCasesGrowth + b_4 * TotalEUDeathsGrowth + b_5 * NewGlobalCasesGrowth + b_6 * NewGlobalDeathsGrowth + b_7 * IndexVolumeChange + b_8 * AIXPercChange + b_9 * MSCIReturn + b_{10} * EURIBOREONIA + b_{11} * Bondyield + b_{12} * Weekday + \varepsilon$$

All of the regressions employ Eicker-Huber-White heteroskedasticity consistent standard errors to account for the heteroskedastic data in the stock returns. The robust standard errors are utilized as the summary descriptive statistics in the Data section demonstrated slight issues with heteroskedasticity, and normality. Several post-regression diagnostic tests are performed. One is the Breusch-Pagan (1979) and Cook-Weisberg (1983) test for linear heteroskedasticity where the heteroskedasticity consistent standard errors are not utilized. The null hypothesis of that test is that the error variances are all equal and constant. A second post-regression diagnostic test is the variance inflation factor (VIF) test for multicollinearity, where the null hypothesis is that an independent, explanatory variable in a multiple regression model can be linearly explained from the others. Severe multicollinearity can be a significant issue as it can increase the variance of the coefficient estimates and make them highly sensitive to slight model alternations (Stine, 1995). Subsequently, the coefficient estimates of the multiple regression may be unstable and hard to interpret and analyze. The most relevant models are chosen in a way to ensure that the VIF value is below 10 as suggested by Hair et al. (1995).

5.2. The relationship between COVID-19 and Dutch stock volatility

To examine the effect of COVID-19 on the volatility of the three Dutch stock indices, firstly, a multiple ordinary least-squares (OLS) regression is performed. In that model, the independent variables are the COVID-19 cases and deaths for all three regions, the sentiment and macroeconomic control variables, and the weekday dummy. The dependent variable is the 20-day rolling standard deviation of the specific index price, producing the following model.

$$
\begin{aligned}
&StandardDeviationPriceIndex \\
&\quad = constant + b_1 * NewDutchCases + b_2 * TotalDutchDeaths + b_3 \\
&\quad * NewEUCasesGrowth + b_4 * TotalEUDeathsGrowth + b_5 \\
&\quad * NewGlobalCasesGrowth + b_6 * NewGlobalDeathsGrowth + b_7 \\
&\quad * IndexVolumeChange + b_8 * AIXRPercChange + b_9 * MSCIReturn + b_{10} \\
&\quad * EURIBOREONIA + b_{11} * Bondyield + b_{12} * Weekday + \varepsilon
\end{aligned}
$$

Afterwards, to commence the time series analysis, a Phillips-Perron (1988) test for unit roots is performed on the returns of the three Dutch indices to test for stationarity, which is required for a valid time series analysis. The null hypothesis of the test is that the time series possesses a unit root, and the alternative is that the variable for the index return was generated by a stationary process. The Phillips-Perron test utilizes Newey–West (1987) standard errors to take into respect serial correlation, whereas the augmented Dickey–Fuller (ADF) test implemented utilizes additional lags of the first-differenced variable. Two versions are utilized, for each of the three indices, with 5 or 10 Newey-West lags.

Subsequently, for examining the volatility of the returns of the three Dutch indices, a Generalized autoregressive conditional heteroskedasticity model (GARCH) is utilized as described in Bollerslev (1986), as a variation of Engle's (1982) ARCH model. Namugaya (2014) suggests that the GARCH (1,1) model performs the best at volatility modelling, where the model incorporates one autoregressive lag and one lag in the moving average portion of the variable. Essentially, the following GARCH (1,1) model predicts the variance in the current period by forming a weighted average of a long-term average, the variance forecasted in the previous period, and the volatility observed in the previous period. The following is the equation concerning the conditional variance:

$$h_t = \omega + \alpha_1 * \varepsilon^2{}_{t-1} + \beta_1 * h_{t-1}$$

The formula for the conditional mean is represented by:

$$y_t = \mu + \varepsilon_t \, , \, \varepsilon_t \ \sim N(0, h_t) \, ,$$

In this model, "y_t" is the mean, "h_t" is the conditional variance, "μ" and "ω" are constants, "α_1" is the ARCH term, "β_1" is the GARCH term, and "ε_t" is the error term.

6. Results

6.1. The relationship between COVID-19 and Dutch stock returns

Table 3.7 (see Appendix) presents the first ordinary least-squares (OLS) regression where the new daily new Dutch COVID-19 cases and the total Dutch COVID-19 deaths are regressed on the daily natural logarithmic return of the AEX index. The regression includes an independent dummy variable for the weekday (to account for day-of-the-week effect). One can argue that the model presents a bad fit as the regression coefficient of determination (i.e. the R-squared value) is solely 0.069, meaning that only 6.9% of the variance of the AEX return is predictable from the independent variables in the regression. Furthermore, only the coefficient for the new COVID-19 cases is significant at the 10% level, with a t-value of 1.76 and a P-value of 0.081. The beta coefficient is quite low at 0.00001, nevertheless, positive, which presents interesting implications that new COVID-19 cases increase AEX returns. The rest of the coefficients are all insignificant. Furthermore, none of the weekdays are statistically significant, including Monday (Weekday 1), whose significance is represented by the P-value of the constant (0.171). Thus, one can state that the AEX index is rather efficient and is not affected by anomalies such as the day-of-the-week effect.

Table 3.8 (see Appendix) regards the same independent variables as in Table 3.7 (see Appendix) regressed on the returns on the AMX index. This model also demonstrates a low R-squared value of 0.077. None of the coefficients are statistically significant except those of the constant, which denotes Monday, and the one for Tuesday (Weekday 2). In addition, the coefficient for Tuesday is positive at 0.015, while the one for Monday (represented by the regression intercept) is negative at -0.012. Thus, one can argue that the returns on the AMX index are more heavily influenced by day-of-the week effects that those of the AEX. AMX returns are, on average, lower on Mondays and higher on Tuesdays.

Table 3.9 (see Appendix) presents the regression of daily Dutch COVID-19 cases and the total Dutch COVID-19 deaths are regressed on the daily natural logarithmic return of the AScX index. The coefficient of determination is still very low at 0.064, indicating a bad model fit. Furthermore, only the total deaths are significant at the 10% significance level, with a P-value of 0.047. In addition, none of the weekdays are statistically significant.

Overall, one can argue the three regression models described above indicate a relatively poor model fit. Nonetheless, Table 4.0 (see Appendix) demonstrates that there are no multicollinearity issues, as the variance inflation factor (VIF) for each independent variable is below 2 and the mean VIF is 1.41.

Table 4.1 (see Appendix) presents an OLS regression where the dependent variable is the return of the AEX index and the independent variables are the daily new European cases, the total

European cases, the daily growth rate of new global cases, the daily growth rate of new global deaths, and a weekday dummy. The model is still a relatively poor fit with a R-squared value of 0.098. Only the coefficient of the daily new European cases is significant at the 10% significance level with a t-value of 2.18 and a respective P-value of 0.031. Tables 4.2 and Tables 4.3 (see Appendix) regress the former independent variables on the AMX and AScX indices, respectively and separately. The regression on the AMX index presents similar results as the AEX one albeit with a slightly higher R-squared value of 0.105. Again, the daily new European cases are statistically significant, at a t-value of 1.74 and P-value of 0.085. Furthermore, Monday (indicated by the intercept term) is negatively correlated with AMX returns at a coefficient of -0.015 (P-value of 0.026) and Tuesday is positively correlated with AMX returns at a coefficient of 0.0163 (P-value of 0.019).

It is interesting to note that for the two regressions on both the AEX index and the AMX index, the daily new European cases are positively and significantly correlated with returns on the two respective indices, albeit at a small coefficient. Thus, perhaps there exist a "COVID-19 risk premium", which can cause higher equity returns. Nevertheless, for the AScX regression, none of the variables is proven statistically significant. Table 4.4 (see Appendix) demonstrates that there are no multicollinearity issues as the highest value is 1.73, with a mean VIF value of 1.46.

Table 4.5 (see Appendix) presents the results of the OLS regression where the COVID-19 cases and deaths for all three regions examined are included as multiple explanatory variables. The dependent variable is the AEX return and the explanatory variables are the daily new Dutch cases, the total Dutch deaths, the daily growth rate of new European cases, the daily growth rate of new European deaths, the daily growth rate of new global cases, the daily growth rate of new global deaths, and a weekday dummy. As data for all three regions is combined as separate independent variables, the R-squared value of the model is increased to 0.191. The sole statistically significant coefficients at the 5% significance level are those for the daily new Dutch cases (t-value of 2.22 and P-value of 0.029) and the daily growth rate of European cases (t-value of -2.56 and P-value of 0.012). The new Dutch cases are positively correlated with AEX returns at a very low beta coefficient of 0.00002, nonetheless, the growth rate of new European cases is more strongly negatively correlated to AEX returns at a beta coefficient of -0.011. Furthermore, the intercept is significant at the 10% significance level with a P-value of 0.096 and a negative coefficient of -0.012, meaning that on Mondays, AEX returns are, on average, lower.

Table 4.6 (see Appendix) demonstrates the regression of the independent variables from the previous one (Table 4.5, see Appendix) on the AMX returns. Again, the new Dutch cases are positively and significantly correlated with AMX returns and the growth rate of new European cases is negatively and significantly correlated with AMX returns (at P-values of 0.057 and 0.017, respectively). However, in addition, the growth rate of new global deaths is further negatively and significantly correlated with AMX returns at a t-value of -2.49 (P-value of 0.014). As with the previous regressions on the AMX index' returns, the dummy variables for Monday and Tuesday are significant with similar directions as stated before.

Table 4.7 (see Appendix) regards the returns on the AScX and the independent variables from Tables 4.5 and 4.6 (see Appendix). As with the other two indices, the new Dutch cases are positively and significantly correlated with AScX returns and the growth rate of new European cases is negatively and significantly correlated with AScX returns (at P-values of 0.070 and 0.017, respectively). As with the AMX index, albeit at a slightly lower degree, the daily growth rate of new global deaths is further negatively and significantly correlated with AScX returns at a t-value of -1.87 (P-value of 0.064). Table 4.8 (see Appendix) demonstrates no presence of multicollinearity as the highest value is 2.58 and regards Wednesday, with a mean VIF of 1.66 for the independent variables.

Then, the research adds the control variables mentioned in the Data and Methodology sections as additional independent variables to the ones used in Tables 4.5 to 4.7 (see Appendix). Thus, the independent variables are the daily new Dutch cases, the total Dutch deaths, the daily growth rate of new European cases, the daily growth rate of new European deaths, the daily growth rate of new global cases, the daily growth rate of new global deaths, the percentage change of the respective index volume, the change of the AIX, the return of the MSCI index, the EURIBOR-EONIA spread, the Dutch bond yield spread, and a weekday dummy. The dependent variable is the return of the AEX index for Table 4.9 (see Appendix), that of the AMX for Table 5.0 (see Appendix), and that of the AScX for Table 5.1 (see Appendix).

Table 4.9 (see Appendix) presents a better model fit at a R-squared of 0.508, albeit perhaps artificially increased with the high number of explanatory variables in the model. All of the variables are statistically insignificant, except the change of the AIX and the return of the MSCI index at P-values of 0.034 and 0.002, respectively. The returns of the MSCI World index are positively correlated with those of the AEX at a high coefficient of 0.390 (t-value of 3.26), further proving that the Dutch financial markets are strongly linked to the global ones. Thus, perhaps logically, purely financial variables such as the change or return of a distinct index, affect the AEX index the most.

Table 5.0 (see Appendix) regards the returns on the AMX where, again the AIX change and the return of the MSCI index are statistically significant. The MSCI returns are even more relevant with a high coefficient of 0.483 (P-value of 0.001). Additionally, the change of the trading volume of the AMX index is positively correlated with AMX returns (P-value of 0.030). There are no day-of-the-week effects for the AMX index in this model, compared to the previous ones regarding that index examined above. Furthermore, none of the six epidemiological variables are statistically significant.

For the AScX index, the change of the index trading volume, the change of the AIX, and the return of the MSCI are further significant, similarly to the AMX index in Table 5.0 (see Appendix). Nevertheless, the growth rate of global new cases is negatively and statistically correlated with AScX returns at a coefficient of -0.014 with a P-value of 0.076, significant at the 10% level (Table 5.1, see Appendix). Table 5.2 (see Appendix) demonstrates that there are no multicollinearity issues regarding the models from Tables 5.0-5.2, where the highest VIF is 2.21 and the mean VIF is 1.76.

6.2. The relationship between COVID-19 and Dutch stock volatility

Tables 5.3 to 5.5 (see Appendix) regress the independent variables from Tables 4.9-5.1 (see Appendix), respectively, on the 20-day rolling standard deviation of each of the three indices. Regarding all three indices, the three models exhibit a relatively good fit at coefficients of determination of 0.699, 0.648, and 0.602 for the AEX, AMX, and AScX, respectively. For all three indices, both the daily new Dutch cases and total Dutch deaths are highly statistically significant at P-values of 0.000. The t-values of the daily new Dutch cases are positive at 4.06, 3.38, and 5.50 for the AEX, AMX, and AScX, respectively. Again, this may indicate a potential risk premium for new Dutch COVID-19 cases. The t-values of the total Dutch deaths are -5.98, -6.15, and -4.45 for the AEX, AMX, and AScX, respectively. It is perplexing as to why new Dutch COVID-19 cases are strongly correlated with higher Dutch stock price volatility, but the total Dutch deaths are strongly correlated with lower Dutch stock price volatility. In addition, the beta coefficient of the new Dutch cases decreased with firm size as it was highest in the regression on the volatility of the AScX (0.065), lower for the AMX volatility (0.032), and lowest with regards to the AEX volatility (0.019). The same holds true for the beta coefficient of the cumulative Dutch COVID-19 deaths, which may indicate potential size effects to Dutch equity volatilty. Furthermore, for all three indices, the macroeconomic variables for the EURIBOR-EONIA spread and the Dutch bond yield spread are significant at the 5% significance level. Thus, perhaps the macroeconomic environment, has a stronger relationship with Dutch equity volatility, than with Dutch equity returns. What is further interesting is that, the EURIBOR-EONIA spread is extremely highly correlated to the price volatility of all three indices, with beta coefficients of -41.712, -95.744, and -158.440 for all three indices. In addition, the growth rate of global COVID-19 cases is very highly and significantly associated with Dutch stock volatility for all three indices. Table 5.6 (see Appendix) indicates a highest VIF value of 2.79 (for Wednesday), thus one can reject the presence of multicollinearity.

Tables 5.7 and 5.8 (see Appendix) illustrate the Phillips–Perron test for unit roots for the AEX returns at 5 and 10 Newey-West lags, respectively. As the P-values of both tests are zero, one can reject the null hypothesis that the AEX return 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 significance values of zero regarding both 5 and 10 Newey-West lags (Tables 5.9 and 6.0 for AMX and Tables 6.1 and 6.2 for AScX, see Appendix).

Tables 6.3 to 6.5 (see Appendix) present the results of the GARCH (1,1) model for the AEX, the AMX, and the AScX index, respectively. In the GARCH (1,1) model concerning the AEX index, the estimate of the lagged value of the error term is 0.429 and the coefficient of the lagged variance is 0.567 (Table 6.3, see Appendix). In addition, the two P-values are all significant at the 5% significance level, subsequently the volatility of the returns of the AEX index can be estimated based on past data. Essentially, the highly significant coefficient 0.567 of the GARCH (-1) implies persistent volatility clustering. In addition, the sum of the ARCH and GARCH coefficients approximates one (0.996), indicating that volatility shocks are quite persistent, which is regularly observed in daily equity return data.

The same implications hold for the AMX index, where the lagged value of the error term is estimated at 0.317 and the coefficient of the lagged variance is 0.774. 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 4.6 (see below) indicates that the AScX index demonstrates similar results, where the lagged value of the error term is estimated at 0.603 and the coefficient of the lagged variance is 0.603. Both lagged values are significant and subsequently for AMX current volatility can be derived from previous volatility that perseveres over time. For both the AMX and the AScX index, the sum of the ARCH and GARCH coefficients approximate one, signifying the existence of persistent volatility shocks.

7. Conclusion and Discussion

7.1. Conclusion

This researched aimed to answer the question of: *What is the relationship between COVID-19 cases and deaths and the returns and volatility on the Amsterdam Stock Exchange*? After deriving and inspecting the statistical results, one can produce an answer to the main research question stated above and its related sub-questions mentioned in the Theoretical Framework of this paper.

The first sub-question of this research is: *What is the relationship between Dutch COVID-19 cases and deaths, and equity stock returns and volatility on the Amsterdam stock exchange?* Fundamentally, the results denoted in the previous section indicate that when controlling for variables such as the return on the MSCI World index and the daily percentage change of the AEX

Volatility Index (AEX), there is no statistically significant relationship between Dutch COVID-19 cases and deaths, and equity returns on the Euronext Amsterdam stock exchange. Nevertheless, both the daily new Dutch coronavirus cases and the cumulative Dutch coronavirus deaths are significantly related to the volatility of the three indices. Perhaps interestingly, the new Dutch cases are positively associated with index returns' volatility while the cumulative Dutch deaths are negatively correlated. One can argue that there may be a short-term (i.e. daily) equity risk premium for new domestic cases. Perhaps more intuitively, that the number of cumulative death cases are associated with decreased stock returns, on average. It is worth to note that, all three indices exhibit persistent volatility clustering as exhibited by the GARCH (1,1) analyses.

The second sub-question of this research is: *What is the relationship between European and global (excluding Dutch) COVID-19 cases and deaths, and equity stock returns and volatility on the Amsterdam stock exchange?* Essentially, the results described in the previous section imply that when controlling for variables such as the return on the MSCI World index and the daily percentage change of the AEX Volatility Index (AEX), there is no statistically significant relationship between European and global (excluding the Netherlands) COVID-19 cases and deaths, and equity returns on the Euronext Amsterdam stock exchange. Only for the AScX index, the daily growth of new global coronavirus cases is statistically significant (at the 10% level) and negatively correlated with AScX returns. Perhaps, this can be due to the fact that the AScX index comprises small-capitalization firms, which can be more inefficient in their stock pricing due to illiquidity, lower investor attention, and general mispricing. Concerning volatility, only the growth rate of global COVID-19 cases is very highly and significantly associated with Dutch stock volatility for all three indices. It is interesting that Dutch equities seem to statistically correlate with global (unlike European) and new cases growth (rather than new deaths growth). One can state that this may be due to the media attention on the large number of global COVID-19 cases, which can reach investors and thus, associate with Dutch equity returns. On a further note, investors in the Dutch equity market that are not residing in the Netherlands or Europe but globally, for example in big economies such as the U.S.A. and China, can experience the growth of the cases outside Europe in a higher degree. Thus, the returns of the three Dutch indices may be lower, as foreign (e.g. U.S. or Chinese) investors' behavior will be affected by the coronavirus.

The third and final sub-question of this research is: *How is the relationship between Dutch, European, and global COVID-19 cases and deaths, and equity stock returns and volatility on the Amsterdam stock exchange influenced by firm size (measured by index market capitalization)?* As theorized in the Literature Review section of this paper, smaller firms can be more inefficient and may possess a countercyclical risk premium. Furthermore, due to their inefficiencies, smaller firms can be more volatile in their price, and thus returns. Thus, it was contributive to examine the behavior of large-, mid-, and small-capitalization companies on the Euronext Amsterdam stock exchange. Regarding index returns, overall, in a given econometric model, the relationships for all three indices were rather similar in terms of their independent variables. The AMX index demonstrated strong and significant day-of-the-week effects in prior models, but when controlling for investor sentiment and macroeconomic variables, there were no day-of-the-week anomalies. In a specific econometric regression model with equity returns as dependent variable, for all three indices, relatively the same variables were statistically significant, having the same relationship sign. Thus, one can argue that the relationship between COVID-19 cases and deaths and index returns is not significantly influenced by firm size (measured by market capitalization). Nonetheless, there were significant size effects present with regards to volatility. The volatility of the AScX index was much more heavily influenced by the new Dutch coronavirus cases and cumulative Dutch coronavirus deaths, than the AMX index, which was more strongly influenced than the AEX index, in its regard (Tables 5.3 to 5.5, see Appendix). Thus, the volatility of smaller Dutch companies is more heavily associated with domestic (Dutch) COVID-19 cases and deaths, than that of larger firms.

7.2. Limitations and suggestions for additional research

One can cogitate on the limitations of this paper and on suggestion for further research. Firstly, perhaps by nature, a limitation of this research is the small sample size due to the relatively recent data regarding the coronavirus. Overall, there were less than 200 observations, which can be deemed relatively low, given the amount of explanatory (including control) variables utilized in this research’s econometric regression models. A suggestion may be to search for data at an even higher frequency such as reported hourly COVID-19 cases (which are reported by the Dutch National Institute for Public Health and the Environment (*RIVM* in Dutch). Then, researchers can perform mixed data sampling (MIDAS) methods. Nevertheless, higher frequency can produce a noisier data.

Secondly, this research does not examine specific countries beside the Netherlands. Further studies can expand examine the relationship between COVID-19 cases and deaths, and equity returns for different geographies and concrete countries. It may prove interesting to examine the relationship in a large non-European market such as the United States of America, China, or Japan.

Thirdly, future research can not only examine the association between COVID-19 cases and deaths, and equity returns, but also scrutinize yields on the bond market. It may be beneficial and contributive to inspect how the markets for bonds issued evolved as the coronavirus crisis developed and how the demand for liquidity affected the market. Furthermore, the relationship between COVID-19 cases and deaths and the returns on more illiquid asset classes such as real estate and farmland may be examined.

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Appendix

Figure 1.2: The price development of S&P 500 index from 2 January 2020 until 2 July 2020 (numbers in euro)

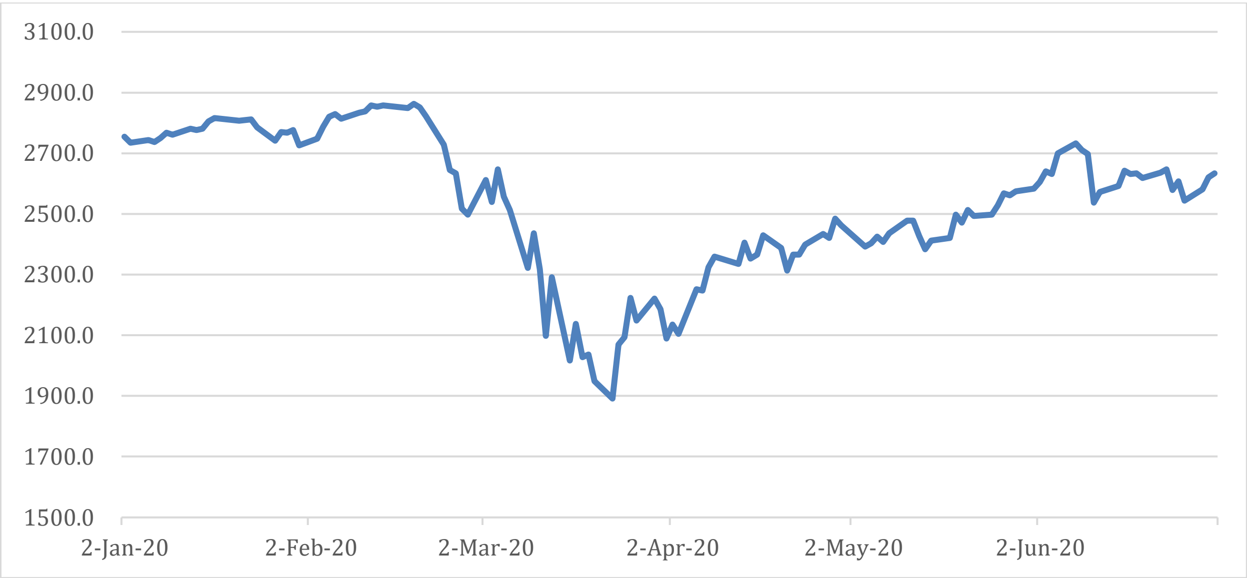

Table 2.2: Correlation coefficients of European (excluding the Netherlands) epidemiological variables regarding COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

Variable	Daily new cases	Daily new cases growth	Total cases	Daily new deaths	Daily new deaths growth	Total deaths
Daily new cases	1.000					
Daily new cases growth	-0.241	1.000				
Total cases	0.208	-0.270	1.000			
Daily new deaths	0.836	-0.152	-0.178	1.000		
Daily new deaths growth	-0.143	0.067	-0.238	0.004	1.000	
Total deaths	0.253	-0.288	0.985	-0.117	-0.255	1.000

Table 2.3: Correlation coefficients of global (excluding the Netherlands) epidemiological variables regarding COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

Variable	Daily new cases	Daily new cases growth	Total cases	Daily new deaths	Daily new deaths growth	Total deaths
Daily new cases	1.000					
Daily new cases growth	-0.173	1.000				
Total cases	0.966	-0.175	1.000			
Daily new deaths	0.735	-0.174	0.589	1.000		
Daily new deaths growth	-0.010	0.322	-0.111	0.022	1.000	
Total deaths	0.958	-0.196	0.977	0.658	-0.125	1.000

Table 2.5: Summary statistics for the six European (excluding the Netherlands) epidemiological variables constructed regarding COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

Variable	Observations	Mean	St. dev	Minimum	Maximum	Skewness	Kurtosis
Daily new cases	147	12394	10398	0	36166	0.1573	1.9058
Daily new cases growth	124	0.073	0.422	-1.099	1.946	1.3187	8.1392
Total cases	147	992582	985876	0	2711008	0.3217	1.4817
Daily new deaths	147	843	1108	0	5123	1.5936	4.8327
Daily new deaths growth	147	0.050	0.459	-1.609	1.332	-0.1860	4.1464
Total deaths	111	83885	81339	0	194807	0.1302	1.2062

Table 2.6: Summary statistics for the six global (excluding the Netherlands) epidemiological variables constructed regarding COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

Variable	Observations	Mean	St. dev	Minimum	Maximum	Skewness	Kurtosis
Daily new cases	147	75905	75007	1	282052	0.7715	2.6723
Daily new cases growth	146	0.061	0.459	-1.792	2.035	0.3938	10.0322
Total cases	147	3921537	4698956	27	1.64e+07	1.0529	2.9338
Daily new deaths	147	2991	2636	0	10323	0.2602	1.9894
Daily new deaths growth	136	0.062	0.513	-2.976	2.099	-1.3198	14.0167
Total deaths	147	203271	216818	0	647739	0.5457	1.7989

Table 2.7: Skewness-Kurtosis test for Dutch COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

				---------- joint ----------	
Variable	Observations	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
Daily new cases	147	0.000	0.007	35.24	0.000
Daily new cases growth	104	0.002	0.000	16.60	0.000
Total cases	147	0.983	-	-	-
Daily new deaths	147	0.000	0.000	53.92	0.000
Daily new deaths growth	98	0.285	0.159	3.22	0.200
Total deaths	147	0.853	-	-	-

Table 2.8: Shapiro-Wilk test of normality for Dutch COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

Variable	Observations	W-value	V-value	z-score	Prob>z
Daily new cases	147	0.765	26.864	7.453	0.000
Daily new cases growth	104	0.956	3.759	2.944	0.002
Total cases	147	0.810	21.793	6.979	0.000
Daily new deaths	147	0.670	37.682	8.219	0.000
Daily new deaths growth	98	0.983	1.366	0.692	0.245
Total deaths	147	0.785	24.544	7.249	0.000

Table 2.9: Skewness-Kurtosis test for European (excluding the Netherlands) COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

				---------- joint ----------	
Variable	Observations	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
Daily new cases	147	0.418	0.000	27.69	0.000
Daily new cases growth	124	0.000	0.000	35.25	0.000
Total cases	147	0.103	0.000	-	-
Daily new deaths	147	0.000	0.002	35.63	0.000
Daily new deaths growth	111	0.400	0.033	5.18	0.075
Total deaths	147	0.502	-	-	-

Table 3.0: Shapiro-Wilk test of normality for European (excluding the Netherlands) COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

Variable	Observations	W-value	V-value	z-score	Prob>z
Daily new cases	147	0.903	11.085	5.448	0.000
Daily new cases growth	124	0.810	18.785	6.583	0.000
Total cases	147	0.842	18.101	6.558	0.000
Daily new deaths	147	0.794	23.610	7.160	0.000
Daily new deaths growth	111	0.981	1.698	1.181	0.119
Total deaths	147	0.803	22.564	7.057	0.000

Table 3.1: Skewness-Kurtosis test for global (excluding the Netherlands) COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

				---------- joint ----------	
Variable	Observations	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
Daily new cases	147	0.000	0.464	11.54	0.000
Daily new cases growth	146	0.049	0.000	26.52	0.000
Total cases	147	0.000	0.924	17.22	0.000
Daily new deaths	147	0.184	0.000	20.56	0.000
Daily new deaths growth	136	0.000	0.000	48.23	0.000
Total deaths	147	0.008	0.000	49.04	0.000

Table 3.2: Shapiro-Wilk test of normality for global (excluding the Netherlands) COVID-19 related cases and deaths (daily new, daily natural logarithmic growth rate, cumulative/total) from 2 January 2020 until 28 July 2020

Variable	Observations	W-value	V-value	z-score	Prob>z
Daily new cases	147	0.877	14.018	5.980	0.000
Daily new cases growth	146	0.773	25.837	7.362	0.000
Total cases	147	0.812	21.478	6.945	0.000
Daily new deaths	147	0.879	13.879	5.957	0.000
Daily new deaths growth	136	0.828	18.449	6.575	0.000
Total deaths	147	0.827	19.783	6.760	0.000

Table 3.5: Skewness-Kurtosis test of the daily natural logarithmic returns of the three Dutch indices (AEX, AMX, AScX) from 2 January 2020 until 28 July 2020

				---------- joint ----------	
Variable	Observations	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
AEX	146	0.000	0.000	35.90	0.000
AMX	146	0.000	0.000	47.43	0.000
AScX	146	0.000	0.000	45.31	0.000

Table 3.6: Shapiro-Wilk test of normality of the daily natural logarithmic returns of the three Dutch indices (AEX, AMX, AScX) from 2 January 2020 until 28 July 2020

Variable	Observations	W-value	V-value	z-score	Prob>z
AEX	146	0.900	11.275	5.484	0.000
AMX	146	0.877	13.964	5.969	0.000
AScX	146	0.886	13.057	5.816	0.000

Table 3.7: Regression of daily new Dutch cases and total Dutch deaths on AEX returns

Number of observations	=	146
F(6,139)	=	1.58
Prob > F	=	0.157
R-squared	=	0.069
Root MSE	=	0.022

AEX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	.00001	5.99e-06	1.76	0.081	-1.31e-06	.00002
Total Dutch deaths	8.15e-07	6.34e-07	1.29	0.201	-4.38e-07	2.07e-06
Weekday						
2	.009	.006	1.63	0.105	-.002	.021
3	.002	.006	0.41	0.682	-.009	.013
4	-.002	.006	-0.29	0.775	-.015	.011
5	-.001	.005	-0.22	0.827	-.012	.009
Constant	-.007	.005	-1.38	0.171	-.017	.003

Table 3.8: Regression of daily new Dutch cases and total Dutch deaths on AMX returns

Number of observations	=	146
F(6,139)	=	1.67
Prob > F	=	0.133
R-squared	=	0.077
Root MSE	=	0.024

AMX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf.	Interval]
Daily new Dutch cases	8.46e-06	6.58e-06	1.29	0.200	-4.54e-06	.00002
Total Dutch deaths	1.12e-06	7.09e-07	1.58	0.117	-2.85e-07	2.52e-06
Weekday						
2	.015	.006	2.52	0.017	.003	.028
3	.005	.006	0.80	0.423	-.007	.018
4	.001	.007	0.18	0.861	-.013	.015
5	.005	.006	1.01	0.316	-.006	.018
Constant	-.012	.006	-2.05	0.042	-.023	.001

Table 3.9: Regression of daily new Dutch cases and total Dutch deaths on AScX returns

			Number of observations	=		146
			F(6,139)	=		1.53
			Prob > F	=		0.174
			R-squared	=		0.064
			Root MSE	=		0.023

AScX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	7..26e-06	6.77e-06	1.07	0.285	-6.12e-06	.00002
Total Dutch deaths	1.37e-06	6.81e-07	2.01	0.047	1.97e-08	2.71e-06
Weekday						
2	.009	.006	1.36	0.177	-.004	.021
3	.002	.007	0.31	0.757	-.011	.015
4	-.003	.007	-0.41	0.685	-.017	.011
5	.000	.006	0.01	0.995	-.012	.012
Constant	-.009	.006	-1.41	0.160	-.021	.004

Table 4.0: Variance inflation factor (VIF) values for the explanatory variables from Tables 3.7-3.9

Variable	VIF	1/VIF
Daily New Dutch cases	1.00	0.997
Total Dutch deaths	1.00	0.998
Weekday		
2	1.62	0.618
3	1.60	0.624
4	1.62	0.618
5	1.59	0.629
Mean VIF	1.41	

Table 4.1: Regression of daily new European cases, total European deaths, daily new global cases growth, and daily new deaths growth on AEX returns

			Number of observations	=		136
			F(6,139)	=		1.34
			Prob > F	=		0.228
			R-squared	=		0.098
			Root MSE	=		0.022

AEX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new EUR cases	4.79e-07	2.20e-07	2.18	0.031	4.36e-08	9.13e-07
Total EUR deaths	-1.26e-09	2.69e-08	-0.05	0.963	-5.45e-08	5.20e-08
Daily new World cases growth	.0003	.004	0.08	0.939	-.007	.007
Daily new World deaths growth	-.005	.003	-1.54	0.126	-.012	.001
Weekday						
2	.010	.006	1.63	0.105	-.002	.022
3	.005	.007	0.7	0.486	-.008	.017
4	-.002	.007	-0.28	0.777	-.015	.012
5	-.0004	.006	0.06	0.949	-.012	.011
Constant	-.009	.006	-1.58	0.116	-.020	.002

Table 4.2: Regression of daily new European cases, total European deaths, daily new global cases growth, and daily new deaths growth on AMX returns

Number of observations	=	136
F(6,139)	=	1.37
Prob > F	=	0.215
R-squared	=	0.105
Root MSE	=	0.025

AMX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new EUR cases	4.27e-07	2.46e-07	1.73	0.085	-5.90e-08	9.13e-07
Total EUR deaths	1.54e-08	2.92e-08	0.53	0.599	-4.24e-08	7.31e-08
Daily new World cases growth	.0005	.004	0.12	0.906	-.008	.009
Daily new World deaths growth	-.005	.003	-1.38	0.169	-.012	.002
Weekday						
2	.016	.007	2.39	0.019	-.003	.030
3	.007	.007	0.95	0.342	-.008	.022
4	.001	.008	0.15	0.881	-.014	.016
5	.006	.006	1.10	0.274	-.006	.020
Constant	-.015	.006	-2.26	0.026	-.027	-.002

Table 4.3: Regression of daily new European cases, total European deaths, daily new global cases growth, and daily new deaths growth on AScX returns

Number of observations	=	136
F(6,139)	=	1.29
Prob > F	=	0.256
R-squared	=	0.093
Root MSE	=	0.024

AScX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf.	Interval]
Daily new EUR cases	3.42e-07	2.41e-07	1.42	0.159	-1.36e-07	8.20e-07
Total EUR deaths	2.45e-08	2.88e-08	0.85	0.397	-3.26e-08	8.15e-08
Daily new World cases growth	-.002	.004	-0.45	0.656	-.010	.006
Daily new World deaths growth	-.005	.004	-1.37	0.172	-.013	.002
Weekday						
2	.010	.007	1.39	0.167	-.004	.024
3	.004	.008	0.54	0.588	-.011	.020
4	-.003	.008	-0.40	0.690	-.018	.012
5	.001	.007	0.19	0.849	-.012	.014
Constant	-.011	.007	-1.51	0.133	-.024	.003

Table 4.4: Variance inflation factor (VIF) values of the explanatory variables from Tables 4.1-4.3

Variable	VIF	1/VIF
Daily New Dutch cases	1.32	0.758
Total Dutch deaths	1.32	0.756
Daily new World cases growth	1.18	0.846
Daily new World deaths growth	1.22	0.818
Weekday		
2	1.64	0.610
3	1.74	0.578
4	1.63	0.612
5	1.60	0.626
Mean VIF	1.46	

Table 4.5: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth on AEX returns

			Number of observations	=		111
			F(6,139)	=		2.40
			Prob > F	=		0.013
			R-squared	=		0.191
			Root MSE	=		0.023

AEX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	.000	7.14e-06	2.22	0.029	1.70e-06	.000
Total Dutch deaths	1.05e-06	1.03e-06	1.02	0.308	-9.86e-07	3.09e-06
Daily new EUR cases growth	-.011	.004	-2.56	0.012	-.020	8.20e-07
Daily new EUR deaths growth	-.003	.005	-0.58	0.564	-.013	8.15e-08
Daily new World cases growth	-.012	.12	-1.01	0.315	-.035	.006
Daily new World deaths growth	-.012	.005	-2.45	0.016	-.021	.002
Weekday						
2	.013	.007	1.74	0.086	-.002	.027
3	.007	.008	0.88	0.381	-.009	.024
4	-.007	.008	-0.08	0.936	-.017	.016
5	.002	.007	0.32	0.752	-.012	.017
Constant	-.013	.007	-1.68	0.096	-.027	.002

Table 4.6: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth on AMX returns

Number of observations	=	111
F(6,139)	=	2.35
Prob > F	=	0.016
R-squared	=	0.223
Root MSE	=	0.025

AMX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	.000	8.19e-06	1.93	0.057	-4.73e-07	.000
Total Dutch deaths	1.54e-06	1.15e-06	1.34	0.183	-7.40e-07	3.82e-06
Daily new EUR cases growth	-.013	.005	-2.42	0.017	-.023	-.002
Daily new EUR deaths growth	-.002	.005	-0.35	0.724	-.013	.009
Daily new World cases growth	-.021	.14	-1.48	0.141	-.050	.007
Daily new World deaths growth	-.014	.006	-2.49	0.014	-.025	-.003
Weekday						
2	.020	.008	2.59	0.011	.005	.036
3	.012	.009	1.29	0.198	-.006	.029
4	.004	.009	0.45	0.657	-.013	.021
5	.013	.008	1.62	0.108	-.003	.028
Constant	-.020	.008	-2.44	0.017	-.037	-.004

Table 4.7: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth on AScX returns

Number of observations	=	111
F(6,139)	=	2.03
Prob > F	=	0.038
R-squared	=	0.224
Root MSE	=	0.025

AScX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	.000	7.99e-06	1.83	0.070	-1.21e-06	.000
Total Dutch deaths	1.79e-06	9.78e-07	1.83	0.070	-1.47e-07	3.73e-06
Daily new EUR cases growth	-.012	.005	-2.42	0.017	-.022	-.002
Daily new EUR deaths growth	-.003	.006	-0.51	0.611	-.014	.008
Daily new World cases growth	-.021	.14	-1.52	0.132	-.050	.007
Daily new World deaths growth	-.013	.007	-1.86	0.064	-.027	.001
Weekday						
2	.014	.009	1.61	0.111	-.003	.032
3	.010	.011	0.94	0.352	-.011	.031
4	-.003	.009	-0.04	0.971	-.019	.018
5	.007	.009	0.70	0.488	-.012	.025
Constant	-.018	.009	-2.00	0.048	-.035	-.0001

Table 4.8: Variance inflation factor (VIF) values for the explanatory variables from Tables 4.5-4.7

Variable	VIF	1/VIF
Daily New Dutch cases	1.14	0.877
Total Dutch deaths	1.40	0.712
Daily new EUR cases growth	1.39	0.718
Daily new EUR deaths growth	1.24	0.808
Daily new World cases growth	1.22	0.817
Daily new World deaths growth	1.50	0.668
Weekday		
2	2.06	0.485
3	2.58	0.387
4	1.90	0.525
5	2.11	0.474
Mean VIF	1.66	

Table 4.9: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth, daily volume index change, daily AEX Volatility Index change, EURIBOR-EONIA spread, and Dutch yield spread on AEX returns

Number of observations	=	111
F(6,139)	=	4.07
Prob > F	=	0.000
R-squared	=	0.508
Root MSE	=	0.019

AEX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	3.36e-06	7.90e-06	0.42	0.672	-.000	.000
Total Dutch deaths	3.62e-07	1.02e-06	0.35	0.723	-1.66e-06	2.39e-06
Daily new EUR cases growth	-.004	.003	-1.22	0.226	-.011	-.003
Daily new EUR deaths growth	.002	.005	0.34	0.731	-.008	.011
Daily new World cases growth	-.006	.007	-0.86	0.394	-.020	.008
Daily new World deaths growth	-.002	.004	-0.45	0.656	-.010	.007
AEX_VC	-.0003	.006	-0.05	0.960	-.013	.012
AEX_VOLIND	-.061	.028	-.2.15	0.034	-.117	-.005
MSCI_R	.390	.120	3.26	0.002	.152	.628
EUREONSPREAD	.007	.027	0.26	0.805	-.047	.060
BONDYIELDS	-.006	.017	-0.36	0.722	-.039	.027
Weekday						
2	.001	.006	0.623	0.822	-.010	.012
3	-.0004	.007	-0.06	0.956	-.014	.013
4	-.007	.007	-1.02	0.308	-.020	.006
5	-.006	.007	-0.88	0.380	-.019	.007
Constant	.002	.007	0.29	0.771	-.012	-.017

Table 5.0: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth, daily volume index change, daily AEX Volatility Index change, EURIBOR-EONIA spread, and Dutch yield spread on AMX returns

Number of observations	=	111
F(6,139)	=	4.62
Prob > F	=	0.000
R-squared	=	0.563
Root MSE	=	0.020

AMX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	4.17e-07	9.06e-06	0.05	0.964	-.000	.000
Total Dutch deaths	6.84e-07	1.00e-06	0.68	0.497	-1.31e-06	2.67e-06
Daily new EUR cases growth	-.003	.005	-0.50	0.618	-.012	-.007
Daily new EUR deaths growth	.004	.005	0.81	0.420	-.006	.013
Daily new World cases growth	-.012	.008	-1.50	0.136	-.028	.004
Daily new World deaths growth	-.005	.004	-1.11	0.270	-.013	.004
AEX_VC	.019	.009	2.20	0.030	.002	.036
AEX_VOLIND	-.067	.029	-.2.36	0.021	-.124	-.011
MSCI_R	.483	.135	3.57	0.001	.215	.751
EUREONSPREAD	.015	.031	0.50	0.621	-.046	.077
BONDYIELDS	-.001	.018	-0.04	0.970	-.036	.034
Weekday						
2	.003	.007	0.35	0.730	-.012	.017
3	.003	.007	0.45	0.652	-.011	.018
4	-.005	.007	-0.69	0.489	-.018	.009
5	.0001	.007	-0.01	0.995	-.014	.014
Constant	-.005	.008	-0.68	0.497	-.021	.010

Table 5.1: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth, daily volume index change, daily AEX Volatility Index change, EURIBOR-EONIA spread, and Dutch yield spread on AScX returns

Number of observations	=	111
F(6,139)	=	5.77
Prob > F	=	0.000
R-squared	=	0.508
Root MSE	=	0.020

AScX Return	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	2.19e-06	9.35e-06	0.23	0.815	-.000	.000
Total Dutch deaths	1.15e-06	9.69e-06	1.19	0.238	-7.73e-07	3.07e-06
Daily new EUR cases growth	.001	.003	0.29	0.769	-.007	-.009
Daily new EUR deaths growth	.003	.005	0.60	0.551	-.007	.012
Daily new World cases growth	-.014	.008	-1.69	0.076	-.029	.002
Daily new World deaths growth	-.006	.005	-1.40	0.165	-.015	.003
AEX_VC	.021	.006	3.24	0.002	.008	.033
AEX_VOLIND	-.058	.023	-2.59	0.011	-.103	-.014
MSCI_R	.397	.121	3.28	0.001	.157	.637
EUREONSPREAD	.021	.032	0.67	0.506	-.042	.085
BONDYIELDS	.003	.018	0.16	0.872	-.032	.038
Weekday						
2	.003	.007	0.47	0.642	-.010	.017
3	.006	.008	0.75	0.455	-.009	.021
4	-.006	.007	-0.87	0.388	-.020	.008
5	-.001	.007	-0.15	0.877	-.015	.013
Constant	-.011	.008	-1.39	0.169	-.026	.005

Table 5.2: Variance inflation factor (VIF) values for the explanatory variables from Tables 4.9 - 5.1

Variable	VIF	1/VIF
Daily New Dutch cases	2.00	0.500
Total Dutch deaths	2.31	0.432
Daily new EUR cases growth	1.57	0.636
Daily new EUR deaths growth	1.29	0.775
Daily new World cases growth	1.25	0.797
Daily new World deaths growth	1.61	0.622
AEX_VC	1.15	0.868
AEX_VOLIND	1.23	0.816
MSCI_R	1.32	0.759
EUREONSPREAD	1.85	0.540
BONDYIELDS	1.54	0.648
Weekday		
2	2.21	0.452
3	2.79	0.358
4	1.98	0.505
5	2.25	0.445
Mean VIF	1.76	

Table 5.3: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth, daily volume index change, daily AEX Volatility Index change, EURIBOR-EONIA spread, and Dutch yield spread on the standard deviation of AEX price

Number of observations	=	111
F(6,139)	=	13.86
Prob > F	=	0.000
R-squared	=	0.697
Root MSE	=	10.154

AEX Standard Deviation	Coef.	Robust Std. Error	t	P>|t|	[95% Conf.	Interval]
Daily new Dutch cases	.019	.005	4.06	0.000	-.010	.028
Total Dutch deaths	-.0043	.001	-5.98	0.000	-.006	-.003
Daily new EUR cases growth	-.180	4.993	-0.04	0.971	-10.093	9.734
Daily new EUR deaths growth	.202	2.829	0.07	0.943	-5.414	5.817
Daily new World cases growth	12.657	6.279	2.02	0.047	.193	25.123
Daily new World deaths growth	4.492	4.061	1.11	0.271	-3.570	12.554
AEX_VC	-.193	3.991	-0.05	0.962	-8.115	7.729
AEX_VOLIND	-8.686	6.840	-1.27	0.207	-22.265	4.892
MSCI_R	-5.912	58.107	-0.10	0.919	-121.268	109.445
EUREONSPREAD	-41.712	11.714	-3.56	0.001	-64.968	-18.456
BONDYIELDS	24.515	9.459	2.59	0.011	5.737	43.293
Weekday						
2	-2.741	3.036	-0.68	0.499	-10.753	5.272
3	-3.866	5.001	-0.77	0.441	-13.793	6.062
4	-1.665	3.592	-0.46	0.644	-8.795	5.466
5	-3.494	3.616	-0.97	0.336	-10.673	3.685
Constant	29.009	6.056	4.79	0.000	16.987	41.032

Table 5.4: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth, daily volume index change, daily AEX Volatility Index change, EURIBOR-EONIA spread, and Dutch yield spread on the standard deviation of AMX price

Number of observations	=	111
F(6,139)	=	9.14
Prob > F	=	0.000
R-squared	=	0.648
Root MSE	=	21.018

AMX Standard Deviation	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	.0317	.009	3.38	0.001	.013	.050
Total Dutch deaths	-.008	.001	-6.15	0.000	-.011	-.006
Daily new EUR cases growth	-1.622	8.785	-0.18	0.854	-19.061	15.818
Daily new EUR deaths growth	.232	5.192	0.04	0.964	-10.074	10.539
Daily new World cases growth	21.754	12.503	1.74	0.085	-3.068	46.577
Daily new World deaths growth	9.966	7.440	1.34	0.184	-4.804	24.736
AEX_VC	-5.404	10.220	-0.53	0.598	-25.694	14.886
AEX_VOLIND	-18.862	13.656	-1.38	0.170	-45.972	8.248
MSCI_R	6.769	123.441	0.05	0.956	-238.293	251.830
EUREONSPREAD	-95.744	25.702	-3.73	0.000	-146.769	-44.718
BONDYIELDS	47.788	19.332	2.47	0.015	9.408	86.168
Weekday						
2	-6.701	8.203	-0.70	0.489	-21.985	10.583
3	-9.348	10.062	-0.93	0.355	-29.304	10.607
4	-4.036	7.568	-0.53	0.595	-19.061	10.988
5	-5.928	7.985	-0.74	0.460	-21.781	9.924
Constant	54.328	11.797	4.61	0.000	30.907	77.748

Table 5.5: Regression of daily new Dutch cases, total Dutch deaths, daily new European cases growth, total European deaths growth, daily new global cases growth, and daily new deaths growth, daily volume index change, daily AEX Volatility Index change, EURIBOR-EONIA spread, and Dutch yield spread on the standard deviation of AScX price

Number of observations	=	111
F(6,139)	=	7.46
Prob > F	=	0.000
R-squared	=	0.602
Root MSE	=	26.521

AScX Standard Deviation	Coef.	Robust Std. Error	t	P>|t|	[95% Conf. Interval]	
Daily new Dutch cases	.065	.011	5.50	0.000	.042	.089
Total Dutch deaths	-.007	.002	-4.45	0.000	-.009	-.004
Daily new EUR cases growth	-2.425	10.106	-0.24	0.811	-22.488	17.639
Daily new EUR deaths growth	-1.173	6.244	-0.19	0.851	-13.569	11.223
Daily new World cases growth	24.343	13.986	1.74	0.085	-3.422	52.109
Daily new World deaths growth	12.295	8.618	1.43	0.157	-4.814	29.405
AEX_VC	-3.969	7.953	-0.50	0.619	-19.758	11.819
AEX_VOLIND	-24.415	16.932	-1.44	0.153	-58.029	9.200
MSCI_R	68.517	143.833	0.48	0.635	-217.03	354.061
EUREONSPREAD	-158.449	33.136	-4.78	0.000	-224.224	-92.658
BONDYIELDS	66.579	27.926	2.38	0.019	11.139	122.020
Weekday						
2	-8.203	9.692	-0.85	0.400	-27.445	11.039
3	-11.040	12.452	-0.89	0.378	-35.760	13.681
4	-3.578	9.344	-0.49	0.625	-23.128	13.973
5	-8.142	10.820	-0.75	0.454	-29.623	13.339
Constant	44.827	14.721	3.05	0.003	15.602	74.052

Table 5.6: Variance inflation factor (VIF) values for the explanatory variables from Tables 5.3-5.5

Variable	VIF	1/VIF
Daily New Dutch cases	2.00	0.500
Total Dutch deaths	2.31	0.432
Daily new EUR cases growth	1.57	0.636
Daily new EUR deaths growth	1.29	0.775
Daily new World cases growth	1.25	0.797
Daily new World deaths growth	1.61	0.622
AEX_VC	1.15	0.868
AEX_VOLIND	1.23	0.816
MSCI_R	1.32	0.759
EUREONSPREAD	1.85	0.540
BONDYIELDS	1.54	0.648
Weekday		
2	2.21	0.452
3	2.79	0.358
4	1.98	0.505
5	2.25	0.445
Mean VIF	1.76	

Table 5.7: Phillips-Perron test for the presence of a unit root in the AEX returns with 5 Newey-West lags

Phillips–Perron test for unit root						
			Number of observations	=		115
			Newey-West lags	=		5
			Interpolated Dickey-Fuller			
	Test Statistic	**1% Critical value**	**5% Critical value**		**10% Critical value**	
Z(rho)	-121.000	-27.500	-20.760		-17.550	
Z(t)	-11.636	-4.035	-3.448		-3.148	
MacKinnon approximate p-value for Z(t) = 0.0000						
AEX return	Coef.	Std. Error	t	P>|t|	[95% Conf. Interval]	
L1.	-.028	.088	-0.32	0.747	-.203	.146
trend	9.05e-06	.000	0.27	0.787	-.000	.000
Constant	-.001	.004	-0.27	0.784	-.009	-.009

Table 5.8: Phillips-Perron test for the presence of a unit root in the AEX returns with 10 Newey-West lags

Phillips–Perron test for unit root						
			Number of observations	=		115
			Newey-West lags	=		10
			Interpolated Dickey-Fuller			
	Test Statistic	**1% Critical value**	**5% Critical value**		**10% Critical value**	
Z(rho)	-120.811	-27.500	-20.760		-17.550	
Z(t)	-11.638	-4.035	-3.448		-3.148	
MacKinnon approximate p-value for Z(t) = 0.0000						
AEX return	Coef.	Std. Error	t	P>|t|	[95% Conf. Interval]	
L1.	-.028	.088	-0.32	0.747	-.203	.146
trend	9.05e-06	.000	0.27	0.787	-.000	.000
Constant	-.001	.004	-0.27	0.784	-.009	-.009

Table 5.9: Phillips-Perron test for the presence of a unit root in the AMX returns with 5 Newey-West lags

Phillips–Perron test for unit root				
			Number of observations =	115
			Newey-West lags =	5
			Interpolated Dickey-Fuller	
	Test Statistic	**1% Critical value**	**5% Critical value**	**10% Critical value**
Z(rho)	-106.276	-27.500	-20.760	-17.550
Z(t)	-10.983	-4.035	-3.448	-3.148

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

AEX return	Coef.	Std. Error	t	P>|t|	[95% Conf.	Interval]
L1.	-.0463	.087	0.53	0.597	-.127	.219
trend	8.36e-06	.000	0.22	0.825	-.000	.000
Constant	-.001	.005	0.14	0.888	-.009	-.008

Table 6.0: Phillips-Perron test for the presence of a unit root in the AMX returns with 10 Newey-West lags

Phillips–Perron test for unit root				
			Number of observations =	115
			Newey-West lags =	10
			Interpolated Dickey-Fuller	
	Test Statistic	**1% Critical value**	**5% Critical value**	**10% Critical value**
Z(rho)	-108.753	-27.500	-20.760	-17.550
Z(t)	-10.949	-4.035	-3.448	-3.148

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

AEX return	Coef.	Std. Error	t	P>|t|	[95% Conf.	Interval]
L1.	-.0463	.087	0.53	0.597	-.127	.219
trend	8.36e-06	.000	0.22	0.825	-.000	.000
Constant	-.001	.005	0.14	0.888	-.009	-.008

Table 6.1: Phillips-Perron test for the presence of a unit root in the AScX returns with 5 Newey-West lags

Phillips–Perron test for unit root						
			Number of observations	=		115
			Newey-West lags	=		5
			Interpolated Dickey-Fuller			
	Test Statistic	**1% Critical value**	**5% Critical value**		**10% Critical value**	
Z(rho)	-78.829	-27.500	-20.760		-17.550	
Z(t)	-9.827	-4.035	-3.448		-3.148	

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

AEX return	Coef.	Std. Error	t	P>|t|	[95% Conf. Interval]	
L1.	0.225	.080	2.81	0.006	.066	.384
trend	3.33e-06	.000	0.10	0.921	-.000	.000
Constant	-.001	.003	-0.31	0.757	-.009	-.007

Table 6.2: Phillips-Perron test for the presence of a unit root in the AScX returns with 10 Newey-West lags

Phillips–Perron test for unit root						
			Number of observations	=		115
			Newey-West lags	=		10
			Interpolated Dickey-Fuller			
	Test Statistic	**1% Critical value**	**5% Critical value**		**10% Critical value**	
Z(rho)	-78.77	-27.500	-20.760		-17.550	
Z(t)	-9.828	-4.035	-3.448		-3.148	

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

AEX return	Coef.	Std. Error	t	P>|t|	[95% Conf. Interval]	
L1.	0.225	.080	2.81	0.006	.066	.384
trend	3.33e-06	.000	0.10	0.921	-.000	.000
Constant	-.001	.003	-0.31	0.757	-.009	-.007

Table 6.3: GARCH (1,1) model of AEX returns

		OPG				
AEX return	Coef.	Std. Error	z	P>|t|	[95% Conf. Interval]	
AEX return						
Constant	.001	.001	0.40	0.712	-.003	.004
ARCH						
arch L1.	.429	.103	2.63	0.014	.069	.724
garch L1.	.567	.198	3.97	0.000	.317	1.278
Constant	-.0001	.0001	-1.32	0.178	0.178	0.000

Table 6.4: GARCH (1,1) model of AScX returns

		OPG				
AMX return	Coef.	Std. Error	z	P>|t|	[95% Conf. Interval]	
AMX return						
Constant	.001	.001	0.52	0.604	-.002	.003
ARCH						
arch L1.	.317	.128	2.47	0.014	.065	.568
garch L1.	.774	.188	4.11	0.000	.405	1.142
Constant	-.0001	.0001	-1.50	0.134	0.134	0.000

Table 6.5: GARCH (1,1) model of AScX returns

		OPG				
AScX return	Coef.	Std. Error	z	P>|t|	[95% Conf. Interval]	
AScX return						
Constant	.001	.001	0.33	0.741	-.002	.003
ARCH						
arch L1.	.461	.122	3.79	0.000	.223	.670
garch L1.	.603	.116	5.20	0.000	.376	0.831
Constant	-.000	.0001	-0.90	0.368	-0.0001	0.000