Stock Market Reactions to International Climate Negotiations

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Abstract

Several studies have shown that investors take environmental regulation into account in their investment decisions. We investigate if international climate negotiations are an effective signal to decarbonize the economy. For that purpose, we analyze short-term market reactions to the outcomes of international climate negotiations, through an event study. We compare the stock price effects on the largest „green" companies with the largest „brown" companies globally. We find that international climate negotiations have a signaling effect on global financial markets. Before 2013, climate negotiations mainly had effects on „green" companies. Only starting in 2013, but especially in 2015 (Paris Agreement), we can find negative effects on „brown" companies. This indicates that the focus has shifted to the risks for brown companies. Although the Paris Agreement was considered a political milestone, it was less effective as an investment signal. A possible explanation is the mismatch between international targets and national policies.

Key words: Event Study, Climate Policy, Responsible Investment, Climate negotiations, Paris Agreement

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1 Introduction

Each year an international climate negotiation is held, as a major effort to set more ambitious emission reduction targets and to reach a binding emission reduction agreement between all countries. During the last 10 years of climate negotiations, the Copenhagen summit (COP15 in 2009) became known for having failed to establish a successor to the Kyoto protocol. Six years later, the Paris summit (COP21 in 2015) became known for reaching a landmark climate deal, the Paris Agreement. However, the introduction of a global price on carbon, often argued to be the most effective policy instrument, has not been achieved yet. Subsequently, the lack of adequate policy implementation at international and national levels creates uncertainties for greenhouse-gas-emitting industries and their investors. This raises the question of whether or not these annual negotiations are perceived as effective steps towards a decarbonisation of the global economy. One way of measuring this is by investigating financial market responses to the announcements of the outcome.

While the most important goal for financial managers is the maximization of shareholder value, environmental responsibility (such as greenhouse gas emission reduction) is usually associated with additional costs and few benefits. Porter and der Linde (1995) have argued for a new framing of the environment-competitiveness debate, by introducing the 'induced-innovation hypothesis' which says that environmental awareness can lead to competitive advantages. Indeed, this view is taken up in concepts like the triple bottom line (Glac; 2015; Henriques and Richardson; 2013), corporate social responsibility (CSR)[1] and stakeholder theory[2] (Freeman; 2010). There is a growing literature that finds a neutral or positive effect of CSR activities on valuation and performance (Busch and Hoffmann; 2011) and on reduced stock price crash risk (Wu and Hu; 2019). In 2016, about 1/6 of Assets-under-management (AuM) (USD 22.89 trillion) were managed under responsible investment strategies (Global Sustainable Investment Alliance; 2016), with Europe (52.6%) and the United States (38.1%) representing the largest market shares. Due to their increasing market share, one can expect their decisions to have an influence on market prices.

We start from the premise that international climate policy influences investors' expectations about tighter environmental regulation in different countries, and that investors have information about how individual companies will be effected by it. To investigate if and to what extent climate policy influences investors' expectations on future cash flows (and therefore the valuation) of companies, we perform an analysis based on the event study methodology. Event studies are a common methodology in finance and management research, testing the statistical significance of stock price changes on selected and subsequent days. In the area of sustainability, event studies have been applied to study the effect of environmental performance disclosure (Gupta and Goldar; 2005), pollution control (McWilliams and Siegel; 1997), sustainability rankings (Lyon and Shimshack; 2015; Murguia and Lence; 2015), sustainable indices (Curran and Moran; 2007; Robinson et al.; 2011), and environmental awards (Klassen and McLaughlin; 1996). Furthermore, event studies have been deployed to study financial-market effects of binding national regulations (Ramiah et al.; 2013) and supra-national regulations (see Koch et al. (2016) and Jong et al. (2014) regarding the EU emission trading system). A meta-analysis by Endrikat (2016) concludes that most event studies focus on a specific country, with the United States typically over-represented. The event-study approach can complement other types of studies on the effectiveness of

[1] There are different reasons for companies to engage in CSR activities, ranging from internal factors, such as employee satisfaction and customer satisfaction, to external factors, such as legal rules and enforcement mechanisms.

[2] Stakeholder theory argues that managers need to satisfy demands of different stakeholders, which are often competing.

government intervention, e.g. by investigating their effect on renewable energy deployment and generation (Carley; 2009; Delmas and Montes-Sancho; 2011), investments (Chevallier et al.; 2009) or investors risk perception (Polzin et al.; 2015).

This paper complements the literature by providing an analysis of financial market effects of climate policy events at the international level. Since international climate accords are not legally binding at the country or even the company level, this study provides an indication of the effectiveness of non-binding international climate negotiations. Furthermore, the analysis goes beyond the energy sector and includes companies that use large amounts of fossil fuels in their production processes as well as companies that produce a large share of green products. Hence, we differentiate between high- and low-carbon companies, to find out how these announcements influence companies that will be affected positively, versus companies that will be affected negatively.

The paper is structured as follows. Section 2 reviews relevant work and sets the background for the present paper. Section 3 describes the selected events and data used. Section 4 describes the methods used. Section 5 presents and discusses the results and Section 6 summarizes the general findings.

2 Background and literature review

Estimating the impact of climate and transition risks on individual financial institutions as well as the financial system as a whole has become an increasingly important issue (Dietz et al.; 2016; Battiston et al.; 2017). However, opinions and estimations for a potential size of such a shock are divided. Griffin et al. (2015) concluded that investors recognized the scientific finding that a substantial share of fossil fuel reserves is unburnable under a 2°C target. However, the effect was not as substantial as expected. One of the reasons stated by the authors was that the timing of strict policy implementation is highly uncertain and therefore sudden portfolio adjustments are unlikely.

On the one hand, stricter policy measures at the international level are required to shift investments from high-carbon to low-carbon activities. On the other hand, investors need to have access to information regarding which companies are engaging in low-carbon activities, taking them into account in investment decisions.

The environmental finance literature addresses both of these points. One strand of the literature is investigating if signalling sustainability leadership has a positive effect on shareholder value, either via self-disclosure (e.g. via sustainability reports and environmental disclosure (Gupta and Goldar; 2005)) or via external parties in sustainability rankings (Lyon and Shimshack; 2015; Murguia and Lence; 2015), sustainable indexes (Curran and Moran; 2007; Robinson et al.; 2011), or environmental awards (Klassen and McLaughlin; 1996). At the global level, Robinson et al. (2011) investigated abnormal returns for firms that where added to the Dow Jones Sustainability Index (DJSI), a global sustainability benchmark. Additions to the index are seen as a signal that a company has reached a certain level of social and environmental performance. Another global analysis by Murguia and Lence (2015) investigates the influence of the 2010 Newsweek "Green Global 100" ranking, listing the largest 100 green companies globally. They find that the release of the ranking changed relative prices, and that the top 50 companies (mainly non-heavy industry) reacted more strongly to the ranking release. Furthermore, stronger reactions were reported for non-US-traded stocks, possibly because they had not been included in the Newsweek US ranking from 2009 or because most non-US-traded companies were European, which are often subject to stronger environmental regulation. The paper by Gupta and Goldar (2005) examined the stock market effect of environmental ratings from the leading environmental NGO in India on stock prices of Indian companies. They find that weak environmental

performance by dirty industries is penalised by negative abnormal returns (as in the paper and pulp industry) and conclude that environmental ratings can increase market pressure especially in emerging market economies were standards and enforcement mechanisms are not as strong.

Another strand of the environmental finance literature investigates how policy changes affect listed stocks. The paper by Ramiah et al. (2013) investigates 19 announcements of environmental regulation on listed equities in Australia between 2005 and 2011[3]. The authors find that more than half of the sectors were affected by the policy announcements (14 out of 35 industries were not affected). 29% of sectors experienced negative abnormal returns, 20% experienced positive abnormal returns. They find that the wealth of shareholders in the electricity sector (in Australia) did not change, which indicates that the biggest polluters are not affected by the green policies. This was explained by the ability to pass on the increased costs to consumers. The oil, gas, real estate and general industrial sectors experienced negative abnormal returns. By analysing systematic risk they find that green policies create uncertainty in the market. Similarly, Koch et al. (2016) investigated the responsiveness of the CO2 price in the EU emission trading system (EU-ETS) to policy events, looking at short-term policy interventions (ETS reform decisions) and decisions regarding the long-term trajectory (2020 and 2030 policy packages).

The existing event-study literature related to sustainability and finance provides evidence that investors take environmental and climate-related news into account, finding effects due to environmental ratings and rankings and due to changes in environmental regulation at the national level. However, a meta-analysis by Endrikat (2016) concludes that most event studies focus on a specific country, with the United States being over-represented. So far, only Mukanjari and Sterner (2018) investigate the effect of international climate policy events, namely the effects of the Paris Agreement and the US presidential election in 2016 on energy sector firms.

This paper complements the literature by extending the scope to a series of international climate negotiations and by including not only energy companies but high-carbon companies as well as low-carbon companies.

3 Events and data

This section first explains which events were analysed and second, which financial data was used to perform the analysis.

3.1 Events

The literature on environmental finance suggests that stock markets react to changes in environmental regulation, leading to positive valuation effects for companies with a positive environmental rating. Despite their non-binding nature, international climate negotiations, the Conferences of the Parties (COP), are among the most important international efforts to reduce carbon emissions. These negotiations and resulting accords set the agenda for the national implementation of climate and environmental policy. Therefore, we expect that climate negotiations which resulted in an international agreement on ambitious emission reductions will lead to negative effects for high-carbon companies (as it would decrease future demand and increase costs) and positive effects for low-carbon companies (via increased revenue expectations) and vice versa.

[3]Using data on 1770 individual stock prices from data stream, the ASX200 index as a proxy for the market, and the 10-year bond yield as proxy for the risk-free rate. The Datastream classification is utilised to construct industry portfolios (45 industries).

We examine a series of international climate negotiations, including all climate negotiations between 2009 and 2016, which aimed to establish a successor of the Kyoto Protocol. The Kyoto Protocol, signed in 1997, was the first international treaty aiming to reduce greenhouse gas concentration in the atmosphere. Its first commitment period lasted until 2012. Our analysis starts with the 15th Conference of the Parties (COP15 in 2009) in Copenhagen, because it was set out to establish a post-Kyoto agreement but failed to do so. This was regarded a major set back in international climate negotiations. At COP17, held in Durban in 2011, the Parties agreed to establish a legally binding treaty by 2015, which secured the Kyoto Protocol but diminished the hope for immediate and serious action (Helm; 2012). At COP18, held in Doha in 2012, the Parties agreed on a second commitment period until 2020, called the Doha Amendment to the Kyoto Protocol (Böhringer; 2014). Finally, the 21st Conference of the Parties (COP21), held in December 2015 in Paris, resulted in the Paris Agreement. The Paris Agreement is regarded a historic deal, as it contained the commitment of all participating countries to "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C [...]" (UNFCCC; 2015, Article 2.1.a).

We performed a financial news search on the terms "climate accord", "climate agreement" and "COP AND climate" and found high media coverage of the climate negotiations on the one hand and the US presidential election in 2016 and the US announcement of the withdrawal from the Paris Agreement in June 2017 on the other hand. The results of the news analysis can be found in Appendix 3.A.

Therefore, we included these two events as additional political events, as they shaped a large part of the international debate on climate change during the last years. The US election in November 2016 created uncertainty about the survival of the Paris Agreement and clearly had an influence on the 22nd Conference of the Parties in Marrakesh (COP22), that followed shortly after the US election. This was followed by the "rose garden speech" in June, 2017, where the US president officially announced the intention of the US government to withdraw from the Paris Agreement. Although, according to the Paris Agreement the withdrawal can only come into effect in 2020, it reduced the credibility of the agreement.

Table 1 contains a list of all events, their respective dates, as well as the main political outcome of the event and the stock price effect we expect from this outcome.

3.2 Data

To obtain the abnormal returns for high-carbon ("brown" companies hereafter) and low-carbon companies ("green" companies hereafter), we prepared two lists of companies and retrieved historical daily stock data. We obtained our list of green companies from the Clean200 (Heaps et al.; 2016), a ranking of the largest 200 publicly-traded companies worldwide with the largest share of revenues from clean energy. This list was released for the first time on August 16th, 2016 by "As you sow" and Corporate Knights[4]. The ranking uses Bloomberg Data on company size (by market-cap) and the share of "green" revenues, which is an estimate on the share of activities from renewable energy, energy smart technologies, carbon capture and storage (CCS), and carbon markets[5]. To be considered for the ranking, companies need to have a market capitalization of at least 1 billion and a minimum of 10% in green revenue. This ranking was used, because a high share of green revenue indicates that the company would directly benefit from an increase in demand for these products.

[4]Since the first release, several updates have been published. However, the list of the Clean200 remains quite stable. For that reason, they are not considered in the analysis.

[5]Bloomberg divides companies into "main driver" (50-100% of value), considerable (25-49%), moderate (10-24%) and minor (below 10%)

Table 1: Selected events, including their dates, the main political outcomes and the expected price effects on green and brown companies. (–) stands for negative, (– –) for very negative (+) for positive and (+ +) for very positive.

Selected event	Date	Main outcome	Expected price effect	
			green	brown
COP15 (Copenhagen)	2009-12-18	Failed to establish a post-Kyoto agreement	(– –)	(++)
COP16 (Cancun)	2010-12-10	Agreement on extension of Kyoto Protocol and on establishing a "Green Climate Fund"	(+)	(–)
COP17 (Durban)	2011-12-09	Agreement on establishing a legally binding treaty but delayed talks until 2015	(–)	(+)
COP18 (Doha)	2012-12-07	Amendment to Kyoto Protocol (EU, AUS, etc.). Agreement to extend Kyoto until 2020	(+)	(–)
COP19 (Warsaw)	2013-11-25	Package to keep climate negotiations on track	no effect expected	
COP20 (Lima)	2014-12-12	Joint emission reduction announcement by US and China	(+)	(–)
COP21 (Paris)	2015-12-14	Paris Agreement as landmark deal	(++)	(– –)
COP22 (Marrakesh)	2016-11-21	No specific outcome reached	no effect expected	
US pres. election	2016-11-08	Announcement to revive the coal industry	(–)	(+)
US withdrawal	2017-06-01	US announcement to step out of Paris Agreement	(–)	(+)

We obtained our list of brown companies from the Global 500 from the CDP Global 500 Report, which is published by CDP on an annual basis. The companies were sorted by their scope 1 CO2 emissions, as reported to CDP[6] and top 200 companies in the list were selected. This approach was chosen, because we expect the companies with the highest emissions to be strongly effected by more ambitious climate policy.

Due to the observation that the set of green companies had a much larger share of companies in emerging markets, we enriched both sets with this additional information: whether a company comes from an emerging or developed market. The classification of the IMF was used. In the set of green companies, 86 are from emerging markets (versus 97 from developed countries). In the set of brown companies, only 24 companies are from emerging markets (versus 162 from developed countries). The list of companies can be found in Appendix 3.B.

Financial data on stock prices and indexes was obtained from Google Finance. Stock market data that was not available from Google Finance was obtained from Yahoo Finance.

We gathered data for non-adjusted daily closing prices for each company and the relevant market indices for the sample period. The data span the period from December 18th, 2008 until June 15th, 2017, covering a one year estimation window before the first event, COP15 in December 2009, until the last event, the US withdrawal from the Paris Agreement in

[6]Scope 1 emissions are direct emissions from the operations of the respective company. Indirect emissions from upstream and downstream activities in the supply chain of that company are included in scope 2 and scope 3 emissions.

June 2017. More details on the estimation and event windows can be found in Section 4. The first set included 187 green companies, while the second one 186 brown companies. 13 companies were omitted from the green set and 14 from the brown set due to incomplete or missing data. For individual events, additional companies had to be dropped when stock price data was missing during the event window. The number of companies analysed for each event is reported in Section 5.

4 Methods

This section will first describe the general methodology of event studies and second, the two types of analysis used, which are based on the event study approach.

4.1 Event study

According to early work by Fama (1991), event studies rely on the efficient market hypothesis (EMH), assuming that new information is priced in immediately. Although, the EMH has been challenged by behavioral finance (Shleifer; 2000), event studies have a clear advantage. They take a forward-looking perspective, as stock prices entail investors' evaluations of the expected future performance of companies (as opposed to the backward-looking perspective of accounting-based approaches). And, as shown by Griffin et al. (2015) the event study methodology can also be utilized to investigate "lagged" responses, as opposed to "rational" responses.

The event study method tries to capture the impact of (one or more) external events on stock prices. It requires a measure of abnormal price return, in other words, the actual return minus the expected return of the stock. MacKinlay (1997) provides an overview on the use of event studies and different methodologies applied in economics and finance and McWilliams and Siegel (1997) discuss theoretical and research design issues in event studies applied in management research.

The event study requires an estimation window and an event window. The estimation window is used to estimate the slope and intercept of the market model and to determine the abnormal return in the event window. Because most climate agreements were made during the weekend after the official last day of the negotiations, which is not a trading day, we chose the official last day as the event day (day 0). The estimation window starts 365 calender days (usually about 245 trading days) before the event and ends 10 calender days before the event day. The event window starts one trading day before the event (day -1), to include possible reactions to early announcements before the finalization of the agreement. And the event window ends four trading days after the event (day 4), to include possible lagged responses. For COP21 in Paris this means that the event day is Friday, 2015-12-11. The event window lasts from 2015-12-10 to 2015-12-17 and the estimation window lasts from 2014-12-11 until 2015-12-01.

The event study procedure starts by calculating the abnormal returns for company i and day τ:

$$AR_i(\tau) = R_i(\tau) - E[R_i(\tau)] \tag{1}$$

where $R_i(\tau)$ denotes the actual daily return of the stock, $E[R_i(\tau)]$ denotes the expected normal (daily) return and $AR_i(\tau)$ the abnormal return.

The model used to determine the expected normal returns in this work is the market model: it assumes a linear relation between the overall market return and the return of the stock (Ranco et al.; 2015; Gabrovšek et al.; 2017). The market model is estimated by using the return of the individual stock and the return of the stock market index, during

the estimation window:

$$E[R_i(\tau)] = \hat{\alpha}_i + \hat{\beta}_i R_{index}(\tau) \ , \tag{2}$$

where $R_{index}(\tau)$ denotes the daily return of a stock market index on day τ.

It is worth noting that since companies used in this analysis are traded on different stock exchanges, the market model is calculated by using the stock market index of the country that the company's headquarter is located in. The information about the country of the headquarter of each company is listed in Tables 4 to 5 in Appendix 3.B.

After calculating the abnormal price returns for each of the n companies, there are two possibilities for further calculations. The first one is to calculate the cumulative abnormal return (CAR) from time τ_1 to τ_2 for one company:

$$CAR_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} AR_i(\tau) \ . \tag{3}$$

The second possibility is to aggregate the AR values for all companies in the set and calculate an average cumulative abnormal return ($\overline{CAR}$) from time τ_1 to τ_2:

$$\overline{AR}(\tau) = (1/n) \sum_{i=1}^{n} AR_i(\tau) \ , \tag{4}$$

$$\overline{CAR}(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} \overline{AR}(\tau) \ . \tag{5}$$

For example, the values of $\overline{CAR}(-1, -1)$ up to $\overline{CAR}(-1, 4)$ are reported in Section 5 for a set of green and a set of brown companies.

According to the definition of the event window, the value of τ_1 in Eq. 5 is set to one day prior to the event day and τ_2 to four working days after the event day.

4.2 Portfolio-based approach in the presence of cross-sectional correlation

In this analysis, we want to investigate the influence of a specific event day on the stock prices of several companies, which is called event-day clustering. In this case, the average (cumulative) abnormal returns of several companies corresponds to an equally-weighted portfolio: a portfolio where every company's price return is weighted the same.

In other words, the portfolio-based approach tests if the stock prices of a set of companies significantly increases or decreases due to the influence of one event. This type of analysis differs from the standard event study analysis (Ranco et al.; 2015; Gabrovšek et al.; 2017). In the presence of event-day clustering, it is known that cross-sectional correlation of the returns appear, which requires different treatment during the statistical inference (Kolari and Pynnönen; 2010). The statistical test used to infer if the average CAR value for a set of companies is significantly (positively or negatively) affected by this event is an adaptation of the t-test.

The statistical significance is calculated by using the standardized version of the abnormal returns, i.e. standardized abnormal returns (SAR). For company i and day τ it is calculated as:

$$SAR_i(\tau) = \frac{AR_i(\tau)}{\sqrt{\frac{1}{T_1 - T_0 - 1} \sum_{t=T_0+1}^{T_1} AR_i(t)^2}} \ , \tag{6}$$

where T_0 and T_1 are the start and end day of the estimation window, respectively. The abnormal returns in the denominator denote the residuals of the market model regression over the estimation window.

The statistical analysis is then performed using the following steps:

- The standardized cumulative abnormal return is calculated: $SCAR_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} SAR_i(\tau)$ where τ_1 is set to T_1, the start of the event window.
- The Patell t statistic on day τ is calculated: $t_P(\tau) = \overline{A}_\tau \sqrt{\frac{n(m-p-3)}{m-p-1}}$, where $\overline{A}_\tau$ is the average $SCAR$ value for all companies on day τ, m is the length of the estimation window and p is the number of estimated parameters in the market model (Patell; 1976).
- The adjusted Patell t statistic on day τ is calculated: $t_{AP}(\tau) = \frac{t_P(\tau)}{\sqrt{1+(n-1)\overline{r}}}$, where $\overline{r}$ is the average of the sample correlations of estimation-period residuals (Kolari and Pynnönen; 2010).
- A two-tailed t-test (at 1%, 5% and 10% significance level) is used with the t_{AP} value.

5 Results and discussion

In this section, we first report our findings for the stock market effects of different international climate negotiations. And second, we report stock market effects of two related events.

5.1 Reactions to international climate negotiations

Using an equally-weighted portfolio analysis, we investigate the differences between the stock price changes of a set of green and a set of brown companies for a series of climate negotiations. The analysis includes all climate negotiations from Copenhagen (COP15) to Marrakesh (COP22). We find that, despite their non-binding nature, some international climate negotiations have a small but significant effect on stock prices in the expected directions.

Table 2 and Figures 1 and 2 show the Average Cumulative Abnormal Returns ($\overline{CAR}$) over different event windows, along with significance results which show which of the $\overline{CAR}$ are significantly different from zero.

We compare the results with the expected effect, as reported in Table 1 and focus on the effects after the event (day 1 to day 4). Unlike expected, the climate negotiations in Copenhagen (COP15), which failed to establish a post-Kyoto Agreement, had no significant effect on the green or brown companies. COP16 in Cancun, where an extension of the first commitment period of the Kyoto protocol was agreed upon, had a positive effect on green companies on day 2, 3 and 4 after the event day (0.9% on day 4). COP17 in Durban, where it was decided to delay further discussions on a binding treaty until 2015, had a significantly negative effect on green companies on day 2, 3 and 4 (-2% on day 4). COP18 in Doha, where an agreement on a second commitment period of the Kyoto protocol was reached, had a positive and significant effect on green companies from day 1 to day 4 (1.6% on day 4). Unlike expected, for COP16 - COP18 we found no significant effects on brown companies (except for day 4 in Cancun).

COP19 in Warsaw, which agreed on a package to keep climate negotiations on track, had a small negative effect on brown companies on day 2, 3 and 4 (-0.3% on day 4). COP20 in Lima, which resulted in an agreement that all countries would declare their Intended Nationally Determined Contributions (INDCs) in Paris in 2015, had a mixed effect. It

Table 2: Average Cumulative Abnormal Returns ($\overline{CAR}$) to international climate negotiations for a set of green and brown companies over a specific event window. Statistical significance is denoted at the 0.1 level by *, at 0.05 level by ** and at 0.01 level by ***, and is calculated according to the adjusted Patell t-test which in turn uses standardized versions of the abnormal returns.

Event	Date	Subset	Num. Comp.	$\overline{CAR}$ $(-1,-1)$	$\overline{CAR}$ $(-1,0)$	$\overline{CAR}$ $(-1,1)$	$\overline{CAR}$ $(-1,2)$	$\overline{CAR}$ $(-1,3)$	$\overline{CAR}$ $(-1,4)$
COP15	2009-12-18	GREEN	93	-0.0046	-0.0129	-0.0133	-0.0151	-0.0148	-0.0172
(Copenhagen)	2009-12-18	BROWN	140	-0.0013	-0.0024	-0.0042	-0.0042	-0.0036	-0.0051
COP16	2010-12-10	GREEN	115	-0.0026	0.0008	0.0024	0.0061 **	0.0082 **	0.0089 **
(Cancun)	2010-12-10	BROWN	137	-0.0003	0.0004	-0.0005	-0.0007	-0.0014	0.0013 **
COP17	2011-12-09	GREEN	116	-0.0007	0.0012	-0.0005	-0.0073**	-0.0157***	-0.0208***
(Durban)	2011-12-09	BROWN	140	-0.0005	0.0007	-0.0006	-0.0050	-0.0024	-0.0009
COP18	2012-12-07	GREEN	116	0.0026	0.0044	0.0119 ***	0.0165 ***	0.0152 ***	0.0164 ***
(Doha)	2012-12-07	BROWN	142	-0.0009	0.0015	0.0019	0.0009	0.0044	0.0028
COP19	2013-11-25	GREEN	116	-0.0021	-0.0011	-0.0025	-0.0008	-0.0015	-0.0001
(Warsaw)	2013-11-25	BROWN	142	-0.0002	-0.0001	-0.0009	-0.0006*	-0.0027**	-0.0033***
COP20	2014-12-12	GREEN	116	0.0010	0.0001	0.0016	-0.0029	-0.0108**	-0.0098
(Lima)	2014-12-12	BROWN	143	-0.0005	-0.0032	-0.0070**	-0.0092**	-0.0024	0.0017 **
COP21	2015-12-14	GREEN	116	-0.0030	-0.0028	-0.0046	-0.0018	0.0043	0.0040
(Paris)	2015-12-14	BROWN	143	0.0009	-0.0020	-0.0038	-0.0065	-0.0091**	-0.0140***
COP22	2016-11-21	GREEN	115	-0.0006	0.0005	-0.0030	-0.0043	-0.0037	-0.0060
(Marrakesh)	2016-11-21	BROWN	143	-0.0006	-0.0027	0.0009	0.0010	-0.0007	-0.0005

showed small but significant negative effects on brown companies on day 1, 2 and 4. The climate negotiations in Paris (COP21) were the first to have a significant negative effect on brown companies above 1% (-1.4% on day 4). The outcome of the climate negotiations in Marrakesh in 2016 (COP22), which lead to no surprising outcome, had no significant effect on prices of both set of companies. Unlike expected, for COP19 - COP22 we found no significant effects on green companies (except for day 3 in Lima).

The effect of the first four events (COP15-18) was small but significant for green companies and mostly insignificant for brown companies. It seems that financial markets had focused on the potential new market opportunities from an international climate deal. Starting in 2013, the effect on green companies for the four subsequent events (COP19-22) was mainly insignificant. For brown companies, however, Warsaw (COP19) and Lima (COP20), but especially the Paris Agreement (COP21) resulted in negative effects. This result indicates that the focus shifted to potential transition risks for high-carbon companies. For COP21, especially, we also see a stronger divergence between the two sets of companies.

Overall the magnitude of the effect is not higher than in previous climate negotiations, although COP21 established a landmark climate deal, which also received large news coverage. Indeed, these results are in line with the findings of Mukanjari and Sterner (2018), who find only a moderate effect of the Paris Agreement.

We performed an additional analysis, where the green and brown companies were divided into companies from developed and emerging markets. The results are reported in Appendix 3.C. Overall, the results show that the effect on companies from emerging markets (green and brown) turn out to be stronger than for developed markets, especially for green companies. We found no effects on brown companies from developed economies from COP15 (in 2009) to COP18 (in 2012). However, in 2013, this started to change. After COP19 (2013) we find very small but significant negative effects (0.26%) on these companies. COP21 (2015) for the first time shows negative cumulative abnormal returns in brown companies from developed economies above 1.5%.

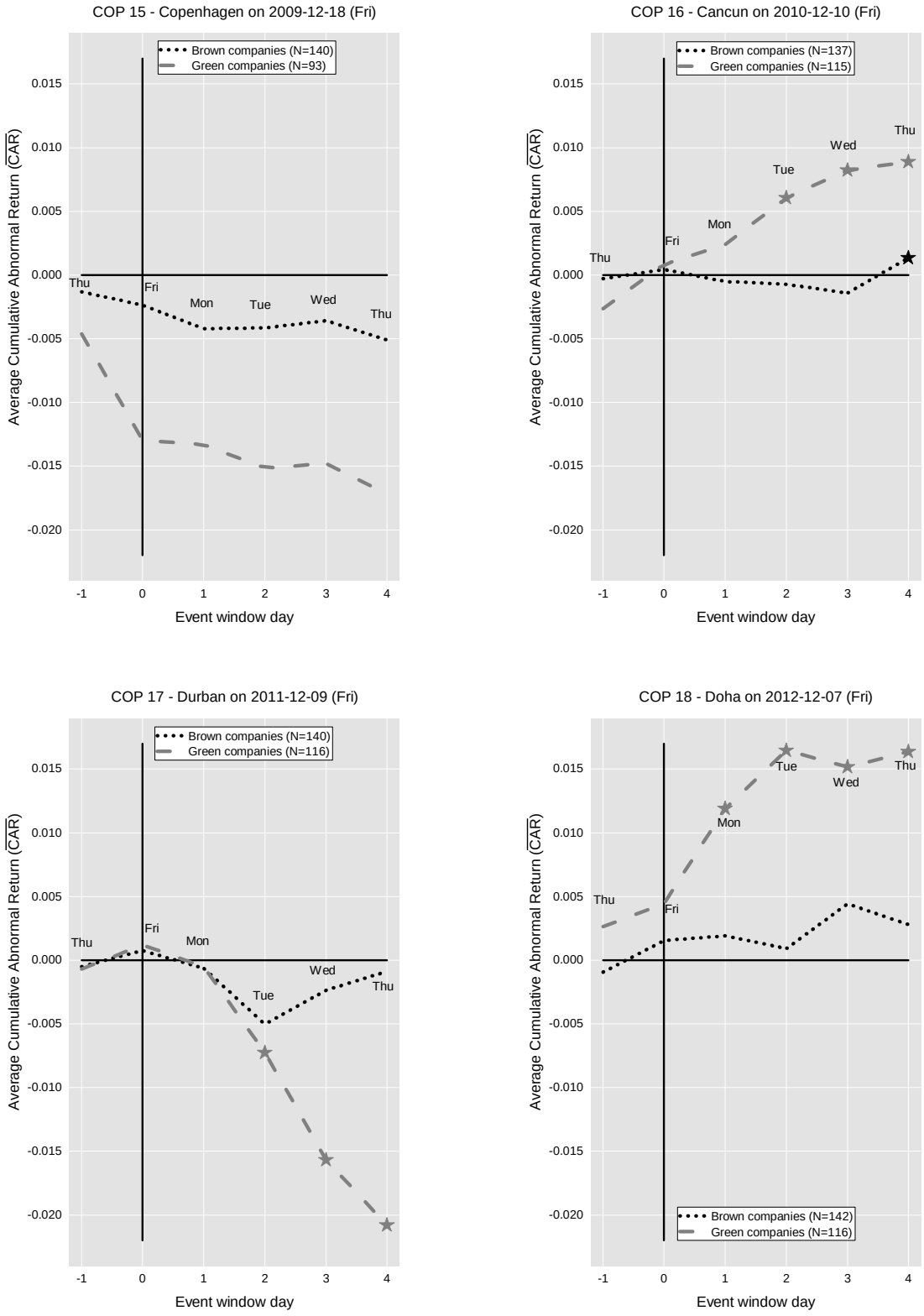

Figure 1: Average Cumulative Abnormal Returns ($\overline{CAR}$) for a set of green and a set of brown companies for COP15 (top right), COP16 (top left), COP17 (bottom right) and COP18 (bottom left). Statistical significance at the 0.1 level is denoted by an asterisk, and is calculated according to the adjusted Patell t-test which in turn uses standardized versions of the abnormal returns.

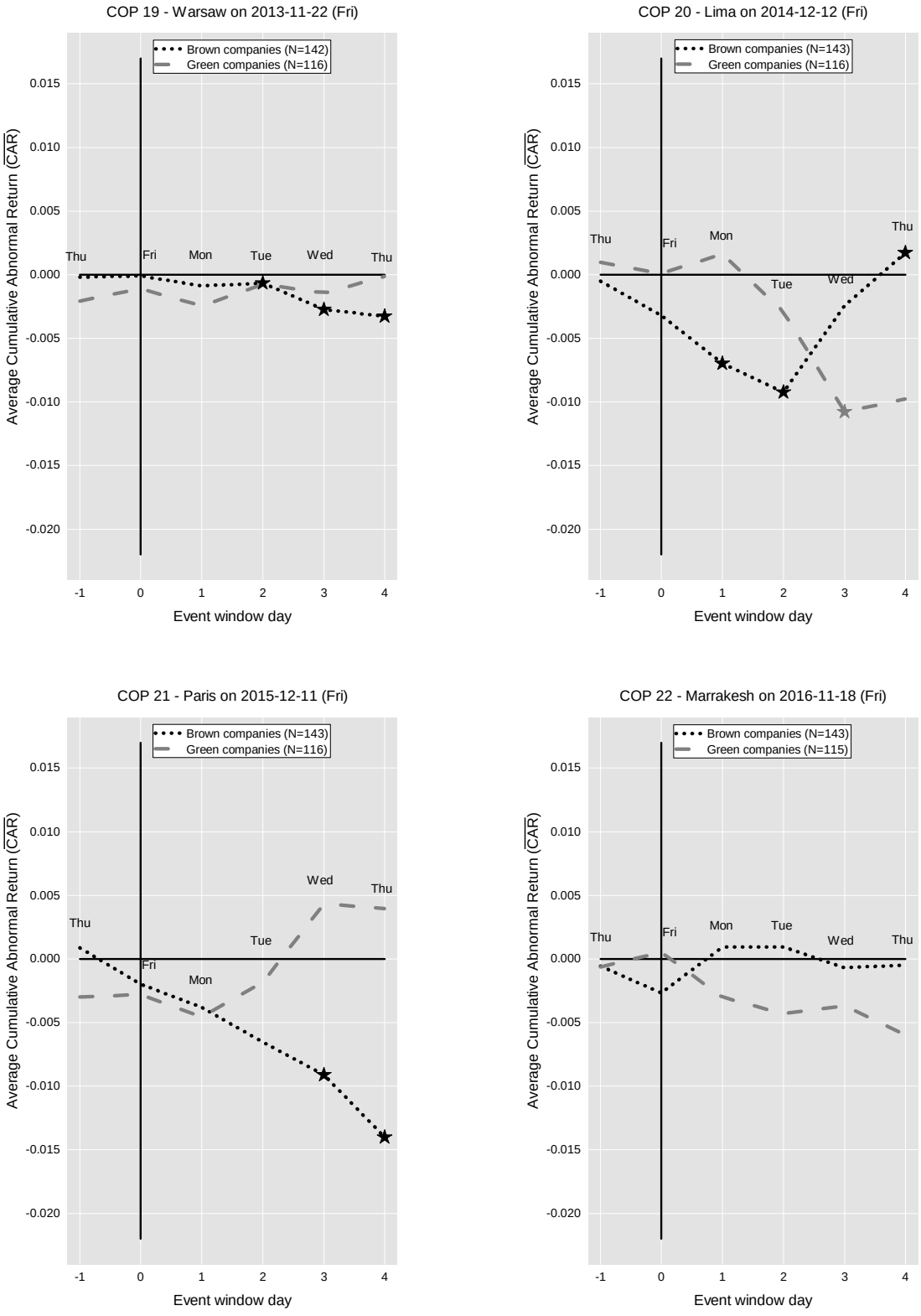

Figure 2: Average Cumulative Abnormal Returns ($\overline{CAR}$) of a set of green and a set of brown companies for COP19 (top right), COP20 (top left), COP21 (bottom left) and COP22 (bottom right). Statistical significance at the 0.1 level is denoted by an asterisk, and is calculated according to the adjusted Patell t-test which in turn uses standardized versions of the abnormal returns.

The stronger effect on green companies in the earlier years might be due to the fact that the market uptake of green companies is more dependent on ambitious climate policy. Furthermore, the negative effects on brown companies, especially from developed economies starting in 2013, might indicate that investors started to realize the potential losses in market demand or potential stranded assets of fossil fuel companies and became more sensitive to risks than to gains. As Griffin et al. (2015) reported, it was only in 2012 and 2013 that the financial press picked up the news that a substantial share of proven fossil fuel reserves could become stranded. An additional reason might be that the number of investors using exclusion criteria as their main responsible investment strategy is growing, especially in the EU and the US.

5.2 Related political events

Two related political events in the US were included in the analysis, due to their influence on international climate policy negotiations as well as the large news coverage they received. Table 3 and Figure 3 show the Average Cumulative Abnormal Returns ($\overline{CAR}$), along with significance results which show which of the $\overline{CAR}$s are different from zero.

Table 3: Average Cumulative Abnormal Returns ($\overline{CAR}$) for brown and green companies, during US election and the US withdrawal from the Paris Agreement (COP21). Statistical significance is denoted at the 0.1 level by *, at 0.05 level by ** and at 0.01 level by ***, and is calculated according to the adjusted Patell t-test, which uses a standardized versions of the abnormal returns.

Event	Date	Subset	Num. Comp.	$\overline{CAR}$ $(-1,-1)$	$\overline{CAR}$ $(-1,0)$	$\overline{CAR}$ $(-1,1)$	$\overline{CAR}$ $(-1,2)$	$\overline{CAR}$ $(-1,3)$	$\overline{CAR}$ $(-1,4)$
2016 US election	2016-11-08	GREEN	116	0.0005	0.0001	-0.0068**	-0.0035	-0.0021	0.0000
	2016-11-08	BROWN	143	0.0012	0.0014	0.0026	-0.0010*	-0.0033*	-0.0065***
US withdrawal from COP21	2017-06-01	GREEN	85	0.0019	0.0031*	0.0016	0.0001	0.0009	-0.0011
	2017-06-01	BROWN	143	-0.0025	-0.0031	-0.0046	-0.0065	-0.0034	-0.0080

The 2016 presidential election in the US came with a promise to revive the coal industry in the US and decreased the likelihood of more ambitious climate policy. In line with our expectations, the effect of the US presidential elections on green companies was negative at first, however returning to zero on day 4. When companies are divided into companies from developed and emerging markets (as reported in Appendix 3.C) we find that the negative effect on companies prevails for green companies from emerging economies. Contrary to our expectations, the US presidential elections had a negative and significant effects on brown companies, especially on day 4 (-0.65 %) and especially for brown companies from developed countries.

On June 1, 2017, the US president announced its intention to withdraw from the Paris Agreement. Although, according to the Paris Agreement, the withdrawal would only come into effect in 2020 at the earliest, it increases the uncertainty of the future viability of the agreement. The announcement had no significant effect on both sets of companies. The stock prices of the brown companies decreased (see Figure 3 right) but remained insignificant. This result indicates that either the withdrawal was already foreseen after the election (and therefore priced in already) or that the withdrawal was considered neither credible nor effective. This might be due to the fact that a withdrawal would only come into effect in 2020 at the earliest. However, when the green and brown companies are divided into companies from developed and emerging markets (as reported in Appendix 3.C we can find a negative effect on green and brown companies from emerging economies.

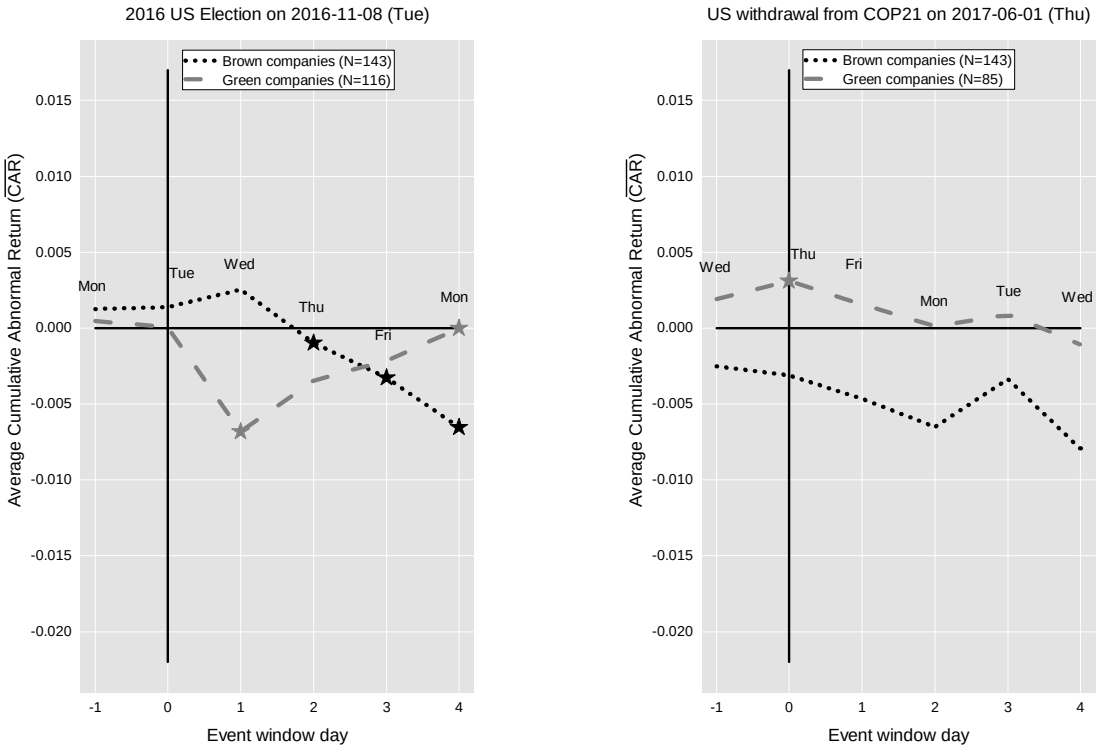

Figure 3: Average Cumulative Abnormal Returns ($\overline{CAR}$) of a set of green and a set of brown companies for the US election in 2016 (left) and the US withdrawal from the Paris agreement (right). Statistical significance at the 0.1 level is denoted by an asterisk, and is calculated according to the adjusted Patell t-test which in turn uses standardized versions of the abnormal returns.

Both, the presidential election and the US withdrawal from the Paris Agreement had a stronger effect on companies from emerging economies. This indicates that companies from emerging economies are more dependent on international climate agreements. The negative effect on brown companies might be explained by the large share of non-US business of large-cap firms, coinciding with Wagner et al. (2017) who found negative effects for companies with large non-US sales (and positive effects for companies with large US-based sales), as well as with Mukanjari and Sterner (2018) who find that globally fossil fuel companies did not benefit from the US presidential elections despite the promise to revive the coal industry.

6 Conclusion

In this paper, we investigated the stock market effects of a series of climate negotiation at global scale, differentiating between high-carbon and low-carbon companies, in an event study.

We provide evidence that international climate negotiations can have a signaling effect on global financial markets. Results show that climate negotiations which facilitate the transition to a low-carbon economy lead to either significant positive wealth effects for green companies, with 0.9% and 1.6% abnormal returns for green companies after the post-Kyoto negotiations in Cancun and Doha respectively (but insignificant effects on brown companies), or to significant negative wealth effects for brown companies, with -1.4% of

abnormal returns for brown companies after the Paris Agreement (but insignificant effects on green companies). We find that over time, financial market actors seem to have shifted from focusing on market opportunities for green companies (positive and negative effects on green companies until 2012, depending on the event) to focusing on including potential carbon risks in the valuation of brown companies (negative effects on brown companies after 2012). A possible reason might be that investors became more concerned about potential losses in market demand or potential stranded assets of fossil fuel companies, making them more sensitive to these risks than before.

However, overall the average effects are small. Although the Paris Agreement was considered a milestone in climate policy, its effect on stock markets did not reflect that to the same extent, as abnormal returns were not substantially higher than for earlier events. We conclude that investors do not seem to expect large direct impacts on cash flows. In order to become more credible, international commitments need to be complemented by (national) implementation strategies, which have predictable cashflow effects on companies.

The main implication for energy and climate policy is that the influence on cashflows of companies (and therefore their valuation) should be taken into account in the design and ex-ante evaluation of energy and climate policies. In order to reach the goal of "Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development." (UNFCCC; 2015, Article 2.1.c), energy and climate policies also need to be evaluated based on their influence on financial market decisions.

Furthermore, the event study methodology can be applied for ex-post evaluation of the effectiveness of different energy and climate policies in making finance flows consistent with the Paris Agreement. In future work, analyzing additional climate policy related events at the international level (such as the UN Climate Summit in New York or the One Planet Summit in Paris) and the national level could provide more detailed results and increase applicability in a global context. Moreover, applying the same methodology to a larger set of companies and differentiating effects by country or sector can lead to better insights into the distribution of effects. Knowing which countries and industries are most vulnerable to sudden changes in climate policy will become more relevant for financial risk analysis in the future.

Acknowledgements

We are grateful to Carlo Jaeger, Utz Weitzel and Jonas Teitge for their advice and suggestions, as well as to the participants of the 2017 "Conference on Finance and Sustainability" in Zurich and the 2018 "ISEFI" conference in Paris for useful comments. All authors acknowledge financial support from the H2020 FET project DOLFINS (grant no. 640772). Darko Aleksovski and Igor Mozetič also acknowledge support from the Slovenian Research Agency (research core funding no. P2-103).

Appendix 3.A: COP and US-related climate events in online news

To check for the importance and the interest in the climate negotiations (COPs) in online news, we performed an extensive news search. We used the NewsStream web portal Kralj Novak et al. (2015); Sluban et al. (2018) where financial news from about 200 worldwide English news and blogs sites are collected. The news acquisition started in October 2011, so we miss the first two COPs (Copenhagen and Cancun) included in the paper. We used a version of the NewsStream portal which allows for a free-text search of archived news and filtering of only environmental news. The web portal is accessible at `http://simpol.ijs.si/Home/NewsSearch`.

Figure 4 shows the results of a search query with the terms "climate accord" and "climate agreement". All the COP events are visible in the peaks of the news volume. Especially the Paris Agreement in December 2015 stands out. Moreover, the announcement of the withdrawal of the US from the Paris agreement shows 4 times the news volume as compared to the Paris Agreement itself.

Figure 5 shows the result of a query "COP and climate". All the COP events are visible in the peaks of the news volume. In addition, the peaks occur at the three State of the Union Addresses by president Obama, and climate protests in New York in 2014.

Figure 6 shows the result of a query "Trump and climate". The two peaks correspond to the results of the 2016 US presidential election and the US withdrawal from the Paris Agreement.

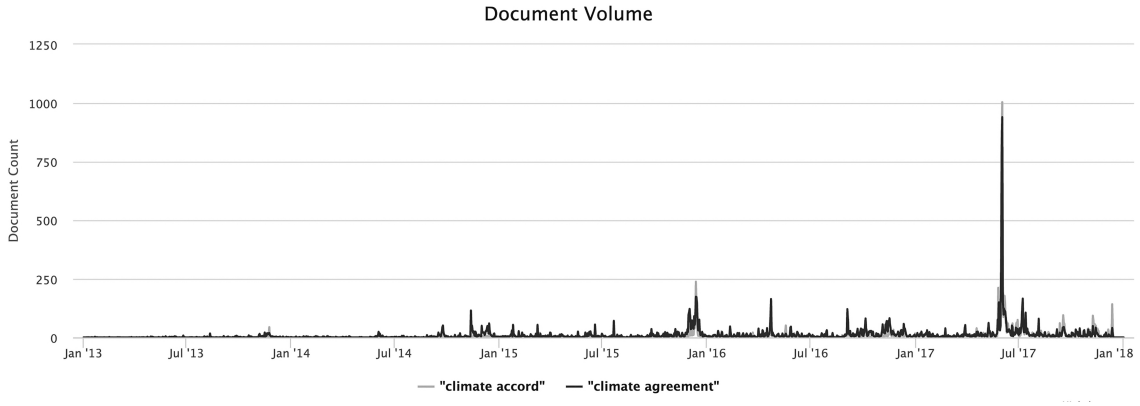

Figure 4: Daily volume of online news with terms "climate accord" and "climate agreement". The two largest peaks correspond to the Paris Agreement and the announcement of the withdrawal of the US from the Paris Agreement.

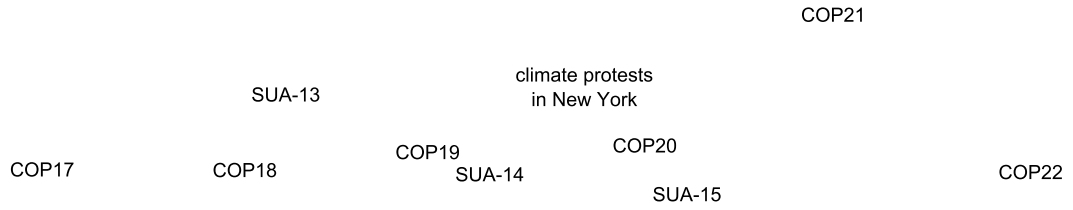

Figure 5: Daily volume of online news with terms "COP" and "climate". Peaks correspond to the COP conferences where COP21 (Paris) dominates. SUA labels indicate State of the Union Addresses delivered by president Obama.

Figure 6: Daily volume of online news with terms "Trump" and "climate". The two peaks indicate announcements of the 2016 US presidential election results, and the US withdrawal from the Paris Agreement.

Appendix 3.B: Green and brown companies

This appendix lists the companies used in the analysis. Table 4 lists the set of green companies, and Table 5 lists the set of brown companies. For each company there is the country of its registration, the stock exchange where it is listed, whether it is considered emerging or developed economy, and its main sector.

Table 4: List of 187 green companies. There are 90 companies from emerging economies, and 97 companies from developed economies.

#	Company Name	Country	Stock Exch.	Emer.	Sector
1	CSR LTD	Australia	Australia	n	Materials
2	ANDRITZ AG	Austria	Vienna	n	Industrials
3	UMICORE	Belgium	Brussels	n	Materials
4	CPFL ENERGIAS RE	Brazil	SaoPaulo	y	Utilities
5	SAO MARTINHO	Brazil	SaoPaulo	y	Cons.Stap.
6	WEG SA	Brazil	SaoPaulo	y	Industrials
7	BOMBARDIER INC-B	Canada	Toronto	n	Industrials
8	BROOKFIELD RENEW	Canada	Toronto	n	Utilities
9	INNERGEX RENEWAB	Canada	Toronto	n	Utilities
10	NEW FLYER INDUST	Canada	Toronto	n	Industrials
11	TRANSALTA RENEWA	Canada	Toronto	n	Utilities
12	ARCPLUS GROUP-A	China	Shanghai	y	Materials
13	BAONENGYUAN-A	China	Shenzhen	y	Utilities
14	BEIJING JINGYU-A	China	Shanghai	y	Info.Tech.
15	BEIJING NEW BU-A	China	Shenzhen	y	Industrials
16	BEIJING SIFANG-A	China	Shanghai	y	Industrials
17	BYD CO LTD-H	China	HongKong	y	Cons.Disc.
18	CECEP WIND POW-A	China	Shanghai	y	Utilities
19	CHINA BAOAN-A	China	Shenzhen	y	Industrials
20	CHINA LONGYUAN-H	China	HongKong	y	Utilities
21	CHINA NORTHERN-A	China	Shanghai	y	Materials
22	CHINA SHIPBUIL-A GRP	China	Shanghai	y	Cons.Disc.
23	CHINA XD ELEC-A	China	Shanghai	y	Industrials
24	COFCO BIOCHEM -A	China	Shenzhen	y	Materials
25	CSG HOLDING CO-B	China	Shenzhen	y	Materials
26	DO-FLUORIDE-A	China	Shenzhen	y	Materials
27	DONGFANG ELECT-A	China	Shanghai	y	Industrials
28	EGING PHOTOVOL-A	China	Shanghai	y	Info.Tech.
29	FAR EAST SMART-A	China	Shanghai	y	Industrials
30	FOSHAN ELEC-B	China	Shenzhen	y	Industrials
31	GUANGDONG CHAN-A	China	Shenzhen	y	Cons.Disc.
32	GUANGDONG EAST-A	China	Shenzhen	y	Info.Tech.
33	HANGZHOU FIRST-A	China	Shanghai	y	Info.Tech.
34	HAREON SOLAR T-A	China	Shanghai	y	Info.Tech.
35	HENGDIAN DMEGC-A	China	Shenzhen	y	Info.Tech.
36	HONGFA TECHNOL-A	China	Shanghai	y	Industrials
37	HUANENG RENEWA-H	China	HongKong	y	Utilities
38	HUAYI ELECTRIC-A	China	Shanghai	y	Industrials
39	HUNAN CORUN NE-A	China	Shanghai	y	Industrials
40	JIANGSU SUNRAI-A	China	Shanghai	y	Industrials
41	KAIDI ECOLOGIC-A	China	Shenzhen	y	Utilities
42	NARI TECHNOLOG-A	China	Shanghai	y	Industrials
43	NINGBO SANXING-A	China	Shanghai	y	Industrials
44	QINGDAO TGOOD-A	China	Shenzhen	y	Industrials
45	RISEN ENERGY-A	China	Shenzhen	y	Info.Tech.
46	RONGXIN POWER -A	China	Shenzhen	y	Industrials

Continued on next page

Table 4 – continued from previous page

#	Company Name	Country	Stock Exch.	Emer.	Sector
47	SANAN OPTOELEC-A	China	Shanghai	y	Info.Tech.
48	SHANGHAI AEROS-A	China	Shanghai	y	Info.Tech.
49	SHENZHEN CLOU-A	China	Shenzhen	y	Industrials
50	SHENZHEN DESAY-A	China	Shenzhen	y	Industrials
51	SHENZHEN HEMEI-A	China	Shenzhen	y	Info.Tech.
52	SHENZHEN JIAWE-A	China	Shenzhen	y	Info.Tech.
53	SHENZHEN KAIFA-A	China	Shenzhen	y	Info.Tech.
54	SIEYUAN ELECTR-A	China	Shenzhen	y	Industrials
55	SINOVEL WIND-A	China	Shanghai	y	Industrials
56	SUNGROW POWER -A	China	Shenzhen	y	Industrials
57	SUZHOU DONGSHA-A	China	Shenzhen	y	Industrials
58	TBEA CO LTD-A	China	Shanghai	y	Industrials
59	TELLHOW SCI-TE-A	China	Shanghai	y	Industrials
60	TITAN WIND-A	China	Shenzhen	y	Industrials
61	TONGYU HEAVY-A	China	Shenzhen	y	Industrials
62	XIAN LONGI SIL-A	China	Shanghai	y	Info.Tech.
63	XIANGTAN ELEC-A	China	Shanghai	y	Industrials
64	XINJIANG GOLD-A	China	Shenzhen	y	Industrials
65	XJ ELECTRIC-A	China	Shenzhen	y	Industrials
66	ZHEJIANG CHINT-A	China	Shanghai	y	Industrials
67	ZHEJIANG DUN'A-A	China	Shenzhen	y	Industrials
68	ZHEJIANG NARAD-A	China	Shenzhen	y	Industrials
69	ZHEJIANG YANKO-A	China	Shanghai	y	Industrials
70	ZHONGLI SCIENC-A	China	Shenzhen	y	Industrials
71	ZHONGTIAN TECH-A	China	Shanghai	y	Industrials
72	ZHONGTONG BUS-A	China	Shenzhen	y	Industrials
73	ZHUZHOU KIBING-A	China	Shanghai	y	Industrials
74	NOVOZYMES-B SHS	Denmark	Copenhagen	n	Materials
75	ROCKWOOL INTL-B	Denmark	Copenhagen	n	Industrials
76	VESTAS WIND SYST	Denmark	Copenhagen	n	Industrials
77	VALMET OYJ	Finland	Helsinki	n	Industrials
78	SCHNEIDER ELECTR	France	Paris	n	Industrials
79	HELLA KGAA HUECK	Germany	Xetra	n	Cons.Disc.
80	INFINEON TECH	Germany	Xetra	n	Info.Tech.
81	NORDEX SE	Germany	Xetra	n	Industrials
82	OSRAM LICHT AG	Germany	Xetra	n	Industrials
83	SIEMENS AG-REG	Germany	Xetra	n	Industrials
84	SMA SOLAR TECHNO	Germany	Xetra	n	Info.Tech.
85	SUEDZUCKER AG	Germany	Xetra	n	Cons.Stap.
86	WACKER CHEMIE AG	Germany	Xetra	n	Materials
87	ATLANTICA YIELD	UK	NASDAQ	n	Utilities
88	DIALOG SEMICOND	UK	Xetra	n	Info.Tech.
89	CHINA AGRI-INDUS	Hong Kong	HongKong	y	Cons.Stap.
90	CHINA EVERBR INT	Hong Kong	HongKong	y	Industrials
91	CHINA HIGH-SPEED	Hong Kong	HongKong	y	Industrials
92	GCL-POLY ENERGY	Hong Kong	HongKong	y	Info.Tech.
93	XINYI GLASS	Hong Kong	HongKong	y	Cons.Disc.
94	XINYI SOLAR HLDS	Hong Kong	HongKong	y	Info.Tech.
95	BHARAT HEAVY ELE	India	India	y	Industrials
96	EXIDE INDUS LTD	India	India	y	Cons.Disc.
97	HAVELLS INDIA	India	India	y	Industrials
98	IDFC LTD	India	India	y	Financials
99	SUZLON ENERGY	India	India	y	Industrials
100	TATA CHEMICALS	India	India	y	Materials
101	THERMAX LTD	India	India	y	Industrials
102	EATON CORP PLC	Ireland	NewYork	n	Industrials

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Table 4 – continued from previous page

#	Company Name	Country	Stock Exch.	Emer.	Sector
103	KINGSPAN GROUP	Ireland	London	n	Industrials
104	PRYSMIAN SPA	Italy	Italy	n	Industrials
105	AZBIL CORP	Japan	Tokyo	n	Info.Tech.
106	DIC CORP	Japan	Tokyo	n	Materials
107	EBARA CORP	Japan	Tokyo	n	Industrials
108	GS YUASA CORP	Japan	Tokyo	n	Industrials
109	HITACHI CAPITAL	Japan	Tokyo	n	Financials
110	HITACHI HIGH TEC	Japan	Tokyo	n	Info.Tech.
111	KINDEN CORP	Japan	Tokyo	n	Industrials
112	KYOCERA CORP	Japan	Tokyo	n	Info.Tech.
113	KYOWA EXEO CORP	Japan	Tokyo	n	Industrials
114	NIDEC CORP	Japan	Tokyo	n	Industrials
115	NISSIN ELECTRIC	Japan	Tokyo	n	Industrials
116	PANASONIC CORP	Japan	Tokyo	n	Cons.Disc.
117	ROHM CO LTD	Japan	Tokyo	n	Info.Tech.
118	SHARP CORP	Japan	Tokyo	n	Cons.Disc.
119	SHIN-ETSU CHEM	Japan	Tokyo	n	Materials
120	STANLEY ELEC CO	Japan	Tokyo	n	Cons.Disc.
121	SUMCO CORP	Japan	Tokyo	n	Info.Tech.
122	SUMITOMO FOREST	Japan	Tokyo	n	Cons.Disc.
123	TOKUYAMA CORP	Japan	Tokyo	n	Materials
124	TOYOTA MOTOR	Japan	Tokyo	n	Cons.Disc.
125	DOOSAN HEAVY	Korea	Korea	y	Industrials
126	HANWHA CHEM CORP	Korea	Korea	y	Materials
127	HYOSUNG CORP	Korea	Korea	y	Materials
128	LS CORP	Korea	Korea	y	Industrials
129	OCI CO LTD	Korea	Korea	y	Materials
130	SAMSUNG SDI CO	Korea	Korea	y	Info.Tech.
131	ARCADIS NV	Netherlands	Amsterdam	n	Industrials
132	ASM INTL NV	Netherlands	Amsterdam	n	Info.Tech.
133	KONINKLIJKE PHIL	Netherlands	Amsterdam	n	Industrials
134	NXP SEMICONDUCTO	Netherlands	NASDAQ	n	Info.Tech.
135	EDP RENOVAVEIS S	Spain	Lisbon	n	Utilities
136	GAMESA	Spain	Spain	n	Industrials
137	JM AB	Sweden	Stockholm	n	Cons.Disc.
138	NIBE INDUSTRIE-B	Sweden	Stockholm	n	Industrials
139	SVENSKA CELL-B	Sweden	Stockholm	n	Cons.Stap.
140	SWECO AB-B	Sweden	Stockholm	n	Industrials
141	ABB LTD-REG	Switzerland	Stockholm	n	Industrials
142	OC OERLIKON CORP	Switzerland	Zurich	n	Industrials
143	SCHWEITER TEC-BR	Switzerland	Zurich	n	Industrials
144	TE CONNECTIVITY	Switzerland	NewYork	n	Info.Tech.
145	DELTA ELECT INC	Taiwan	Taiwan	y	Info.Tech.
146	SIMPLO TECHNOLOG	Taiwan	Taiwan	y	Info.Tech.
147	TECO ELEC & MACH	Taiwan	Taiwan	y	Industrials
148	DELTA ELEC THAI	Thailand	Bangkok	y	Info.Tech.
149	ENERGY ABSOLUTE	Thailand	Bangkok	y	Energy
150	TOFAS	Turkey	Istanbul	y	Cons.Disc.
151	ACUITY BRANDS	USA	NewYork	n	Industrials
152	ANALOG DEVICES	USA	NASDAQ	n	Info.Tech.
153	ANDERSONS INC	USA	NASDAQ	n	Cons.Stap.
154	APOGEE ENTERPR	USA	NASDAQ	n	Industrials
155	APPLIED MATERIAL	USA	NASDAQ	n	Info.Tech.
156	BORGWARNER INC	USA	NewYork	n	Cons.Disc.
157	COMFORT SYSTEMS	USA	NewYork	n	Industrials
158	COVANTA HOLDING	USA	NewYork	n	Industrials

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Table 4 – continued from previous page

#	Company Name	Country	Stock Exch.	Emer.	Sector
159	CREE INC	USA	NASDAQ	n	Info.Tech.
160	EMCOR GROUP INC	USA	NewYork	n	Industrials
161	EMERSON ELEC CO	USA	NewYork	n	Industrials
162	ESCO TECH INC	USA	NewYork	n	Industrials
163	FIRST SOLAR INC	USA	NASDAQ	n	Info.Tech.
164	GENTHERM INC	USA	NASDAQ	n	Cons.Disc.
165	GIBRALTAR INDUST	USA	NASDAQ	n	Industrials
166	HANWHA Q CEL-ADR	USA	NASDAQ	n	Info.Tech.
167	HEXCEL CORP	USA	NewYork	n	Industrials
168	ITRON INC	USA	NASDAQ	n	Info.Tech.
169	JOHNSON CONTROLS	USA	NewYork	n	Cons.Disc.
170	MONOLITHIC POWER	USA	NASDAQ	n	Info.Tech.
171	NEXTERA ENERGY P	USA	NewYork	n	Utilities
172	ORMAT TECHNOLOGI	USA	NewYork	n	Utilities
173	OWENS CORNING	USA	NewYork	n	Industrials
174	PATTERN ENER	USA	NASDAQ	n	Utilities
175	PERKINELMER INC	USA	NewYork	n	Health Care
176	QUANTA SERVICES	USA	NewYork	n	Industrials
177	REGAL BELOIT COR	USA	NewYork	n	Industrials
178	REPUBLIC SVCS	USA	NewYork	n	Industrials
179	SMITH (A.O.)CORP	USA	NewYork	n	Industrials
180	SUNPOWER CORP	USA	NASDAQ	n	Info.Tech.
181	TERRAFORM POWE-A	USA	NASDAQ	n	Utilities
182	TESLA MOTORS	USA	NASDAQ	n	Cons.Disc.
183	TETRA TECH INC	USA	NASDAQ	n	Industrials
184	TIMKEN CO	USA	NewYork	n	Industrials
185	TRIMBLE NAVIG	USA	NASDAQ	n	Info.Tech.
186	UNIVERSAL DISPLA	USA	NASDAQ	n	Info.Tech.
187	WOODWARD INC	USA	NASDAQ	n	Industrials

Table 5: List of 186 brown companies. There are 24 companies from emerging economies, and 162 companies from developed economies.

#	Company Name	Country	Stock Exch.	Emer.	Sector
1	Wesfarmers	Australia	Australia	n	Cons.Stap.
2	Woodside Petroleum	Australia	Australia	n	Energy
3	Woolworths Ltd	Australia	Australia	n	Cons.Stap.
4	Ambev Cia de Beb. das Am.	Brazil	SaoPaulo	y	Cons.Stap.
5	Petroleo Brasil. SA Petrobras	Brazil	SaoPaulo	y	Energy
6	Vale	Brazil	SaoPaulo	y	Materials
7	Barrick Gold Corp	Canada	Toronto	n	Materials
8	Canadian National Railway	Canada	Toronto	n	Industrials
9	Canadian Natural Res. Ltd	Canada	Toronto	n	Energy
10	Cenovus Energy	Canada	Toronto	n	Energy
11	Enbridge	Canada	Toronto	n	Energy
12	Goldcorp	Canada	Toronto	n	Materials
13	Husky Energy	Canada	Toronto	n	Energy
14	Imperial Oil	Canada	Toronto	n	Energy
15	Manulife Financial Corp	Canada	Toronto	n	Financials
16	Potash Corp of Saskatchewan	Canada	Toronto	n	Materials
17	Suncor Energy	Canada	Toronto	n	Energy
18	Teck Resources Ltd	Canada	Toronto	n	Materials
19	TransCanada Corp	Canada	Toronto	n	Energy
20	Air Liquide	France	Paris	n	Materials

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Table 5 – continued from previous page

#	Company Name	Country	Stock Exch.	Emer.	Sector
21	Carrefour	France	Paris	n	Cons.Stap.
22	Danone	France	Paris	n	Cons.Stap.
23	EDF	France	Paris	n	Utilities
24	GDF Suez	France	Paris	n	Utilities
25	Orange	France	Paris	n	Telecom.
26	Pernod Ricard	France	Paris	n	Cons.Stap.
27	Saint-Gobain	France	Paris	n	Industrials
28	SANOFI	France	Paris	n	Health Care
29	Total	France	Paris	n	Energy
30	Vinci	France	Paris	n	Industrials
31	BASF SE	Germany	Xetra	n	Materials
32	Bayer AG	Germany	Xetra	n	Health Care
33	BMW AG	Germany	Xetra	n	Cons.Disc.
34	Continental AG	Germany	Xetra	n	Cons.Disc.
35	Daimler AG	Germany	Xetra	n	Cons.Disc.
36	Deutsche Post AG	Germany	Xetra	n	Industrials
37	Deutsche Telekom AG	Germany	Xetra	n	Telecom.
38	E.ON SE	Germany	Xetra	n	Utilities
39	Linde AG	Germany	Xetra	n	Materials
40	RWE AG	Germany	Xetra	n	Utilities
41	SAP AG	Germany	Xetra	n	Info.Tech.
42	Volkswagen AG	Germany	Xetra	n	Cons.Disc.
43	CLP Holdings Ltd	Hong Kong	HongKong	y	Utilities
44	Power Assets Holdings Ltd	Hong Kong	HongKong	y	Utilities
45	ITC Ltd	India	India	y	Cons.Stap.
46	Larsen Toubro	India	India	y	Industrials
47	ENEL SpA	Italy	Italy	n	Utilities
48	Eni SpA	Italy	Italy	n	Energy
49	Canon	Japan	Tokyo	n	Info.Tech.
50	Honda Motor	Japan	Tokyo	n	Cons.Disc.
51	Inpex Corp	Japan	Tokyo	n	Energy
52	Mitsubishi Electric Corp	Japan	Tokyo	n	Info.Tech.
53	Nippon Telegraph/phone Corp	Japan	Tokyo	n	Telecom.
54	Nissan Motor	Japan	Tokyo	n	Cons.Disc.
55	Seven I Holdings	Japan	Tokyo	n	Cons.Stap.
56	Shin-Etsu Chemical	Japan	Tokyo	n	Materials
57	Takeda Pharmaceutical Ltd	Japan	Tokyo	n	Health Care
58	Arcelor Mittal	Luxembourg	Amsterdam	n	Materials
59	Fresnillo Plc	Mexico	Mexico	y	Materials
60	Industrias Penoles	Mexico	Mexico	y	Materials
61	Wal Mart de Mexico	Mexico	Mexico	y	Cons.Stap.
62	Airbus Group	Netherlands	Paris	n	Industrials
63	Heineken NV	Netherlands	Amsterdam	n	Cons.Stap.
64	Royal Dutch Shell	Netherlands	Amsterdam	n	Energy
65	Royal Philips	Netherlands	Amsterdam	n	Cons.Disc.
66	Statoil ASA	Norway	NewYork	n	Energy
67	Telenor Group	Norway	Norway	n	Telecom.
68	Gazprom OAO	Russia	Moscow	y	Energy
69	Novatek	Russia	Moscow	y	Energy
70	Kumba Iron Ore	South Africa	SouthAfrica	y	Materials
71	MTN Group	South Africa	SouthAfrica	y	Telecom.
72	Sasol Ltd	South Africa	SouthAfrica	y	Energy
73	Hyundai Motor	South Korea	Korea	y	Cons.Disc.
74	Korea Electric Power Corp	South Korea	Korea	y	Utilities
75	LG Chem	South Korea	Korea	y	Materials
76	POSCO	South Korea	Korea	y	Materials

Continued on next page

Table 5 – continued from previous page

#	Company Name	Country	Stock Exch.	Emer.	Sector
77	Samsung Electronics	South Korea	Korea	y	Info.Tech.
78	Endesa	Spain	Spain	n	Utilities
79	Gas Natural SDG SA	Spain	Spain	n	Utilities
80	Iberdrola SA	Spain	Spain	n	Utilities
81	Repsol	Spain	Spain	n	Energy
82	Holcim Ltd	Switzerland	Switzerland	n	Materials
83	Nestle	Switzerland	Switzerland	n	Cons.Stap.
84	Novartis	Switzerland	Switzerland	n	Health Care
85	Roche Holding AG	Switzerland	Switzerland	n	Health Care
86	Syngenta Intl AG	Switzerland	NewYork	n	Materials
87	Taiwan Semiconductor Manuf.	Taiwan	Taiwan	y	Info.Tech.
88	Teva Pharma. Industries Ltd	Israel	TelAviv	y	Health Care
89	PTT	Thailand	Bangkok	y	Energy
90	PTT Explor. Prod. Pub. Co	Thailand	Bangkok	y	Energy
91	Anglo American	UK	London	n	Materials
92	Antofagasta	UK	London	n	Materials
93	Associated British Foods	UK	London	n	Cons.Stap.
94	AstraZeneca	UK	London	n	Health Care
95	BAE Systems	UK	London	n	Industrials
96	BHP Billiton	UK	London	n	Materials
97	BP	UK	London	n	Energy
98	British American Tobacco	UK	London	n	Cons.Stap.
99	BT Group	UK	London	n	Telecom.
100	Carnival Corp	UK	London	n	Cons.Disc.
101	Centrica	UK	London	n	Utilities
102	Diageo Plc	UK	London	n	Cons.Stap.
103	GlaxoSmithKline	UK	London	n	Health Care
104	National Grid	UK	London	n	Utilities
105	Rio Tinto	UK	London	n	Materials
106	Rolls-Royce	UK	London	n	Industrials
107	SSE	UK	London	n	Utilities
108	Tesco	UK	London	n	Cons.Stap.
109	Tullow Oil	UK	London	n	Energy
110	Unilever Plc	UK	London	n	Cons.Stap.
111	Vodafone Group	UK	London	n	Telecom.
112	3M	USA	NewYork	n	Industrials
113	Abbott Laboratories	USA	NewYork	n	Health Care
114	Air Products Chemicals	USA	NewYork	n	Materials
115	Altria Group	USA	NewYork	n	Cons.Stap.
116	American Electric Power	USA	NewYork	n	Utilities
117	Anadarko Petroleum Corp	USA	NewYork	n	Energy
118	Apache Corp	USA	NewYork	n	Energy
119	AT&T	USA	NewYork	n	Telecom.
120	Baker Hughes Inc	USA	NewYork	n	Energy
121	Baxter Intl	USA	NewYork	n	Health Care
122	Boeing	USA	NewYork	n	Industrials
123	Bristol-Myers Squibb	USA	NewYork	n	Health Care
124	CenturyLink	USA	NewYork	n	Telecom.
125	Chevron Corp	USA	NewYork	n	Energy
126	Colgate Palmolive	USA	NewYork	n	Cons.Stap.
127	ConocoPhillips	USA	NewYork	n	Energy
128	Corning Inc	USA	NewYork	n	Info.Tech.
129	Costco Wholesale Corp	USA	NASDAQ	n	Cons.Stap.
130	CSX Corp	USA	NASDAQ	n	Industrials
131	Cummins	USA	NewYork	n	Industrials
132	CVS Caremark Corp	USA	NewYork	n	Cons.Stap.

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Table 5 – continued from previous page

#	Company Name	Country	Stock Exch.	Emer.	Sector
133	Deere & Co	USA	NewYork	n	Industrials
134	Devon Energy Corp	USA	NewYork	n	Energy
135	Dow Chemical	USA	NewYork	n	Materials
136	Duke Energy Corp	USA	NewYork	n	Utilities
137	Ecolab	USA	NewYork	n	Materials
138	EI du Pont de Nemours	USA	NewYork	n	Materials
139	Eli Lilly & Co	USA	NewYork	n	Health Care
140	Exelon Corp	USA	NewYork	n	Utilities
141	Exxon Mobil Corp	USA	NewYork	n	Energy
142	FedEx Corp	USA	NewYork	n	Industrials
143	Ford Motor	USA	NewYork	n	Cons.Disc.
144	Freeport-McMoRan Cop/Gold	USA	NewYork	n	Materials
145	General Electric	USA	NewYork	n	Industrials
146	General Mills	USA	NewYork	n	Cons.Stap.
147	General Motors	USA	NewYork	n	Cons.Disc.
148	Halliburton	USA	NewYork	n	Energy
149	Hess Corp	USA	NewYork	n	Energy
150	Hewlett-Packard	USA	NewYork	n	Info.Tech.
151	Honeywell Intl	USA	NewYork	n	Industrials
152	Intel Corp	USA	NASDAQ	n	Info.Tech.
153	IBM	USA	NewYork	n	Info.Tech.
154	Johnson & Johnson	USA	NewYork	n	Health Care
155	Kellogg	USA	NewYork	n	Cons.Stap.
156	Kimberly-Clark Corp	USA	NewYork	n	Cons.Stap.
157	Las Vegas Sands Corp	USA	NewYork	n	Cons.Disc.
158	Lockheed Martin Corp	USA	NewYork	n	Industrials
159	Lowe	USA	NewYork	n	Cons.Disc.
160	Merck & Co	USA	NewYork	n	Health Care
161	Mondelez Intl Inc	USA	NASDAQ	n	Cons.Stap.
162	Monsanto	USA	NewYork	n	Materials
163	Newmont Mining Corp	USA	NewYork	n	Materials
164	Noble Energy	USA	NewYork	n	Energy
165	Norfolk Southern Corp	USA	NewYork	n	Industrials
166	Occidental Petroleum Corp	USA	NewYork	n	Energy
167	PepsiCo	USA	NewYork	n	Cons.Stap.
168	Pfizer	USA	NewYork	n	Health Care
169	Philip Morris Intl	USA	NewYork	n	Cons.Stap.
170	PPG Industries	USA	NewYork	n	Materials
171	Praxair	USA	NewYork	n	Materials
172	Procter Gamble	USA	NewYork	n	Cons.Stap.
173	Schlumberger Ltd	USA	NewYork	n	Energy
174	Starbucks Corp	USA	NASDAQ	n	Cons.Disc.
175	Sysco Corp	USA	NewYork	n	Cons.Stap.
176	Target Corp	USA	NewYork	n	Cons.Disc.
177	Texas Instruments Inc	USA	NASDAQ	n	Info.Tech.
178	Coca-Cola	USA	NewYork	n	Cons.Stap.
179	The Home Depot	USA	NewYork	n	Cons.Disc.
180	Union Pacific Corp	USA	NewYork	n	Industrials
181	United Technologies Corp	USA	NewYork	n	Industrials
182	UPS	USA	NewYork	n	Industrials
183	Verizon Communications	USA	NewYork	n	Telecom.
184	Wal-Mart Stores	USA	NewYork	n	Cons.Stap.
185	Walt Disney	USA	NewYork	n	Cons.Disc.
186	Yum! Brands	USA	NewYork	n	Cons.Disc.

Appendix 3.C: Results for emerging and developed economies

For the same COP and political events, we investigated differences between companies that are located either in emerging or developed economies. Details on the locations of companies (emerging or developed markets) are in Appendix 3.B.

The results are similar to the results reported in Section 5 and can be found in Figures 7, 8 and 9. However, some differences in effects are worth taking into account. The climate negotiations in Cancun (COP16) showed positive effects on green companies from developed countries, while Durban (COP17) showed negative effects on green companies from developed economies, as well as on green and brown companies from emerging markets. After the Doha climate negotiations (COP18), we find positive effects on green companies from emerging and developed economies from day 1 to day 4 after the event. Furthermore, we find positive effects on brown companies from emerging economies on day 3 and 4 after the event. After the climate negotiations in Warsaw (COP19), we find negative effects on brown companies from emerging economies from day 1 to day 4 and negative effects on brown companies from developed economies on day 3 and 4. In Lima (COP20), we find mixed results, on day 1 negative effects on brown companies from emerging and developed companies, which returned to zero on the subsequent days. For green companies from emerging economies we find positive effects on green companies from emerging economies on day 1, however turning negative on day 3. The Paris agreement (COP21) showed negative effects on the brown companies from developed countries on day 2, 3 and 4 and insignificant effects on the other groups of companies. The climate negotiations in Marrakesh (COP22) showed significant price decreases for green companies from emerging markets and increases for brown companies from emerging markets.

For the 2016 US presidential election, we found significantly negative effects for green companies from emerging economies from day 1 until day 4. Furthermore, brown companies from developed economies show significantly negative stock price effects on day 2 to day 4. The US withdrawal from the Paris agreement, on the other hand, had significant negative effects on companies from emerging markets (brown and green).

This indicates that emerging economies were expected to lose from the withdrawal, possibly due to a fear that the US will try to become more energy independent and that imports from abroad (e.g. China, the largest country group within the green companies) might become subject to higher taxes.

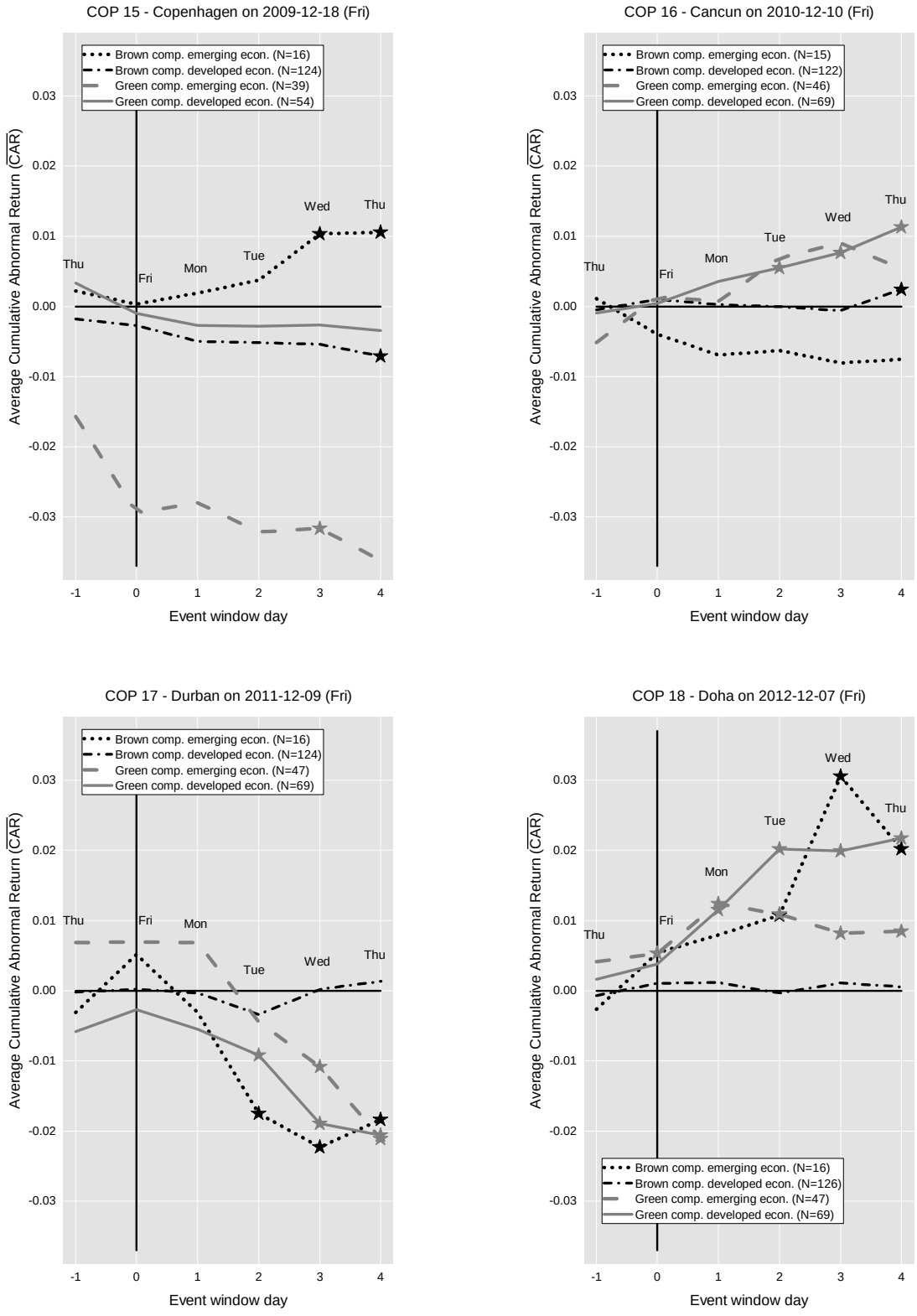

Figure 7: Average Cumulative Abnormal Returns ($\overline{CAR}$) for a set of green and a set of brown companies from emerging markets and developed markets for COP15 (top right), COP16 (top left), COP17 (bottom right) and COP18 (bottom left). Statistical significance at the 0.1 level is denoted by an asterisk, and is calculated according to the adjusted Patell t-test which in turn uses standardized versions of the abnormal returns.

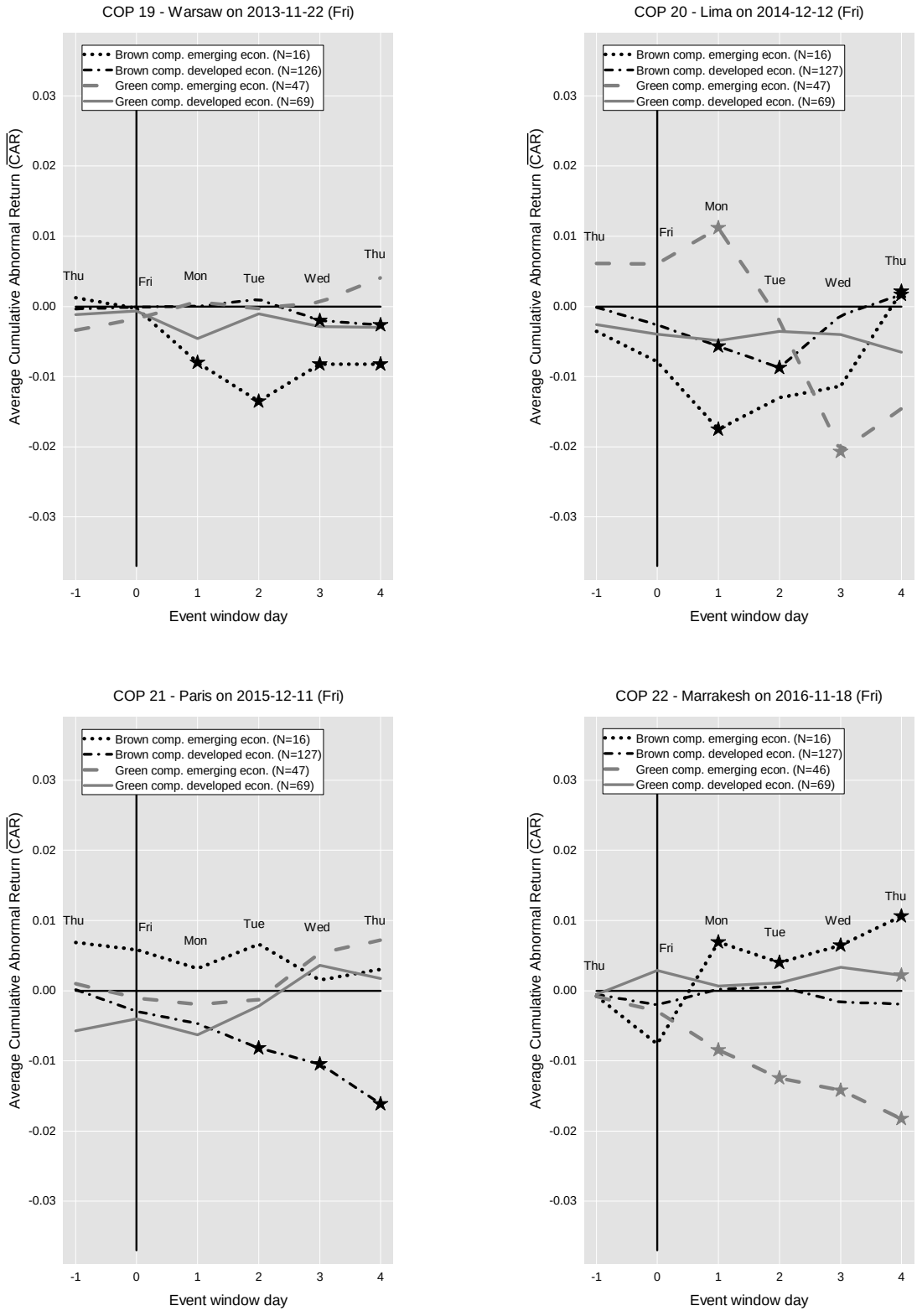

Figure 8: Average Cumulative Abnormal Returns ($\overline{CAR}$) of a set of green and a set of brown companies from emerging markets and developed markets for COP19 (top right), COP20 (top left), COP21 (bottom left) and COP22 (bottom right). Statistical significance at the 0.1 level is denoted by an asterisk, and is calculated according to the adjusted Patell t-test which in turn uses standardized versions of the abnormal returns.

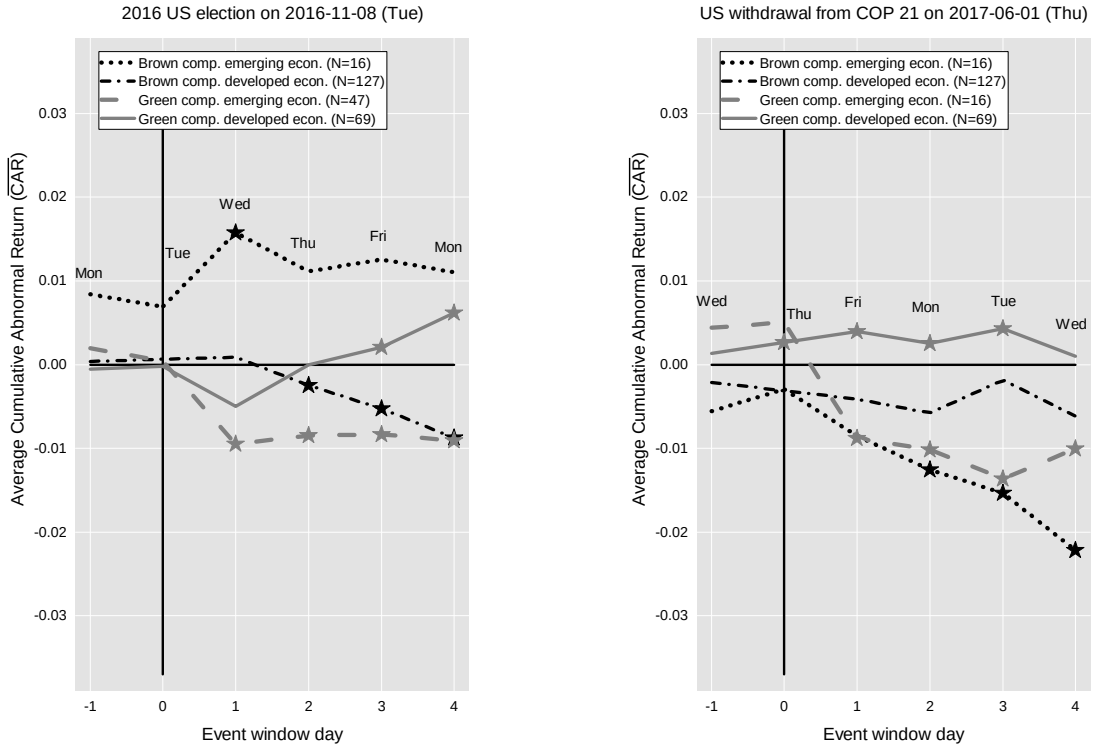

Figure 9: Average Cumulative Abnormal Returns ($\overline{CAR}$) of a set of green and a set of brown companies from emerging markets and developed markets for the US election in 2016 (left) and the US withdrawal from the Paris Agreement (right). Statistical significance at the 0.1 level is denoted by an asterisk, and is calculated according to the adjusted Patell t-test which in turn uses standardized versions of the abnormal returns.

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