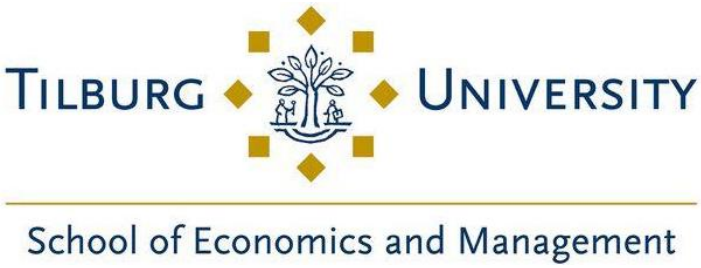
A Work Project, presented as part of the requirements for the Award of a Masters Degree in Finance from the Tilburg University – School of Economics and Management.



The Impact of the Paris Climate Agreement on the Market Value: Event Study Analysis

Abstract:

This study examines the relationship between the Paris Climate Agreement (PCA) and financial performance. Following an event study methodology within two event dates, the PCA Convention Date and the PCA Signature Date, it analyses the cumulative abnormal returns (CARs) of companies within Europe and the United States using Stoxx600 and S&P500 indices. The study concludes that markets reacted negatively to the PCA resulting in negative abnormal returns. Furthermore, the analysis is divided into sectors, where it can be observed that the most polluting industries, i.e. Financials, Industrial and Energy, show negative CARs for the convention date and a positive impact on the signing date reversing the impact to investors. To finalize, it compares Green (less polluting) and Brown (highly polluting) companies, where it is possible to see that green companies were more negatively impacted during the PCA Convention Date in comparison to the highly polluting companies, but this effect is reversed on the PCA Signature Date where the green companies observe higher abnormal returns than brown companies.

Key words: Paris Climate Agreement, Market Value, Stock Prices, Event Study, Abnormal Returns, Climate Risk Management

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The Impact of the Paris Climate Agreement on the Market Value: Event Study analysis

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1. Introduction

During recent years, the climate crises has been discussed worldwide as we are reaching a point of no return in terms of environmental impact. Consequently, policy makers and governments have been changing their agendas in order to place climate change as one of the topics (Renner, 2011). There is strong evidence that climate change is largely caused by anthropogenic activities (human impact on environment) which have driven up the level of CO_2 and other types of emissions, leading to the greenhouse gas (GHG) effect (Stern, 2010). The total annual anthropogenic GHG emissions continued to increase between 1970 and 2010 giving enough evidence that changes need to be performed in order to adapt more sustainable and climate-friendly developments (Figure 1) (Leo Meyer, Sander Brinkman, Line van Kesteren, Noëmie Leprince-Ringuet, 2015).

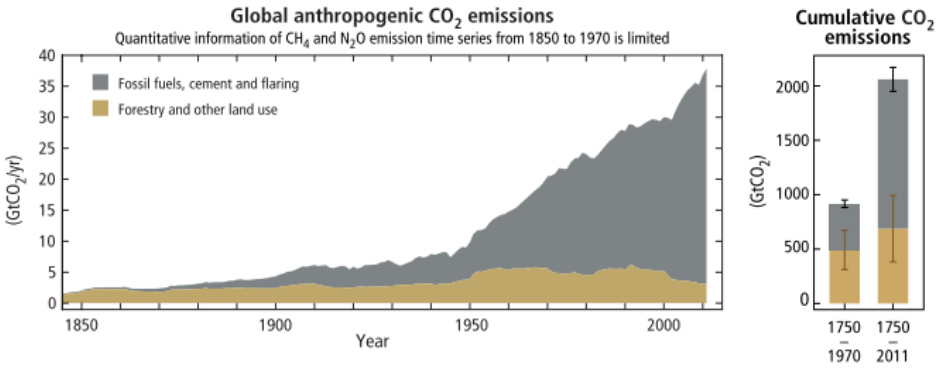

Figure 1 Source: Climate Change 2014 Synthesis Report

As a result of the climate change, policy makers and governments came together in Paris to take action. In order to limit the impact of the GHG effect, the Paris Climate Agreement (PCA) has been one the topic discussed.

The PCA was established on the 12th of December 2015 by the United Nations Framework Convention on Climate Change (UNFCCC), bringing all nations together for a common reason: to combat climate change and to intensify investments needed for a sustainable low carbon future. The countries were able to sign it from the 22nd of April 2016 onwards. The agreement entered into force on the 4th of November 2016 with a total of 55 country signatures which together represent 55% of total global emissions. The agreement reached a total of 125 signatures in 2017, from the 197 countries that were present during the initial Convention (UNFCCC, 2015).

Considering the PCA Convention and Signature dates, it is important to quantify the impact of such agreement in different regions of the world and what consequences or changes of behavior it might have had for investors and companies themselves. The PCA aims to encourage responsible investments towards greener and less pollutant markets, but do investors value such shift? These new markets are not only important for portfolio diversification purposes, but also as instruments for return seeking strategies.

Existing knowledge around the topic of the PCA done by peer researchers is mainly published in environmental journals, focusing on climate and environmental issues. The other contributions from financial journals have several studies with focus on the market value of firms in different contexts. However, there is not any research connecting the announcement of a climate change agreement and market value of companies that could be found. The fact that the PCA objectives are being put to question lately makes it relevant to examine if there has been any impact on the market value of companies. In this study, I will examine the impact of the PCA announcement on the market value of firms in both European and United States stock indices.

I intend to fill in the gap in the literature by conducting an event study around two event dates. More specifically the 12th of December 2015 and 22nd of April 2016, which correspond to the PCA Convention and Signature dates. The event study will analyze the impact of the previously mentioned agreement on financial markets, aiming to provide practical use of the findings by answering the following research question:

What is the impact of the Paris Climate Agreement on Market Value?

This thesis finds that the Paris Agreement had an overall negative effect on the market value of companies and this effect is greater for the PCA Convention Date, since this date was revealing more new information to the market. Furthermore, highly polluting sectors observe a more negative effect during the PCA Convention Date but observe higher abnormal returns during the PCA Signature Date.

This thesis is structured as follows: in Section 2 the existing literature will be analyzed with the set criteria described above to give an overview of existing body of knowledge; in Section 3, the research plan for the different questions will be presented and explained; then, Section

4 will explain the methodology used. The following section will show the results and the last two sections will explain the results and present the conclusions.

2. Literature Review

Climate change policies are becoming vital in recent years. In terms of value, performance and future investment strategies, companies are more restricted due to the limitations imposed by climate policies such as the PCA, which drove the focus of this thesis research.

This chapter analyses the existing literature regarding the link between climate change policies and financial performance in a way to support the hypotheses that will be developed.

2.1. Paris Climate Agreement

The PCA was achieved after years of political discordance. Several ambitious negotiations to lower the GHG emissions globally took place prior to the PCA, a historic multilateral diplomatic agreement. For instance, in the Durban Conference in 2011, a new negotiation was launched that intended to create a new climate agreement by 2015. The new agreement should govern, regulate and incentivize the new generation of climate actions while having the 1992 Framework Convention on Climate Change and the 1997 Kyoto Protocol as a base, which are considered as important instruments that were inadequately implemented (Rajamani, 2016).

In 2015, after two weeks of negotiations, the agreement was created. It aims to limit the rise of global temperature to 2°C above the pre-industrial levels until 2100, and to strive to limit the temperature increase to 1.5°C on a more ambitious level. The agreement also aims to provide countries with the ability to deal with climate change (United Nations, 2015). To achieve the stipulated goals, the CO_2 emissions need to be reduced and major changes need to be undertaken in terms of financial investments, capacity-building support and new technology framework among others.

2.2. Climate change risks

There are several consequences rising from the increase in the global temperature, both to mankind and ecosystems. It threatens food supply due to extreme weather periods, increase

in the amount of heatwaves, increase the risk of flooding due to the rise of sea levels and the shrinking of the ice polar caps, as well as increasing the acidity of the oceans.

According to recent reports from the Intergovernmental Panel on Climate Change (IPCC), human-induced heat reached approximately 1°C, providing a one-in-two chance of heat increase remaining below 1.5°C until 2100.

Climatology research papers have been addressing climate change and its respective risks for a long time. However, the mitigations of such risks at company and industry levels are a rather recent topic. According to Linnenluecke, Griffiths and Winn, firms and industries are noted to have a central role when it comes to support the impact of climate change, especially in the most affected industries: agriculture, construction, forestry and transportation. Despite its relevance, firms and industries have been showing a lack of engagement towards adaptability to the impact of climate change in businesses (Linnenluecke, Griffiths, & Winn, 2013).

A paper, from Lash and Wellington, states that directly or indirectly, all industries will be affected by climate change. Effects of climate change for companies are perceived to be regulatory, reputational, physical, legal and financial. Regulatory risks are seen as the most obvious ones by the authors, as it intends to regulate the emissions of the manufacturing processes and companies are already subject to such regulations, for example under the Kyoto Protocol. Reputational risks are linked to the judgement of the public. Physical risks to the changing in climate, as companies need to find ways of avoiding damages from floods, storms, among others. Legal risks relate to possible lawsuits that companies can find themselves on if they don't adequately address climate changes and the reduction of GHG emissions. Lastly, financial risks consider the evaluation of suppliers, since carbon related costs are transferred from suppliers to their customers, and the product and technological risk, as companies are expected to exploit their businesses and find new climate-friendly products and services.

Nonetheless, climate change risk can also be the source for new competitive advantages if companies assess their risks correctly and adapt procedures to mitigate those risks within the business before their rivals, benefiting at the same time from new profit opportunities. Investors play an important role as they can discount share prices of companies as a way of punishment for poor investments in a competitive world. Additionally, consumers can also

have an impact through making more informed and conscious choices of consumption (Lash & Wellington, 2007). Their paper goes in depth on the steps that should be taken in order to adapt business and create competitive advantages from the involved risks. However, it does not specify what are the impacts related to the different industries.

Climate policies, which aim to reduce carbon emissions, are not perceived to be that effected, which can even lead to an increase of the GHG emissions when policies are first introduced. This phenomenon is known as the Green Paradox. (Jensen, Mohliny, Pittelz, & Sterner, 2015)

2.3. Climate Policies affecting financial performance

As the PCA will be examined with a focus on the impact that its announcement represented to the market value of different companies and industries, it is also relevant to understand in which scope market value is usually approached in different literatures. Studies about market value that have been using it as an indicator of R&D performance, controlling for different components such as shareholders concentration, firm performance or country specific laws, using OLS and NLLS methods, concluded that indeed R&D performance is an important indicator of the market value of a firm (Hall & Oriani, 2006). Other studies examine how Corporate Social Responsibilities (CSR) and Institutional Ownership (IO) affects firm value using a difference-in-difference method, comparing non-CSR firms with CSR firms in order to conclude the impact of it on firm value. The approach uses crisis events as thresholds, suggesting that CSR has a positive effect in low IO firms before crisis and in high IO firms during crisis, finding evidence that overinvestment concerns happens during crisis (Buchanan, Cao, & Chen, 2018).

Many studies focus on examining the effects from environmental news on stock markets. Using different methodologies and different samples, all these papers tend to find that markets react negatively to firms that present negative environmental news (Bhat, 1999; Bosch, Eckard, & Lee, 1998; Hamilton, 1995).

Beatty and Shimshack, use an event study to analyze the impact that climate change information has on stock markets. By analyzing climate rankings of companies, which takes into account the measuring, reporting and reduction of GHG emissions, it concludes that they have a statistically significant and large impact on stock returns when firms are poorly rated

and that there are no significant benefits for firms that are positively rated. Moreover, several papers that study environmental information impact in stock prices through event studies find evidence that the majority of the stock prices increase when there are positive news and decline when facing bad environmental news (Beatty & Shimshack, 2010). This paper is particularly important since it addresses a similar issue of the one that is analyzed in this study and it uses the same methodology. However, it focuses on the climate ranking of companies and not in a single policy agreement.

There is still not a clear agreement in published literature if environmental agreements create or deteriorate value. As shown above, environmental news tend to deteriorate value since firms tend to react negatively to negative news, damaging the economy and leading to a rise in the costs of production as well as a fall in sales. On the other hand, it is also possible to find papers arguing the opposite, stating that environmental regulations have failed consistently in finding significant negative effects, where even the big pollutant firms have a slight positive abnormal effect when facing news on environmental regulations (I. Shapiro & Irons, 2011).

In addition, it is relevant to analyze the increase in the consumption and investment in Renewables and, at the same time, to acknowledge that fossil fuels have a pre-determined expiration date. In theory, this means that renewables should grow as an alternative to fossil fuels and that CO_2 emissions should be decreased in this shifting process.

Based on the extraction levels of 2018 rates, it is expected, at current global production levels, that reserves will last for the following years: oil for 50 years, coal for 132 years and natural gas for 50,9 years (Gurney, 2019).

However, despite the effort to decrease CO_2 emissions as stipulated in the PCA, in 2018 we have seen an increase in energy demand, contributing to a 2% growth of carbon emissions from energy used, being the fastest expansion in seven years. And, despite the increase in the consumption of renewals worldwide, one can also see that the consumption of oil, coal and natural gas (represents 40% of the increase) have also increased in 2018 for all regions when compared to previous years, especially in Asia Pacific, showing that regions are still very dependent on non-renewable sources of energy (Gurney, 2019).

By summarizing the existing literature, it has been concluded that several authors did research elements regarding market value of a firm, stock price changes and climate change.

However, there is not a study that addresses the raised research question, providing evidence on the relationship between climate agreements, in particular the PCA, and financial performance of firms.

3. Research Plan

In this section, the different questions that intend to clarify the chosen topic will be described and explained and the expectations of the study will be presented.

The topic chosen for this thesis is "The Impact of the Paris Climate Agreement on the Market Value: Event Study analysis" and can be divided into two questions: (A) What is the impact of the PCA on the Market Value; (B) What is the impact of the PCA on the Market Value of different sectors (Green vs Brown). This segregation will allow to capture the effect that the PCA has on each industry and on a more detailed level on the behavior that each industry has towards adaptability to achieve the goals of the PCA.

Hypothesis I: "The Paris Climate Agreement announcement has significant negative effects on market values."

This thesis focuses on two event dates of the PCA: the Convention Date and the Signature Date.

The PCA Convention Date corresponds to the first time that the action points and specifications of the agreement were introduced to the public. In efficient markets, prices are expected to adjust to new information in some minutes. However, markets in practice don't adapt to the information right away and it can take some time for the information to be fully taken into account. Thus, first time that the agreement is presented, it is expected to have a bigger impact on the market value of companies since the Signature date only brings out new information regarding which countries are actually signing the agreement. Furthermore, companies did not have the time to adjust their business processes in a way to comply with the stipulated in the newly introduced agreement at the Convention date and could adjust their business after the PCA was made public, reassuring investors. For this reason, the impact is expected to be more negative and statistically significant during the PCA Convention Date.

Hypothesis II: "The market value reactions to the Paris Climate agreement are different between sectors"

As mentioned in the previous sections, it is expected that all industries will feel the consequences of climate change in a direct or indirect way. The impact that the PCA has on industry levels should reflect such consequences, especially for the industries with the biggest amount of CO_2 emissions, which is one of the key points in the PCA. With the implementation of the PCA, the objective to limit the temperature rise to 1.5°C implicit requires companies to change the way they operate in several perspectives.

Focusing on the industry level, the automobile industry is the second largest industry contributing to CO_2 emissions (Cristina De Stefano, Montes-Sancho, & Busch, 2016). Hence, this industry should be heavily affected by the agreement. Nonetheless, in this thesis, the focus will be at the sector level.

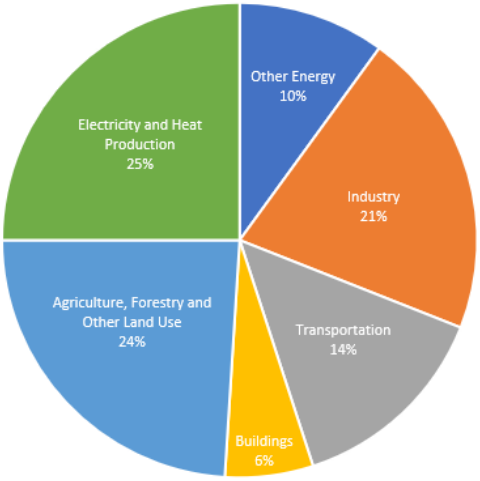

Figure 2 Global GHG emissions by Economic sector 2014. Source: EPA

In order to understand which will be the most affected sectors from the introduction of the PCA, it is important to first assess the GHG emissions at a sector level. From Figure 2, it is possible to see that the Energy sector is the one with higher GHG emissions, approximately 25% of total emissions. This sector is followed by the Agriculture, Forestry and Other Land Use, which corresponds to about 24% of total emissions. The third biggest GHG emitter sector is Industry corresponding to about 21%. In this thesis, it is expected that these sectors will suffer a bigger and negative impact as they are the ones that require the biggest amount of investments and sector transformation.

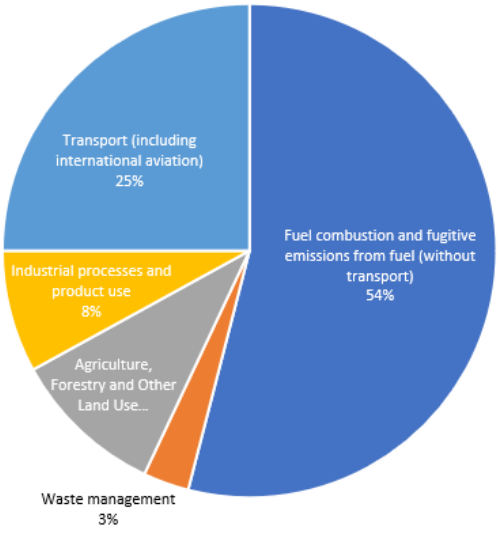

Figure 3 GHG Europe by sector 1990-2017. Source: Eurostat

If the information is now split into regions, it is possible to see that in Europe (2017), the most pollutant sector is the one connected to Fossil Fuel (54%), followed by Transports (25%).

On the other hand, the United States have Transports as the biggest GHG emitter (29%), followed by Electricity (28%) according to 2017 data from the United Stated Environmental Protection Agency (EPA).

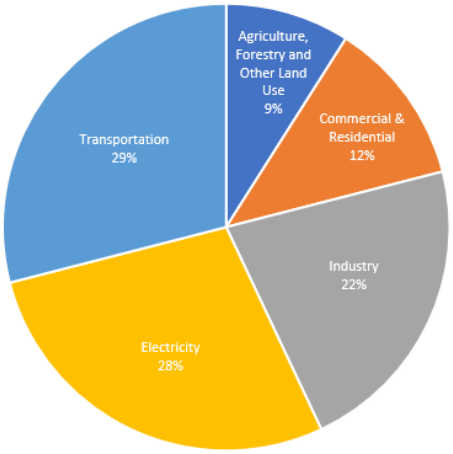

Figure 4 Total US GHG emissions by Economic Sector in 2017. Source: EPA

Nevertheless, one cannot forget that China is still the most pollutant country, counting with more CO_2 emissions than the United States and Europe together in 2017 (United Nations, 2018) .

However, nowadays it can be observed that companies are gradually increasing their compliance costs incurred by climate regulations and legislations as well as growing liabilities of their carbon footprint as a way for companies to actively manage and reduce their emissions level. Moreover, companies still try to anticipate climate regulations as well as the risks that such new regulations would mean to their businesses, hence they try to adjust by setting emissions target goals (Damert, Paul, & Baumgartner, 2017).

Nonetheless, companies suffer pressure to comply and present proof of regulations by different parties. The power that shareholders can have was already mentioned in the previous section. Besides shareholders, financial institutions can also put pressure on companies to reduce their carbon emissions and increase transparency, especially in highly regulated countries that also consider carbon regulations (Schneider, 2011).

Besides all the pressure already being exerted in corporations, media and the rising interest of society towards climate change is also forcing companies to provide evidence and include environmental compliance on their business strategies.

The decrease of GHG emissions at industries levels should be possible by progressively moving towards cleaner and more regulated strategies, at least in the long run, as changes take time to be effective and visible.

Hypothesis III: "The Paris Climate agreement has a smaller impact on green companies which are further ahead in their environmental compliances."

The PCA intention of limiting the temperature raise to 1.5°C by reducing the overall CO_2 emissions comes as a restriction to highly pollutant firms. Highly pollutant firms are seen as the ones that emit higher amounts of GHG to the atmosphere. In order to decrease such emissions, firms are required to incur in extra costs in R&D, technology and new ways of operating in order to transform the business to a greener one. For this reason, brown sectors are expected to be more negatively affected by the PCA in comparison to green sectors.

4. Research Methodology

In order to measure the impact of an event in financial markets, event studies are the most commonly used methodology. In this section, the event study methodology will be described in detail.

4.1. Event Study

Event study methodology has been used for many years and in many different domains. Due to being considered a quite mature approach, it is one of the most important research approaches in corporate finance for measuring the effect of an event.

An event study analysis tries to analytically conclude what are the deviations of a certain occurrence from the efficient market hypothesis (EMH). These deviations are known as abnormal returns (AR), also referred to as disturbances of the EMH. For the scope of this study, a Semi-Strong Market Efficiency is considered, where all the stock prices incorporate all market and public information, meaning that there should be no AR in the data.

In order to calculate the AR, one should subtract the normal/expected returns (NR) from the actual returns (R). The NR are the expected returns that should have been earned in case of no event, which are computed over the estimation window, using the calculated returns.

$$AR_{i,t} = R_{i,t} - NR_{i,t} \quad (1)$$

In the above equation and all subsequent ones, *i* denotes the firm and *t* stands for period.

4.2. Event Definition

In order to conduct an event study, there are around five steps that need to be followed, which were identified by Bowman, and can be summarized in three steps. The first one is to

identify the event being studied and its timings. The events that will be analyzed are the PCA Convention and Signature dates, where the event days are the 12th of December 2015 and the 22nd of April 2016 (Period T_0). Daily data was found to be more powerful than monthly or yearly data, since there is the identification of an accurate announcement date (Brown & Warner, 1985). For this reason, daily returns will be used to summarize and explain the findings.

Although stated in different literatures that market prices should reflect the new information in some minutes, MacKinlay stated that it is still common to find event windows of 181 trading days. However, Brown and Warner also pointed out that as the event window increases the reliability of the results decrease, for this reason, a short horizon is used for this thesis. The event windows considered are of 3, 5, 11 and 21 days (Period T_1 to T_2), respectively comprising 1, 2, 5 and 10 trading days prior and 1, 2, 5 and 10 trading days after the event day.

Also, for event windows, the general suggestion is to have a horizon from 100 to 300 trading days without overlapping with the event window. The event estimation window considered is of 250 daily returns, as exemplified by MacKinlay, with a gap of 25 days before the first event date (period T_0), which makes the estimation window [-275; -25], avoiding that the parameters of the normal return model are influenced by the returns around the event (MacKinlay, 1997). For the second event, the estimation window is composed by the same 250 days, making the second event estimation window [-370, -120], with a gap of 120 days before the second event date (period T_0). The same estimation window was considered in both events in order to avoid the first event date to be part of the second event estimation window, as this can influence the normal performance model parameter estimation.

Financial information is collected from Thomas Reuters DataStream database for two indices, the Stoxx600 Europe and S&P500, gathering all daily prices, on the closing date, for each individual company that belongs to the indices as well as the respective industries and sectors. Daily returns were then calculated using the logarithmic returns:

$$Daily\ Returns = \ln(\frac{P_t}{P_{t-1}}) \quad (2)$$

Once the daily returns are calculated, one can choose the benchmark for NRs calculation.

4.3. Benchmark model

The second step is to specify which benchmark model will be used to compute the NRs. There are several, statistical and economical, models available in the literature that use different benchmarks.

As statistical models, where the returns behavior follow a set of statistical assumptions, it is possible to identify the mean adjusted model and the market model. These models assume that the returns are normally, independently and identically distributed. In the first model, the NRs are calculated as the average return over the estimation window period, but this model omits the market movements. While the second model corrects the omission of the market movements by calculating NRs on a market index. Other statistical models are the factor models, which have the benefit of reducing the variance of the ARs, although the benefits of these multi-factor models are generally limited for event studies.

Economic models, on the other hand, impose restrictions to the statistical models, as they also rely on assumptions based on investors' behavior. These models depend on less strong assumptions and provide the opportunity to calculate more precise measures of NRs. Two models are also possible to be identified: The Capital Asset Pricing Model (CAPM) and the Arbitrage Pricing Theory (APT). For the CAPM model, the NRs are determined by its covariance with the market portfolio, while for the APT the NRs are a linear combination of a multiple risk factors.

As stated by MacKinlay, in practice the assumptions of the statistical model do not lead to problems, as assumptions are empirically reasonable and NRs models tend to be robust to deviations from the assumptions. Also, the statistical models are simpler to compute. Hence, the model that will be followed in this thesis as a benchmark is the Market Model.

The Market Model assumes that firm *i* is a linear regression of $R_{i,t}$ on $R_{m,t}$:

$$R_{i,t} = \propto_i + \beta_i R_{m,t} + \varepsilon_{i,t} \quad (3)$$

NRs can be calculated using the formula (4), where the ARs are defined as the residual of the market. The parameters are estimated using Ordinary Least Squares (OLS).

$$NR_{i,t} = \hat{\propto}_i + \hat{\beta}_i R_{mt} \quad (4)$$

4.4. Analyzing Abnormal Returns

Once all the AR are calculated for each of the event windows chosen, the changes on the market value around the events can be studied. However, most movements of the event are caused by unrelated information.

The first approach to get more relevant information from the analysis would be to calculate the cross-sectional average of the ARs over the number of firms being considered:

$$AAR_t = \frac{1}{N}\sum AR_{i,t} \quad (5)$$

Even though conclusions can be taken from a single period, the information should be aggregated to have a better magnitude of the event, reflecting also the periods surrounding the event. This can be calculated using the second approach, the Cumulative Abnormal Returns, where all AR are aggregated for the event window being considered (from period T_1 until period T_2):

$$CAR_t = \sum_{T_1}^{T_2} AR_{i,t} \quad (6)$$

Once CARs are calculated for each of the event windows being considered, the results should be displayed into a table or graph. One should expect a large positive or negative effect of the study on the event date (T_0), suggesting that there are ARs from the event which were not expected would the event have not taken place.

After all the analysis has been performed, the event can be tested for statistical significance of the results.

4.5. Testing the Event

The third and final step is to test the abnormal performance. In this step, one is interested in assessing the significance with which ARs are different from zero at a certain significance level. For such test, the null hypothesis is the one where ARs have no impact on the event, which happens when ARs are zero. Mathematically, it can be translated in:

$$H_o : E\left(AR_{i,t}\right) = 0 \quad (7)$$

On the other hand, the alternative hypothesis is that where the ARs are significantly different from zero.

According to Brown and Warner (1980), it is recommended to use a two-tailed test, unless there is evidence regarding the direction of the test. Additionally, regarding the level of confidence, a 95% confidence level is considered to be sufficient. Hence, for this study, a 1% and 5% significance level will be considered, which represents 0,5% and 2,5% respectively at a two-tailed statistical test.

There are several different statistical tests that can be used. All of them try to address different statistical properties of the market returns and abnormal returns. Nonetheless, all statistical tests seem to reach the same conclusions and there is no evidence that one is better than the other (Bartholdy, Olson, & Peare, 2007).

The statistical test that will be used is the cumulative abnormal returns:

$$\mathrm{H_o} : \mathrm{E}\left(\mathrm{CAR_{i,t}}\right) = 0 \quad (8)$$

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(CAR_{i,t} - \widehat{CAR_t}\right)^2} \quad (9)$$

$$T - test = \sqrt{N}\frac{\widehat{CAR_t}}{s} \approx N(0,1) \quad (10)$$

Nevertheless, there are several complications linked to the different tests. First, there is heteroscedasticity, which comes from the assumption that ARs are identically distributed. This is a rather strong assumption that most of the times tends to fail as some returns are more volatile than others. Second, Cross-sectional dependency means that when there are event clusters, the assumption that ARs are uncorrelated between events will fail. Third, one can identify that the assumption that variance is the same for event and non-event periods, fails when there is event-induced variance. Last but not the least, as the test statistic assumes that returns are normally distributed, this assumption will fail in case ARs have a non-normality distribution.

4.6. Non-parametric tests

Besides the different statistical tests, nonparametric tests should also be considered even if the parametric assumptions are satisfied, as complementary to the validity of the statistical

inferences, since they make less restrictive assumptions then the t-test, including normal distribution assumption (Bowman, 1983). The most common nonparametric test is the signed rank test of Wilcoxon. This test performs better if there is evidence of skewness and outliers in the data. Especially, when in the presence of daily data, distribution tends to have more fat tails, making the critical values under a normal distribution too small, increasing the possibility of rejection of the null hypothesis.

The sign test assesses whether there are many negative/positive ARs on the event date. It is described by Brown and Warner "for a given sample, the null hypothesis is that the proportion of sample securities having positive measures of abnormal performance (e.g., positive residuals) is equal to 0.5; the alternative hypothesis (for any particular level of abnormal performance) is that the proportion of sample securities having positive performance measures is greater than 0.5". Statistically it can be translated in equation 11, where *p* represents the proportion of positive ARs.

$$test_{sign} = 2\sqrt{N}(p - 0.5) \sim N(0,1) \quad (11)$$

On the other hand, the rank test accounts for the magnitude of ARs on the event date. In this test, abnormal returns for the whole period are ranked and denoted by $K_{i,t}$. The test is constructed and denoted as:

$$test_{rank} = \sqrt{N}\left[\frac{1}{N}\sum_{i=1}^{N}\frac{U_{i,t} - 0{,}5}{s_u}\right] \sim N(0,1) \quad (12)$$

Where $U_{i,t} = \frac{K_{i,t}}{T}$ and s_u is the standard deviation of $U_{i,t}$. Hence, given the fact that we are present to daily data, the signed rank test is performed in this thesis. As the rank test should be tested over a single AR, for the test the event day (Period T_0) for each event date and index will be used.

5. Description of data set

In this section, the main characteristics of the data chosen will be described, as well as the segmentation of industries, sectors, and the difference in green and brown sectors.

In order to understand what type of data should be chosen, one should first closely analyze the characteristics of the PCA when it comes to the countries and regions that have signed the agreement. There are a total of 197 countries that were part and have signed the agreement. If we separate them in regions, all five world regions have representative countries. The regions that are represented in the PCA with the biggest number of signing countries are Europe, Asia & Pacific and Africa, representing 25%, 24% and 22% respectively, and Middle East is the region with less signatures, representing only 11% of the total (Table 1).

Paris Climate Agreement Regions

This table has information regarding regions that have signed the Paris Climate Agreement

Regions	*No. Countries*	*%*
Asia & Pacific	47	24%
Europe	49	25%
The Americas	35	18%
Africa	44	22%
Middle East	22	11%
Total	*197*	*100%*

Table 1 Paris Climate Agreement Regions. Source: United Nations

The United States and Europe are the two regions being considered for this study. Asia & Pacific and Africa, although represented in bigger percentage, are disregarded from the analysis since these regions are exposed to more and different risks, which would mean that results would be affected by more endogenous variables, and since daily data on stocks is not easily accessible. As the biggest percentage for The Americas belongs to the United States and there are representative stock indices, United States was chosen as representative of The Americas region.

In order to take a good sample of the companies within Europe, the Stoxx600 is chosen. This index includes 600 companies listed in the European stock index and is considered representative of Europe since it covers approximately 90% of the market capitalization in the European Stock Market. Representing the United States, the most widely used index and considered the most representative is the S&P500, which includes the 500 largest companies listed in the United States stock index and captures approximately 80% of the available market capitalization (Bloomberg, 2019). Indices with the largest companies per region are a good choice since there is more pressure from different parties, like media, shareholders or governments, on large companies in order to make them release more information publicly and to show their commitment towards new sustainable strategies (Eleftheriadis & Anagnostopoulou, 2015).

For the relevance of the event study, the companies that didn't present returns for the whole event time, including estimation and event window, were disregarded from the sample. At the end, Stoxx600 Europe accounts for a total of 594 companies, while S&P500 remains with all companies, a total of 500.

When it comes to sectors, companies were divided considering the Level 2 of industries segmentations from the MSCI Global Industry Classification Standard (GICS), which is represented by 11 different sectors. The overview of all sectors can be found in Figure 5.

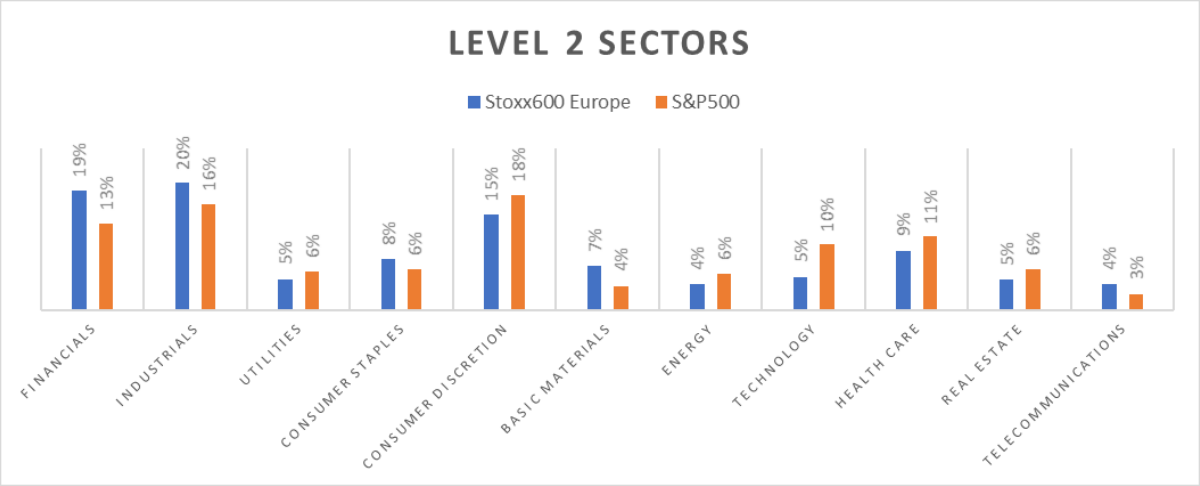

Figure 5 Level 2 sectors segregation following GICS sectors distribution

In Europe, 20% of the index is composed by companies from the Industrial sector, being one of the most representative, followed by the Financial sector, representing 19% of the total index and the third biggest industry is Consumer Discretion, representing 15% of the total index. All other industries in Europe represent between 4% and 8% each of the total index, being Telecommunications the sector with the lowest percentage. In the United States, the number of companies per industry are slightly more balanced, being the most representative industries Consumer Discretion, Industrials and Financials, accounting for 18%, 16% and 13% respectively, and the remaining industries vary between 11% and 3% of the total index, being Telecommunications again the sector with lowest percentage.

For the third hypothesis, sectors were divided into Green and Brown, based on Green Revenue provided in the Newsweek Green Ranking. The Global 500 companies of the Newsweek Green Ranking were considered, which consists of an assessment of sustainability performance of the 500 largest publicly-traded companies in the world at the end of the

previous year of each report ranking. The Green Revenue corresponds to the percentage of potential green revenues from the total revenue stated on the annual and sustainability reports of all companies (Newsweek, 2017).

The Global 500 companies were aggregated in the 11 sectors mentioned before, and the Green Revenue for the years 2015 and 2016 was averaged per sector.

Newsweek Green Ranking

This table has information regarding the Green Revenue (GR) for each sector that was considered, in total amount and average. Dummy variable specifies to which energy sector is each sector integrated based on the GR. Dummy value of 1 stands for Brown sectors and value of 0 stands for Green sectors.

Level 2 Sectors	*Variable Sector*	*2015 GR*	*GR/n*	*n*	*2016 GR*	*GR/n*	*n*	*Dummy*
Financials	*1*	13.4800	0.1123	120	13.884	0.112878	123	1
Industrials	*2*	6.3190	0.1128	56	5.962	0.112491	53	1
Utilities	*3*	2.0440	0.1136	18	2.064	0.121412	17	0
Consumer Staples	*4*	3.8000	0.0864	44	4.341	0.088592	49	1
Consumer Discretion	*5*	6.9220	0.1116	62	6.678	0.109475	61	1
Basic Materials	*6*	1.5590	0.0742	21	1.562	0.082211	19	1
Energy	*7*	1.3490	0.0300	45	0.998	0.028514	35	1
Technology	*8*	7.1540	0.1460	49	7.111	0.148146	48	0
Health Care	*9*	6.7310	0.1432	47	7.376	0.144627	51	0
Real Estate	*10*	1.8350	0.1223	15	2.31	0.121579	19	0
Telecommunications	11	3.6580	0.1590	23	4.014	0.16056	25	0
N				500			500	

Table 2 Industry sectors (Green vs Brown). Source: Newsweek Green Ranking

The six sectors with the lowest average were considered as Brown sectors (dummy takes value of 1) while the five sectors with the highest average were considered the Green sectors (dummy takes value of 0). For both years, the green and brown sectors coincide, and they can be found in the Table 2 where the top three brown sectors are Energy, Basic Materials and Consumer Staples.

For the first approach, at the sectors level, Industrials, Finance and Consumer Discretionary are the most representative sectors in both regions. Hence, expected to have a significant impact. From a GHG emissions perspective, Energy and Industrials are expected to have the most significant and negative impact as these are the most pollutant sectors. When considering the Green vs Brown sectors, the Brown sectors are expected to have the most significant and negative impact.

6. Empirical results and interpretation

In this section, the empirical results derived from the above sections will be presented and discussed.

6.1. Event Study

The interpretation of CARs has been done following two different approaches for each of the event dates. In the first approach, CARs have been calculated for the four event windows, accounting for each index individually but also aggregated. The results can be seen in Table 3. In the second approach, CARs have been calculated for each index separately, in each event window, dividing the information in sectors, which will be explained further in this chapter.

Cumulative Abnormal Returns

This table has information regarding the cumulative abnormal returns of both event dates for the different indexes. First columns of each event represents CARs of both indeces together, remaining columns represent CARs of each index separately. P-values are in between brackets. These P-values have been calculated using *robust standard errors* control for heteroskedasticity. *,**,*** indicate that the coefficient is statistically significant at the 10%, 5% and 1% level respectively.

	PCA Convention Date			*PCA Signature Date*		
Event Window	*CAR*	*CAR Stoxx600*	*CAR S&P500*	*CAR*	*CAR Stoxx600*	*CAR S&P500*
[-10;10]	-0.00262	0.00214	-0.00828***	0.000510	-0.00445	0.00640*
	(0.157)	(0.357)	(0.0051)	(0.832)	(0.156)	(0.0837)
[-5;5]	-0.00964***	-0.00894***	-0.0105***	0.000267	-0.00479**	0.00627**
	(0.000)	(0.000)	(0.000)	(0.874)	(0.0223)	(0.0214)
[-2;2]	-0.00655***	-0.00796***	-0.00488***	-0.000977	-0.00722***	0.00644***
	(0.000)	(0.000)	(0.0003)	(0.413)	(0.000)	(0.0005)
[-1;1]	-0.00236***	-0.000579	-0.00448***	-0.00116	-0.00371***	0.00188
	(0.00176)	(0.572)	(0.000)	(0.175)	(0.000627)	(0.164)
N	1094	594	500	1094	594	500

Table 3 Cumulative Abnormal Returns

The first detail that is possible to identify from the results is that for most of the event windows, the PCA has a negative effect on market value. Furthermore, the PCA Convention Date has more negative and statistically significant results than the PCA Signature Date, as it was expected since it corresponds to the first time that the PCA was announced. This shows that for the two regions, individually and aggregated, the PCA action points had a negative effect on future earning of the firms, resulting in a drop of the market value due to investors acknowledging it as a value destroying announcement. Additionally, the biggest event window [-10; 10] has no statistical significance for most of the analysis, except for the S&P500.

In this case, a large number of stocks (total of 1094) are being measured against two events, which should be done using a small, fixed-length event window of one to two trading days in order to reduce possible noise of coexisting events. For daily data, it is extremely difficult to find any variance on a one trading day event window (Krivin, Patton, Rose, & Tabak, 2005). Therefore, only the [-2; 2] event window will be considered for the analysis of CARs, to both capture the abnormal returns surrounding the event and reducing potential noise when using large samples.

Focusing on the PCA Convention Date, it has a negative and statistically significant impact on Stoxx600, S&P500 and both indices together, as all of them show a negative coefficient at a 1% significance level, which means that shareholders reacted negatively to the announcement and the impact the PCA represented for firms and are worried about the potential harm on future earnings. The results are in line with expectations, as when new policies are presented for the first time, industries do not have the time to anticipate such policies nor to adapt its business in order to meet such goals. In this case, the PCA demands changes on the ways that companies operate and high investments in the short term in order to reduce GHG emissions and comply with its objectives.

On the other hand, when focusing on the PCA Signature Date, the impacts are slightly different. It can be observed that when considering the two indices together, there is no statistically significant impact, but the sign is still negative in the five-day event window. For the European stock exchange, the effect on the Stoxx600 Europe is negative and statistically significant, which once again reveals that investors are reacting negatively on the new regulations. However, when it comes to the United States Stock Exchange, the impact is positive and statistically significant. This positive impact can have been influenced by two factors. The first factor is that the United States already had an internal climate plan developed by President Obama, the Climate Action Plan, which was first announced in 2013 (Office, 2013). In the long term, the two agreements together, which aim to tackle carbon emissions, gave American companies the time to adapt and the United States indeed decreased its CO_2 emissions until late 2016 (Irfan, Umair. 2019). The second reason are the elections, which were taking place during this period, and the different parties were sharing its own promises contributing for possible noise within the event window.

For the event windows where results of CARs were not significant, it can be assumed that the announcements were not substantial enough to affect the market.

The rank and sign test were also performed for each of the indices. The check using non parametric tests intends to perform a robustness check on the parametric tests. Table 4 shows the test statistics and the significance. The results are similar to the ones described using the parametric tests, showing the concrete effect of the two announcements on each index.

Signed Rank Test

This table has information the sign and rank tests of the abnormal returns of both event dates for the different indexes. *,**,*** indicate that the coefficient is statistically significant at the 10%, 5% and 1% level respectively.

	Sign Test	*Rank Test*
PCA Convention Date		
Stoxx600 Europe	-21.4949***	-21.7470***
S&P500	-18.2951***	-19.0311***
PCA Signature Date		
Stoxx600 Europe	-9.3868***	-10.1999***
S&P500	9.5574***	9.1063***

Table 4 Signed Rank test

For the second approach, the CARs of both indices together have been disregarded, as it is seen to add no additional insights. Tables 5 and 6 present the main results with CARs when controlling for sectors. For the same reason as stated above, only the [-2; 2] event window will be analyzed and interpreted.

The first difference to be spotted for both indices is that during the PCA Convention Date the number of sectors that have suffered a negative and statistically significant impact has been higher than during the PCA Signature Date, which is in line with the firm-specific results and once again confirms the expectations that the reactions were more negative during the first announcement of the agreement. Another difference between the two dates is that Stoxx600 Europe sees most of the impacts of the PCA as negative and statistically significant, while S&P500 has some positive and statistically significant impacts. This systematic differences between Europe and the United States within sectors will be analyzed further.

PCA Convention Date CARs per Sector

This table has information regarding the cumulative abnormal returns on the PCA Convention date for the different indexes per sector.
P-values are in between brackets. These P-values have been calculated using *robust standard errors* control for heteroskedasticity.
*,**,*** indicate that the coefficient is statistically significant at the 10%, 5% and 1% level respectively.

	CAR Stoxx600				*CAR S&P500*			
Level 2 Sectors	*[-10;10]*	*[-5;5]*	*[-2;2]*	*[-1;1]*	*[-10;10]*	*[-5;5]*	*[-2;2]*	*[-1;1]*
Financials	0.00616	-0.00121	-0.00799**	-0.000857	-0.0191***	-0.0277***	-0.00938***	-0.0108***
	(0.208)	(0.772)	(0.0140)	(0.785)	(0.000)	(0.000)	(0.00430)	(0.000726)
Industrials	-0.00576	-0.0149***	-0.0121***	0.000940	-0.0251***	-0.0290***	-0.00649**	-0.00139
	(0.202)	(0.000131)	(0.000)	(0.593)	(0.000)	(0.000)	(0.0247)	(0.521)
Utilities	0.00628	-0.00619	0.00529	0.00254	0.0406***	0.0412***	-0.000438	-0.0161***
	(0.513)	(0.209)	(0.161)	(0.497)	(0.000)	(0.000)	(0.901)	(0.000586)
Consumer Staples	-0.00575	-0.00911*	-0.00845**	-0.00676***	0.0319***	0.0242***	0.00368	0.00328
	(0.435)	(0.0687)	(0.0102)	(0.00734)	(0.000)	(0.000)	(0.238)	(0.222)
Consumer Discretion	0.0151**	-0.00590	-0.00849***	0.000135	-0.0241***	-0.0110**	-0.0146***	-0.00536**
	(0.0459)	(0.279)	(0.00879)	(0.953)	(0.000929)	(0.0313)	(0.000)	(0.0496)
Basic Materials	-0.0253***	-0.0320***	-0.0124*	-0.00383	0.00320	-0.0323***	-0.000963	-0.0227***
	(0.00484)	(0.00218)	(0.0761)	(0.480)	(0.796)	(0.00454)	(0.881)	(0.00333)
Energy	-0.00463	-0.0452***	0.00708	-0.00955	-0.109***	-0.113***	0.00548	-0.0176**
	(0.749)	(0.00561)	(0.354)	(0.153)	(0.000)	(0.000)	(0.628)	(0.0258)
Technology	0.0150	-0.0122	-0.00994	0.00597	0.0112	-0.00976	-0.0135***	-0.00288
	(0.338)	(0.434)	(0.488)	(0.378)	(0.366)	(0.162)	(0.00492)	(0.368)
Health Care	0.0114	0.00709	-0.00512	0.00282	0.0171***	0.0270***	0.00692**	0.0101***
	(0.121)	(0.165)	(0.156)	(0.262)	(0.00801)	(0.000)	(0.0215)	(0.000121)
Real Estate	0.00908*	0.0107*	-0.0112***	-0.00241	0.0237***	0.0306***	0.00544*	0.00436*
	(0.0846)	(0.0516)	(0.000714)	(0.346)	(0.000580)	(0.000)	(0.0775)	(0.0994)
Telecommunications	-0.00717	-0.00929	-0.00842	-0.000592	-0.0159	-0.0205	-0.00799	-0.0146*
	(0.323)	(0.101)	(0.107)	(0.858)	(0.445)	(0.440)	(0.210)	(0.0649)
N	594	594	594	594	500	500	500	500

Table 5 PCA Convention Date CARs per Sector

Table 5 outlines the CARs for the different sectors according to the GICS sectors distribution during the PCA Convention Date. Sectors Finance, Industrials and Consumer Discretion all have a negative and statistically significant abnormal impact for both indices, due to the PCA Convention Date. These three sectors are the most representative ones in both regions and expected to have a significant impact due to the strict environmental regulations in the agreement. Industrial sector includes primary sectors such as mining and agriculture, which are considered to be highly pollutant sub-sectors. Consumer Discretion includes industries like automobiles, the second biggest CO_2 emission contributor (Cristina De Stefano et al., 2016), and fashion which emit large quantities of pollutants and depends on high levels of water and energy consumption (Lo, Yeung, & Cheng, 2012). Financial sector on the other hand is one of the biggest investors in oil and gas companies (R. J. Shapiro & Pham, 2014). Hence, given the composition of each sector, investors have negatively reacted to the announcement of the PCA, resulting in a drop-in market value of firms in these sectors, since investments to

reduce GHG emissions will lead to an increase in production costs and a decrease in profit margins in the short term. This will lead to uncertainty for investors.

Nonetheless, Europe has also seen a negative and statistically significant impact for Consumer Staples, Basic Materials and Real Estate. Consumer Staples is directly linked to the manufacturing and distribution of food and beverages. As it corresponds to a first necessity sector it is not influenced by economic fluctuations, and its demand should remain at similar values in case of economic crisis. However, the distribution sector is one of the most pollutants, being included in the transportation industry. Shareholders had a negative reaction towards the announcement which drove the market value of companies in this sector down. Basic Materials is the sector responsible to develop and processing raw materials, like mining, chemical products and forestry products. The market value of these companies is expected to decrease, as such products are directly linked to the negative impact already described in the Industrials sector. Finally, Real Estate sees energy consumption as a very important factor. Controlling for the CO_2 emissions, the PCA demands buildings to be more energy efficient as well as making energy prices more affordable (Chau & Zou, 2018; European Commission Directorate, 2013). On the other hand, Real Estate sector is exposed to the climate change risks when it comes to unpredictable flooding, hurricanes and other natural disasters (Starkmann & Kok, 2018).

Contrary to Europe, in the United States it is possible to see a positive impact on the Real Estate sector, as well as in Health Care sector and a negative impact on the Technological sector. The negative impact that the United States have for the Real Estate sector, goes against the previously explained reason by the European Commission Directorate and Chau et al. (2018). Since this variable is statistically significant it shows that shareholders see the PCA is not a threat for future earnings of the sector, which drove the market value up. These expectations were in line with the positive wave that the sector was facing at the end of 2015 (Soergel, 2016). The Health Care sector corresponds to the manufacture of medical equipment and drugs as well as to provide medical services. This sector is highly connected with huge amounts of waste and GHG emissions, being the fourth largest contributor of mercury to the environment and a significant contributor of dioxins (Zimmer & McKinley, 2008). As it would be expected that a sector which produces high quantities of waste would have a negative impact, it becomes relevant to analyze the investments in transformation and

innovation of the sector that were done during the year of 2015 and beginning of 2016, which correspond to an increase of more than 2% growth of spending (Kamal, Cox, 2018; Agarwal, Gao, DesRoches, & Jha, 2010). This factor gives shareholders a positive feeling regarding the sector which is reflected on the fact that the market value of the firms also went up. The Technological sector offers a wide range of products and it is mainly connected with the manufacturing of electronics and creation of software and other products. The PCA was seen as a green light when it comes to the new technological breakthrough, where clean technology can start selling its patents and more easily get into the current market, being technology considered an environmentally friendly industry in this sense and for this reason expected to react positively (Linnenluecke, Smith, & McKnight, 2016).

Energy sector was expected to be highly negatively affected by the introduction of the PCA, since it is one of the biggest polluters when it comes to GHG emissions. However, the sector has not experienced a statistically significant abnormal return for both regions during the PCA Convention Date. The PCA has the intent to reduce the GHG emissions in order to limit the temperature increase to 1.5°C, which consequently should lead to negative abnormal returns for big pollutant sectors. The non-reaction of the Energy sector might imply that the PCA failed to target the biggest polluters to reduce GHG emissions. This interpretation might in fact be a flawed one because what appears to be a flaw in the agreement may actually be an ability of the Energy sector to pass its extra costs from investing in greener solutions to the consumers, as it has an inelastic demand, keeping profitability unaffected (Ramiah, Martin, & Moosa, 2013).

PCA Signature Date CARs per Sector

This table has information regarding the cumulative abnormal returns on the PCA Signature date for the different indexes per sector.
P-values are in between brackets. These P-values have been calculated using *robust standard errors* control for heteroskedasticity.
*,**,*** indicate that the coefficient is statistically significant at the 10%, 5% and 1% level respectively.

	CAR Stoxx600				*CAR S&P500*			
Level 2 Sectors	*[-10;10]*	*[-5;5]*	*[-2;2]*	*[-1;1]*	*[-10;10]*	*[-5;5]*	*[-2;2]*	*[-1;1]*
Financials	0.0175**	-0.00558	0.00485	-0.000204	0.0569***	0.0205***	0.0142***	0.00306
	(0.0219)	(0.102)	(0.133)	(0.925)	(0.000)	(0.000)	(0.0001)	(0.252)
Industrials	-0.0134***	-0.00435	0.000364	0.00180	0.0197***	0.00972***	0.00528*	0.00366
	(0.00587)	(0.153)	(0.886)	(0.439)	(0.0001)	(0.00287)	(0.0582)	(0.173)
Utilities	-0.0116	-0.00778	-0.00560	-0.00444	-0.0356***	-0.0206***	-0.0276***	-0.00284
	(0.259)	(0.179)	(0.127)	(0.208)	(0.0001)	(0.000)	(0.000)	(0.211)
Consumer Staples	-0.0600***	-0.0229***	-0.0235***	-0.0148***	-0.0406***	-0.0109**	-0.0129***	-0.00275
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.0223)	(0.0009)	(0.318)
Consumer Discretion	-0.0384***	-0.0195***	-0.0120***	-0.00670**	-0.0136**	-0.0106**	-0.00602	-0.00610*
	(0.000)	(0.000)	(0.00164)	(0.0268)	(0.0151)	(0.0289)	(0.145)	(0.0999)
Basic Materials	0.0377**	0.00154	-0.00873**	-0.0159***	0.0602***	0.0336***	0.000373	-0.00369
	(0.0247)	(0.799)	(0.0348)	(0.000846)	(0.00178)	(0.00106)	(0.928)	(0.483)
Energy	0.0467**	0.00492	0.00265	0.00271	0.0769***	0.0328***	0.0140**	0.00505
	(0.0183)	(0.537)	(0.724)	(0.651)	(0.000)	(0.000)	(0.0209)	(0.308)
Technology	-0.0645***	-0.0287***	-0.0200***	-0.00553	-0.0165*	-0.00692	0.00778	0.00320
	(0.000)	(0.000)	(0.000)	(0.122)	(0.0784)	(0.364)	(0.291)	(0.617)
Health Care	-0.0525***	-0.0124**	-0.00689	0.00693*	-0.00371	0.00784	0.0116**	0.00687
	(0.000)	(0.0133)	(0.122)	(0.0940)	(0.620)	(0.233)	(0.0425)	(0.200)
Real Estate	-0.0691***	-0.0227***	-0.00650	-0.00198	-0.0206**	-0.000134	-0.00644**	0.00886***
	(0.000)	(0.000)	(0.119)	(0.559)	(0.0129)	(0.979)	(0.0343)	(0.001)
Telecommunications	-0.0540***	-0.0285***	-0.0267***	-0.0227***	0.0155	0.0279*	0.0162	0.0184
	(0.0003)	(0.00540)	(0.00353)	(0.00777)	(0.509)	(0.0983)	(0.184)	(0.102)
N	594	594	594	594	500	500	500	500

Table 6 PCA Signature Date CARs per sector

Table 6 outlines the CARs for the different sectors according to the GICS sectors distribution during the PCA Signature Date. All statistically significant reactions of the Stoxx600 Europe to this event have been negative, while S&P 500 sees again some positive statistically significant reactions. It is possible to find negative and statistically significant impacts in five sectors when considering the Stoxx600 Europe: Consumer Staples, Consumer Discretion, Basic Materials, Technological and Telecommunications sectors. For this date, S&P500 accounts with positive and statistically significant impacts connected to the Financials, Industrials, Energy and Health Care sectors and negative and statistically significant impacts for Utilities, Consumer Staples and Real Estate sectors.

Consumer Staples, Consumer Discretion and Basic Materials show a persistent negative and significant impact when compared to the PCA Convention Date, which shows that the systematic risks derived from these sectors are still higher than the market expects it to be. A

possible explanation is the lack of actions undertaken by these sectors towards a greener production since the PCA Convention Date.

Stoxx600 Europe also shows Technology and Telecommunications with a negative and statistically significant abnormal returns. During the PCA Convention Date, these sectors also showed negative abnormal returns, although they were not statistically significant. S&P500 shows the same behavior within Utilities sector. Hence, this result can be seen as a delayed reaction of shareholders to the impact that the PCA has on these sectors, reflecting in a negative market value impact for the PCA Signature Date.

Energy sector in the United States can also be seen as a delayed reaction of shareholders, but in this case the impact is positive. The Energy sector was said to expect a negative impact since this is a highly pollutant sector. However, in this case the impact is seen as positive and statistically significant, keeping the same sign as in the PCA Convention Date. From the result, the shareholders are expecting the sector to gain from the PCA, which in this case confirm the very rigid demand towards energy sector and the capacity of transferring the cost to the consumers.

For the S&P500, results show that Financial, Industrials and Real Estate sectors exhibit mixed reactions, as they had negative abnormal returns during the PCA Convention Date, turning into positive and statistically significant abnormal returns during the PCA Signature Date. A possible interpretation of such mixed investors' behavior towards both announcement dates can be that investors were uncertain about the true effects of the PCA on their industries (Pham, Nguyen, Ramiah, Saleem, & Moosa, 2019). Also, in the long term the production costs related to investments in greener solutions decrease and it is no longer profitable to engage in polluting activities, which can lead to the mixed reactions observed in these sectors, supported by the fact that the United States had already in place the Climate Action Plan since 2013.

The Health Care sector in the United States shows a persistent positive and statistically significant abnormal returns. The reasoning behind it was explained previously as the sector was investing in technology and innovation during the gap between the two events.

Multivariate regression results

This table has information regarding the multivariate regressions with CARs as the dependent variable. The Green/Brown dummy variable captures the difference between highly and less pollutant sectors. First columns of each event represents CARs of both indices together, remaining columns represent CARs of each index separately. P-values are in between brackets. These P-values have been calculated using *robust standard errors* control for heteroskedasticity. *,**,*** indicate that the coefficient is statistically significant at the 10%, 5% and 1% level respectively.

	PCA Convention Date			*PCA Signature Date*		
Event Window	*CAR*	*CAR Stoxx600*	*CAR S&P500*	*CAR*	*CAR Stoxx600*	*CAR S&P500*
	[-2;2]	*[-2;2]*	*[-2;2]*	*[-2;2]*	*[-2;2]*	*[-2;2]*
Greendummy	-0.00463**	-0.00313	-0.00564**	0.00660**	0.00904***	0.00689*
	(0.0285)	(0.360)	(0.0303)	(0.0133)	(0.00627)	(0.0874)
constant	-0.00341*	-0.00571*	-0.00131	-0.00546**	-0.0137***	0.00207
	(0.0544)	(0.0629)	(0.492)	(0.0162)	(0.000)	(0.549)
N	1094	594	500	1094	594	500
R-Squared	0.005	0.002	0.008	0.006	0.012	0.007

Table 7 Multivariate regression with Green dummy variable

Table 7 has the results of the regression of CARs using the green dummy variable as explanatory variable. The green dummy variable was found using the average Green Revenue per sector retrieved from the Newsweek Green Ranking. The six sectors with the lowest average were considered as Brown sectors (dummy takes value of 1) while the five sectors with the highest average were considered the Green sectors (dummy takes value of 0). The Model uses a single explanatory variable, which allows to avoid multicollinearity. From the table it can be seen that during the PCA Convention Date, the impact on the market value of the Brown companies has been negative. This is in line with expectations, as the Brown companies are the ones considered heavily pollutant and expected to require higher investments in order to transform the industry and in this way comply with the PCA. Nonetheless, it is also possible to observe that the Brown companies were the ones that benefit from the PCA during the Signature date. In Table 6 it was observed that the US had several sectors with a positive and statistically significant impacts mostly on brown sectors, which can explain the result.

7. Summary and conclusions

7.1. Conclusion and discussion

As the interest towards climate change increases, policy makers, governments and firms have been pressured to increase regulations, transparency and procedures to control and mitigate its risks. The Paris Climate Agreement was created in order to limit the temperature increase to 1.5°C, aiming to decrease the GHG emissions continuously and to provide countries with the ability to make the transition to a low carbon economy. This thesis has the purpose to examine the impact that the PCA Convention and Signature dates had on the market values of companies. The study was conducted using companies from the Stoxx600 Europe and S&P500. More specifically, the changes in the cumulative abnormal returns were examined for the two regions and per sector. In general results show that Europe is more negatively affected than the United States during both event dates.

The first hypothesis intended to test if the PCA had effect on the market value. Considering the two approaches used, it is possible to conclude that both regions, had negative and statistically significant abnormal returns surrounding the PCA Conventions Date and PCA Signature Date. This can be a result of the uncertainty regarding future earnings of the companies. The same conclusion is possible to be derived from the sectors analysis, as the number of sectors per region showing negative and statistically significant abnormal returns is higher for the PCA Convention Date then the PCA Signature Date. This hypothesis is then accepted.

The second hypothesis analyzed the different reactions per sector for both event dates. The sectors that emitted higher amounts of GHG, were expected to have higher negative and statistically significant abnormal returns. Analyzing at a region level, the sectors that are more representative of each region are also expected to have more significant impacts. The analysis shows that pollutant sectors tend to have a mixed reaction, meaning that the impact of the PCA Convention Date is showed to be negative while during the PCA Signature Date these become positive, suggesting that investors' behavior changed due to the uncertainty related to the impact that the agreement would have on such sectors. This is the case for the Financial, Industrial, Real Estate sectors. Another finding corresponds to the delayed reactions where sectors like Energy, Utilities and Technology showed not statistically significant values

during the PCA Convention Date, while during the PCA Signature Date values were statistically significant and with the same sign. The third finding corresponds to the persistently negative and statistically significant abnormal returns for pollutant sectors, Consumers Discretionary, and sectors that are dependent of pollutant sectors, Consumers Staples and Basic Materials. This hypothesis can be accepted.

Additionally, sectors were analyzed with the help of the Green Dummy, which labels each sector as green or brown using the average of Green Revenue available in the Newsweek green ranking. The analysis shows that brown sectors were negatively impacted by the PCA on the Convention date and positively impacted by the PCA during the Signature date in comparison to the green sectors. This hypothesis can be partly accepted.

From the analysis, it is possible to conclude that in general the Paris Climate Agreement has been serving its purpose of punishing the more pollutant firms and promoting innovations in greener sectors. It can be concluded that there is a negative relationship between the Paris Climate Agreement and financial performance. Investors tend to react negatively to the agreement if they are investing in pollutant sectors and highly affected by the agreement due to uncertainty about future earnings.

7.2. Limitations and further research

Several limitations to the analysis and validity of the results can be relevant to this research.

In this study, the only benchmark considered is the market value on mayor indices. However, country indices are expected to have a higher correlation with firms' value, giving a better and more relevant explanation in the normal returns. This is mostly true for the Europe in this research, since the S&P 500 is already a country index. Future researched can consider the possibility of using country specific indices as benchmark.

A second limitation of this study is connected to the fact that only sectors and a dummy variable are used as explanatory variables. Future researches should analyze the impact of the PCA on market values using different firm-specific indicators, controlling for any effect of these variables on the abnormal returns. There might be a chance of omitted variable bias.

A third limitation is related to the data used. Europe and the United States are two developed regions with quite stable economic and social status. However, there are other countries,

especially in regions like Asia or Africa that are exposed to different economical and financial risks and have a huge impact on the GHG emissions. Future researches should expand the analysis into riskier and more pollutant regions.

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