Corporate Responses to Climate Change and Financial Performance: The Impact of Climate Policy

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Abstract

This paper examines the relationship between corporate activities to address climate change and stock performance. By separately analyzing the US and European stock markets for different sub-periods, we highlight the impact of the underlying climate policy regime. Methodologically, we compare risk-adjusted returns of stock portfolios comprising corporations that differ in their responses to climate change. In this respect, we apply the flexible Carhart four-factor model besides the restricted one-factor model based on the Capital Asset Pricing Model (CAPM). While our portfolio analysis shows negative relationships over the entire observation period from 2001 to 2006, we find that a trading strategy, which bought stocks of corporations with a higher level of responses to climate change and sold stocks of corporations with a lower level, led to negative abnormal returns in regions and periods with less ambitious climate policy, but to positive abnormal returns in regions and periods with stringent climate policy.

Keywords:

Climate change, Climate policy, Corporate environmental performance, Financial performance, Portfolio analysis, Asset pricing models

JEL:

Q54, Q48, M14, G11, G12

1. Introduction

Does it pay for a firm to be green? This issue has already been analyzed for a while, especially in empirical studies (e.g., Hart and Ahuja, 1996, King and Lenox, 2001, Telle, 2006). Knowledge about the effect of corporate environmental performance on financial performance contributes to the debate about whether managers systematically miss profit opportunities if they decide against corporate activities to protect the natural environment (e.g., King and Lenox, 2002). In this respect, it is also interesting to identify specific success factors for environmental strategies that are able to decrease operating costs and/or to increase sales. Furthermore, an understanding of this relationship is relevant for investors: The question is whether "green investments", for example, on the basis of a trading strategy which buys stocks or stock portfolios of corporations with stronger environmental performance and sells stocks or stock portfolios of corporations with weaker environmental performance, are rewarded or penalized by the stock markets (e.g., Derwall et al., 2005).

Knowledge of this relationship is also important for the discussion of different environmental policy instruments: If a positive effect of corporate environmental performance on economic success really existed, it could be argued that traditional mandatory command and control regulations as well as market based approaches – such as green taxes – should be relaxed (e.g., Khanna, 2001). Instead, these regulations could be supplemented or even substituted by information-based instruments, namely by improving the flow of information with respect to this effect (e.g., Telle, 2006). Just like other non-mandatory proactive approaches to environmental protection – such as voluntary unilateral agreements by firms regarding environmental management systems according to ISO 14001 – these regulations can be thought to be cost-efficient because they leave firms with the flexibility to choose the cheapest pollution abatement strategy and reduce governments' enforcement costs (e.g., Alberini and Segerson, 2002).

While several former empirical studies regarding the effect of corporate environmental performance on financial performance examine environmental performance indicators such as toxic emissions (e.g., Hart and Ahuja, 1996, King and Lenox, 2001, 2002), other studies are based on broad corporate environmental assessments by rating agencies such as Innovest (e.g., Derwall et al., 2005). In contrast, specific corporate responses to climate change have – to our knowledge – not been analyzed so far, in part due to the unavailability of appropriate data. Indeed, climate change has in the meantime been considered unequivocally existent (e.g., IPCC, 2007) and is certainly one of the most important environmental and societal challenges. As a consequence, climate change can be assumed to have become a relevant corporate topic (e.g., Porter and Reinhardt, 2007). Against this background, this paper analyzes the specific relationship between corporate activities to address climate change and financial performance.

Our empirical analysis is first based on general theoretical arguments on the relationship between corporate environmental performance and economic success, for example, with respect to high operating costs of environmental activities or increasing reputation due to these activities. Indeed, we especially argue that the ambiguous positive or negative relationships can additionally be influenced by the underlying climate policy regime. For example, it is likely that ambitious regulations in this respect strengthen the aforementioned reputation argument for corresponding corporate activities. Since the stringency of regulations changes over time, we analyze different sub-periods within the entire observation period from 2001 to 2006. Furthermore, climate policy differs between countries or groups of countries (i.e. governments) with possible consequences on the analyzed relationship. Due to our availability of the same indicators for corporate responses to climate change for different regions, we perform a comparative analysis for two main players in international climate policy (e.g., Lange et al., 2008), namely the USA and Europe (including the European Union, EU).

Using stock returns as an indicator for corporate financial performance, we examine the average stock performance of portfolios that differ with respect to the corporate environmental performance, i.e. corporate responses to climate change. In contrast to corresponding econometric analyses at the firm level (e.g., Filbeck and Gorman, 2004, Ziegler et al., 2007a) or even short-run event studies (e.g., Konar and Cohen, 1997, Khanna et al., 1998, Dasgupta et al., 2001, Gupta and Goldar, 2005), the portfolio analysis approach weakens possible influences of firm-specific variances on the estimation results. Our portfolio analysis implies an investor perspective and especially considers whether a trading strategy, which buys stocks of corporations with a higher level of responses to climate change and sells stocks of corporations with a lower level, leads to positive or negative abnormal returns. In order to estimate these risk-adjusted returns, portfolio analyses have to incorporate asset pricing models. In this respect, we apply the four-factor model according to Carhart (1997) besides the restricted one-factor model based on the Capital Asset Pricing Model (CAPM). While the corresponding factors for this flexible model are publicly available for the US and some other stock markets, they have to be calculated for the entire European stock market. This seems to be an important reason why multifactor models have not often been applied for this region yet.

The remainder of the paper is structured as follows: On the basis of theoretical considerations, the second section develops the working hypotheses for our empirical analysis. In the third section, we present our portfolio analysis approach and the data we used. The fourth section discusses the estimation results and the final section concludes.

2. Theoretical Background

2.1 General Arguments

Portfolio analyses with an environmental focus are mostly discussed in the broader area of socially responsible investing (SRI), also called ethical or sustainable investments (e.g., Renneboog et al., 2008). This investment strategy refers to the practice of choosing investments on the basis of social responsibility indicators (e.g., Barnett and Salomon, 2006). SRI is therefore not only based on environmental, but also on social screens. In this respect, the popular term "corporate social responsibility" (CSR) comprises both corporate social and environmental activities (e.g., Waddock and Graves, 1997, Orlitzky, 2001, Orlitzky et al., 2003). According to the well-established definition of McWilliams and Siegel (2001), CSR are "actions that appear to further some social good, beyond the interest of the firm and what is required by law". Another definition of CSR emphasizes – besides the avoidance of distributional conflicts – "actions which reduce the extent of externalized costs" (Heal, 2005).

Overall, current theory on the relationship between corporate environmental performance or CSR and financial performance is rather inconclusive (e.g., Waddock and Graves, 1997, Guenster et al., 2006). For example, McWilliams and Siegel (2001) show within a model with two firms which produce identical products, where one firm adds an additional CSR attribute or feature to the product which is valued by the market, that in equilibrium the overall effect of this attribute is neutral (see also McWilliams et al., 2006). Similarly, MacKey et al. (2007) use a theoretical decision making model comprising the supply and demand for CSR which shows that environmental or social activities have in some cases no impact on the market value. While these studies are based on the discussion of CSR, they can also be transferred to general corporate environmental performance or – as in this paper – to corporate activities to address climate change. In our empirical analysis we consider two specific measures: First, 'climate impact statement' indicates whether a firm states that climate change can lead to corporate risks and/or opportunities. Therefore, this indicator displays the general relevance a firm attributes to climate change and the need for appropriate corporate responses. Second, 'carbon reduction measures' refer to actual corporate activities to decrease CO_2 or CO_2 equivalents in the production process. Therefore, this measure displays whether a firm has already implemented corporate responses to climate change in terms of concrete actions.

General arguments for a negative relationship between corporate environmental performance or CSR and financial performance can be based on neoclassical microeconomics. According to this, it is emphasized that the operating costs of corporate environmental activities (e.g., Telle, 2006) outweigh their financial benefits (e.g., cost reductions through energy savings), so that the underlying principle of shareholder wealth maximization is weakened. It is argued that such activities require significant portions of corporate financial resources, although their benefits are often in a distant future if any benefits occur. As a consequence, corporate environmental (or social) measures can lead to reduced profits, decreased firm values, or competitive disadvantage besides lower stock returns, so that already Friedman (1970) argues that there is no role for CSR. While this general cost argument applies for corporate carbon reduction measures, it is less clear for climate impact statements because their operating costs are rather marginal.

This neoclassical rationale is supported by corporate governance theory (e.g., Shleifer and Vishny, 1997, Tirole, 2006). According to a rather narrow definition, corporate governance comprises all measures – such as optimal incentive or control structures – which assure that investors get an adequate return for their investments. Only if corporate governance structures are properly installed, management will choose the profit-maximizing path. According to this, it can, for example, be argued that the consideration of goals of other groups – such as the general public – as motivation for corporate carbon reduction measures unnecessarily enlarges the latitude of management which could be misused for maximizing the utility of managers, so that the risk of counterproductive measures with respect to shareholder wealth and economic success increases. In other words, investors have to consider lower returns on their investments if the respective corporations deviate from the optimal path due to excessive environmental activities (e.g., Heinkel et al., 2001, Beltratti, 2005). In contrast, investors in purely profit-maximizing firms with a lower intensity of such measures can expect higher investment returns. While this corporate governance argument generally applies for corporate activities to address climate change, carbon reduction measures can lead to stronger negative effects on corporate financial performance than climate impact statements since they refer to concrete activities that potentially involve extensive investments.

As a consequence of both the cost and the corporate governance arguments, a general negative relationship between corporate responses to climate change and financial performance – especially strong for carbon reduction measures – can be expected. In summary, this leads to Hypothesis 1a and Hypothesis 1b:

Hypothesis 1a: *The relationship between corporate responses to climate change and financial performance is generally negative.*

Hypothesis 1b: *The negative relationship between corporate responses to climate change and financial performance is stronger for carbon reduction measures than for climate impact statements.*

However, positive relationships between corporate environmental performance or CSR and financial performance can also be based on neoclassical microeconomics by emphasizing the role of respective measures in reducing the extent of externalized costs. Friedman (1970) assumes in his criticism on CSR that the government defines property rights, so that no external effects exist. In this view, corporate environmental activities that benefit shareholders are pure profit-maximization, while measures not benefiting investors are theft from shareholders. In contrast, Heal (2005) argues that the government does not fully resolve all problems with external effects and that the competitive markets are not efficient. Therefore, corporate environmental (or social) activities can substitute missing markets (and thus missing regulations) if external costs arise from them and can reduce conflicts between firms and stakeholder groups such as non-governmental organizations. As a consequence, it can be argued that the reduction of these conflicts increases corporate profits or financial performance at least in the long term, which also makes firms with a high environmental performance more attractive to investors. This argument for a positive relationship with corporate financial performance applies to a larger extent for corporate carbon reduction measures than for climate impact statements because the latter generally do not reduce external costs.

The stakeholder argument can be strengthened according to insights from the strategic management literature (e.g., Waddock and Graves, 1997, Barnett and Salomon, 2006). Stakeholder theory suggests that management must satisfy several groups (e.g., the government, the general public, non-governmental organizations, competitors, employees, clients) that have some interest or “stake” in a firm and can influence its outcome (e.g., McWilliams et al., 2006). Regarding corporate financial performance, it can therefore be worthwhile for firms to engage in environmental (or social) activities because otherwise these stakeholders could withdraw their support. For example, corporate carbon reduction measures to comply with regulations can lead to better relationships with government that could be beneficial for corporate legislative and political lobbying which is common in climate policy (e.g., Anger et al., 2008). Furthermore, general corporate activities to address climate change and especially concrete carbon reduction measures can reduce risk due to, for example, aggressive campaigns of non-governmental organizations.

These arguments from stakeholder theory can be embedded in the resource-based view of the firm (e.g., Barney, 1991), which suggests that economic success and competitive advantage evolves from internal resources and capabilities that are valuable, rare, and difficult to imitate or substitute (e.g., Russo and Fouts, 1997, Klassen and Whybark, 1999, King and Lenox, 2001, McWilliams et al., 2006). In this respect, stakeholder management can be considered an important organizational capability. Furthermore, a good reputation due to corporate activities to address climate change is a good example for an intangible resource. This could particularly lead to higher sales among customers who are sensitive to such issues and therefore increase corporate profits or financial performance. In this respect, new technologies which are installed due to concrete proactive corporate carbon reduction measures are an example for a tangible or physical resource if these technologies can be capitalized and not easily imitated by competitors.

Overall, the resource-based view of the firm and the stakeholder theory suggest – in the same way as the external effect argument from Heal (2005) – a positive relationship between corporate responses to climate change and financial performance, which is indeed stronger for carbon reduction measures than for climate impact statements. In summary, this leads to Hypothesis 2a and Hypothesis 2b:

Hypothesis 2a: *The relationship between corporate responses to climate change and financial performance is generally positive*.

Hypothesis 2b: *The positive relationship between corporate responses to climate change and financial performance is stronger for carbon reduction measures than for climate impact statements*.

2.2 Impact of Climate Policy

Based on these general considerations, we especially argue that the underlying climate policy regime can have strong impacts on the financial performance of corporations or entire industries. Against this background, a recent study of Oberndorfer (2008) considers the effect of the EU Greenhouse Gas Emission Trading Scheme (EU ETS) on the stock performance of European electricity corporations. According to this, EU Emission Allowance (EUA) price changes and stock returns are positively related. However, we do not analyze the direct effect of climate policy on corporate financial performance, but whether it has different financial relevance for firms which react to climate change and firms which do not react. In this respect, it seems plausible that the stakeholder theory argument as discussed above is strengthened when climate change legislation is stringent. Compared with – for a long time – rather weak regulations (e.g., Böhringer and Vogt, 2004), such climate policy regimes, which are accompanied by a social climate demanding corporate responses to climate change, imply that good relationships with stakeholders such as the general public or non-governmental organizations can especially be negatively affected if firms do not react. In this case a good reputation due to corporate responses to climate change seems to be a more important intangible resource than in an unambitious climate policy regime.

Similarly, the cost argument, as discussed above, implying a negative relationship between corporate activities to address climate change and financial performance can be weakened if more stringent climate policy leads to higher operating costs when firms do not react to climate change. For example, the introduction of the EU ETS has assigned a monetary value to CO_2 emissions in Europe and leads to higher expenditures for firms that are covered by the scheme and whose actual emissions exceed the emission allowances freely allocated to them (in the first phase of the EU ETS, grandfathering, i.e. free allocation, is the dominant mechanism for emission allowance allocation). Furthermore, firms can sell the allowances freely allocated to them and therefore realize revenues instead of emitting CO_2. As a consequence, the difference between operating costs of corporate responses to climate change and their financial benefits is now smaller than before because the benefits comprise the prevented expenditures for the emission allowances. Therefore, it can be hypothesized that both the strengthening of the stakeholder argument and the weakening of the cost argument through more stringent climate policy benefits firms which react to climate change. When these benefits are financially relevant, it can be expected that the relationship between corporate responses to climate change and financial performance is more positive in an ambitious climate policy regime than with unambitious climate change regulations.

An analysis of US climate policy until recently – and especially over the entire observation period from 2001 to 2006 – shows that the corresponding climate policy framework is rather weak. Before 2007 (i.e. before the Conference of Parties, COP, in Bali), the US government challenged anthropogenic climate change and thus dismissed the necessity to reinforce a reduction of greenhouse gas emissions by legislation. Similarly, climate policy in Europe was not fundamentally different in the first half of this period, even when the debate on climate change measures clearly began earlier than in the USA. In December 2003, however, the European Commission stated that the EU was likely to miss its greenhouse gas emission targets under the Kyoto Protocol and rigorously sharpened its climate policy. Based on this, the EU member states were requested to implement additional climate change regulations. Therefore, the end of 2003 can be considered a tipping point at which it became very clear that firms in Europe would soon face more stringent climate change legislation, even though the EU ETS was not launched until the beginning of 2005.

As a consequence, the strengthening of the stakeholder argument and the weakening of the cost argument as discussed above is particularly relevant for Europe in the years after 2003. In summary, this leads to the following Hypothesis 3 and Hypothesis 4:

Hypothesis 3: *The relationship between corporate responses to climate change and financial performance is more positive in Europe than in the USA.*

Hypothesis 4: *The relationship between corporate responses to climate change and financial performance in Europe becomes more positive over time*.

3. Portfolio Analysis Approach and Data

3.1 Methodological Approach

In order to examine these hypotheses, we perform a portfolio analysis which compares the average stock performance of portfolios comprising corporations that differ in their responses to climate change. In line with recent studies (e.g., Derwall et al., 2005, Bauer et al., 2005, 2007, Kempf and Osthoff, 2007) we consider the risk-adjusted returns of different stock portfolios that are estimated on the basis of asset pricing models. So far, the traditional asset pricing model is the one-factor model based on the market model (e.g., Sharpe, 1963) and the CAPM (e.g., Lintner, 1965, Fama and French, 2004, Perold, 2004). This model can be formulated for a portfolio i in month t (i = 1,…,N; t = 1,…,T) as:

$$r_{it} - r_{ft} = \alpha_i + \beta_i (r_{mt} - r_{ft}) + \varepsilon_{it}$$

In this approach r_{it} and r_{mt} are the (continuous) stock returns of corporation i and the market at the end of month t, r_{ft} is the risk-free interest rate at the beginning of month t, and ε_{it} is the disturbance term with $E(\varepsilon_{it}) = 0$ and (unknown) $var(\varepsilon_{it}) = \sigma_\varepsilon^2$. Finally, the one-factor alpha α_i (i.e. Jensen's alpha) and β_i are further unknown parameters which are estimated by ordinary least squares (OLS). It is assumed that β_i capture the non-diversifiable risk of each stock portfolio in the explanation of the excess returns r_{it}-r_{ft}.

Based on the "anomalies" discussion which questions the validity of the CAPM (e.g., Banz, 1981, DeBondt and Thaler, 1985, Fama and French, 1992), Fama and French (1993) developed a three-factor model which includes – besides the excess returns r_{mt}-r_{ft} of the market – two additional factors with respect to size and value to explain the excess returns r_{it}-r_{ft}. Many empirical studies show that this three-factor model has more explanatory power than the one-factor model based on the CAPM, for example, Fama and French (1993, 1996) for the US, Berkowitz and Qiu (2001) for the Canadian, Hussain et al. (2002) for the British, and Schrimpf et al. (2007) or Ziegler et al. (2007b) for the German stock market. At the same time, however, a broad discussion about another factor, namely the momentum factor, began (e.g., Jagadeesh and Titman, 1993, Rouwenhorst, 1998, Jagadeesh and Titman, 2001). As a consequence, the following four-factor model of Carhart (1997), which additionally includes this factor besides the three Fama-French factors, is the most common asset pricing model for applications in financial economics (e.g., L'Her et al., 2004, Bollen and Busse, 2005) and especially for SRI portfolio analyses:

$$r_{it} - r_{ft} = \alpha_i + \beta_{i1} (r_{mt} - r_{ft}) + \beta_{i2} SMB_t + \beta_{i3} HML_t + \beta_{i4} MOM_t + \varepsilon_{it}$$

In this model the Fama-French size factor SMB_t is (at the end of month t) the difference between the returns of portfolios comprising stocks of "small" corporations and portfolios comprising stocks of "big" corporations. The Fama-French value factor HML_t is (at the end of month t) the difference between the returns of portfolios comprising stocks of firms with a "high" book-to-market equity and portfolios comprising stocks of firms with a "low" book-to-market equity. Finally, the Carhart momentum factor MOM_t is (at the end of month t) the difference between the returns of portfolios comprising stocks of "winners" in the past and portfolios comprising stocks of "losers" in the past. The unknown parameters are now the four-factor alpha α_i as well as β_{i1}, β_{i2}, β_{i3}, and β_{i4} besides $var(\varepsilon_{it}) = \sigma_\varepsilon^2$ which are again estimated by OLS.

The main interesting parameter in both approaches is α_i, which is interpreted as the average monthly risk-adjusted or abnormal return of stock portfolio i that cannot be explained by the single risk factor in the one-factor model based on the CAPM or the four risk factors in the Carhart multifactor model. It is thus treated as a measure for stock return out- or underperformance of portfolios comprising corporations with a higher or lower level of responses to climate change compared with the stock market. Furthermore, we consider a trading strategy which buys stocks of corporations with a higher level of responses to climate change and sells stocks of corporations with a lower level of responses to climate change. For this analysis we examine returns of stock portfolios which are constructed by the difference between the returns of stock portfolios comprising firms with a higher level of responses to climate change and the returns of stock portfolios comprising corporations with a lower level. The corresponding aggregated parameter can be calculated by the difference between the two separated one- or four-factor alphas α_i.

3.2 Data for Corporate Responses to Climate Change

Recent SRI portfolio analyses, which compare the risk-adjusted returns of stock portfolios that differ in environmental and/or social measures, either refer to existing funds or virtual funds constructed by the researcher. While the first approach (e.g., Bauer et al., 2005, 2007) is more appropriate to examine real investment decisions, it has the drawback that the effect of fund management skills cannot be separated from the SRI effect. In this respect, portfolio analyses on the basis of virtual funds seem to be more attractive. However, one problem of former portfolio analyses is that the driving factors for possible positive or negative relations cannot be clearly identified among the multitude of aggregated environmental and social ratings, for example, from KLD Research & Analytics (e.g., Kempf and Osthoff, 2007). This problem even remains for portfolio analyses that are only based on aggregated environmental measures, for example, from Innovest (e.g., Derwall et al., 2005).

In contrast to these studies, we use specific disaggregated time series data for corporate environmental performance from the Swiss company ASSET4. This firm is a world-wide leading provider of impartial and measurable extra-financial information of firms. The in-depth information comprises several corporate economic, environmental, social, and governance measures. Based on this, ASSET4 constructs, for each firm, economic, environmental, social, and governance ratings as well as an aggregated overall rating. The main advantage of the raw data is that they are exclusively taken from publicly available sources such as annual reports. In contrast, former SRI portfolio analyses, for example, based on data from Innovest or KLD Research & Analytics include highly subjective elements. ASSET4 has gathered data from world-wide leading firms, including the S&P 500, Morgan Stanley Capital International (MSCI) Europe, and FTSE 350 corporations for the period from 2001 to 2006. In the future, ASSET4 will cover the entire MSCI World Index.

Due to the focus of our study, we consider unique measures for corporate responses to climate change. In this respect, ASSET4 has first investigated a corporate measure for climate impact attention based on the question: "Does the company make a clear statement that it believes that climate change can represent commercial risks and/or opportunities?". Second, ASSET4 has explored an indicator for corporate carbon reduction measures based on the question: "Does the company report on initiatives or new production techniques, to recycle, reduce, reuse, substitute or phase out CO_2 or CO_2 equivalents in the production process?". In this respect, the number of world-wide firms for which such information is available (and appropriate) increases from 614 in 2001 to 1790 in 2006 for the first measure and from 447 in 2001 to 1372 in 2006 for the second indicator.

3.3 Financial Data and Variables

In our separated portfolio analysis for Europe and the USA we indeed examine those corporations with this information which were members of the MSCI Europe Index or the MSCI USA Index at least once in the period from 2001 to 2006. The corresponding financial data on total return indexes (which contain both stock prices and cash flows to the investor), market values, and book values (in US $, respectively) stem from Thomson Financial Datastream. We calculated the monthly stock returns (in %) of all European and US corporations in the empirical analysis with these total return indexes. The time-series regressions of the asset pricing models also require the inclusion of a risk-free interest rate. In this respect, we used the monthly return of one-month US Treasury Bills. Furthermore, the regressions additionally require the inclusion of the monthly excess returns r_{mt}-r_{ft}. For the USA we directly used the corresponding data (in %) from the Kenneth R. French data library. Our calculation of the monthly returns r_{mt} of a European stock market portfolio (in %) is based on the total return indexes of the MSCI Europe (in US $).

In the same way as r_{mt}-r_{ft} we directly extracted the factors SMB_t, HML_t, and MOM_t for the US stock market from the Kenneth R. French data library. In contrast, these factors are not publicly available for the entire European stock market and thus had to be constructed based on several stock portfolios. The basis for this construction was built by all European corporations which were member of the MSCI Europe at least once in the period from 2001 to 2006. Regarding SMB_t and HML_t, firms were ranked each year on their market capitalization in June and independently on their ratio between the published book value for the last year and the market value in December of the last year. Then the median of the market capitalizations as well as the 30% and 70% percentiles of the book-to-market value ratios were calculated, so that six portfolios could be constructed from these three values. In each June over time the corporations were allocated again to one of these six portfolios and stay there from July for the next 12 months.

These portfolios only comprise those corporations with corresponding available data for June of the respective year and additionally with positive book values for the last year. Furthermore, stock return and market value data for the next 12 months had to be available. The resulting times-series of the monthly value-weighted returns of these six stock portfolios (from January 2001 to June 2006) were the basis for the final calculations of SMB_t, which is the (weighted) difference between the monthly stock returns of “small” corporations and “big” corporations, as well as HML_t, which is the (weighted) difference between the monthly stock returns of corporations with a “high” book-to-market equity and the monthly stock returns of corporations with a “low” book-to-market equity (according to the procedure of Fama and French, 1993).

Concerning MOM_t, corporations were ranked in each month t-1 on their market capitalization and independently on the average stock returns between the months t-12 and t-2. Then the median of the market capitalizations as well as the 30% and 70% percentiles of the average stock returns were calculated leading to six portfolios based on these three values. The firms were allocated again in each month t-1 over time to one of these six portfolios. The construction of these portfolios only incorporates those corporations with an available market value for this and the next month and additionally with available stock returns for the next month t and for each month between t-12 and t-2. The resulting times-series of the monthly value-weighted returns of four portfolios with respect to the bottom and top 30% of the past average stock returns were the basis of the final calculations of MOM_t, which is the (weighted) difference between the monthly returns of "winners" in the past and the monthly returns of "losers" in the past (according to the procedure described on the Kenneth R. French data library).

3.4 Construction of Portfolios on Corporate Responses to Climate Change

Subsequently, we had to construct the average stock returns across several corporations in our portfolios that refer to different responses to climate change for both regions as discussed above. In this respect, the corporations were allocated again in each year over time to a portfolio 'climate impact statement' and to a portfolio 'no climate impact statement'. Similarly, the corporations were allocated again in each year to a portfolio 'carbon reduction measures' and to a portfolio 'no carbon reduction measures'. Furthermore, we constructed two portfolios based on the aggregation of both indicators for corporate activities to address climate change. In other words, the corporations were allocated again in each year to a portfolio 'both corporate responses' incorporating firms with both a climate impact statement and additionally carbon reduction measures as well as to a portfolio 'no corporate response' comprising firms that neither make such a statement nor perform carbon reduction measures.

The corresponding corporations stay in these six portfolios for all 12 months of the following calendar year. Moreover, the first indicators for corporate responses to climate change for the year 2001 are also used for the allocation of the portfolios in 2001 besides 2002. The portfolios only include those firms for which such information is available in the respective years and which – as discussed above – were member of the MSCI Europe Index or the MSCI USA Index at least once in the period from 2001 to 2006. Furthermore, stock return data for the respective months had to be available. Table 1 reports the corresponding numbers of corporations in the different portfolios for each year from 2001 to 2006. According to this, the numbers increase over time in each portfolio of both regions which – as discussed above – is due to the rising number of firms for which data for corporate responses to climate change are available. Moreover, it can be seen that the portfolios 'climate impact statement', 'carbon reduction measures', and 'both corporate responses' comprise clearly smaller numbers of firms than the other portfolios.

Based on this, we received for both the European and the US stock market a time series of monthly returns of these six stock portfolios which were calculated with the average stock returns across all corporations in the respective portfolios. Even when these time series are available from January 2001 to December 2006, we only examine the period until June 2006 since the time series for SMB_t and HML_t are only available for the European stock market over this period. Table 1 additionally reports the corresponding average monthly stock returns of the portfolios for the entire observation period from 2001 to 2006 as well as for the subperiods from 2001 to 2003 and from 2004 to 2006. According to this, these average returns strongly increase over time for all six portfolios in both regions, respectively.

Finally, we additionally constructed for the two disaggregated and the aggregated corporate response indicators "long-short" portfolios. These portfolios are based on a trading strategy which buys stocks of corporations with a higher level of responses to climate change and sells stocks of corporations with a lower level. For the aggregated indicators, for example, this means that stocks of corporations with a clear statement that climate change can represent commercial risks and/or opportunities and additionally with initiatives or new production techniques to recycle, reduce, reuse, substitute or phase out CO_2 or CO_2 equivalents in the production process are bought and stocks of corporations with none of these activities are sold. The time series of the monthly returns of the three “long-short” stock portfolios can be calculated by the differences between the monthly returns of the ‘climate impact statement’ and ‘no climate impact statement’ stock portfolios, between the ‘carbon reduction measures’ and ‘no carbon reduction measures’ stock portfolios, as well as between the ‘both corporate responses’ and ‘no corporate response’ stock portfolios.

4. Results

Table 2 and Table 3 report the estimation results for the different portfolios regarding corporate climate impact statements. The “long-short” portfolios here refer to a trading strategy which goes long in the ‘climate impact statement’ portfolio and short in the ‘no climate impact statement’ portfolio. The tables show the estimation results for the entire observation period from 2001 to 2006 as well as for the sub-periods from 2001 to 2003 and from 2004 to 2006. While Table 2 refers to the European stock market, Table 3 corresponds to the US stock market. The first row for each portfolio refers to the one-factor model based on the CAPM and the second row to the Carhart four-factor model. Similarly, Table 4 and Table 5 report the corresponding estimation results for the different portfolios which are based on corporate carbon reduction measures. The “long-short” portfolios here refer to a trading strategy which goes long in the ‘carbon reduction measures’ portfolio and short in the ‘no carbon reduction measures’ portfolio. Finally, Table 6 and Table 7 report the respective estimation results based on the aggregated corporate response indicators. The “long-short” portfolios here refer to a trading strategy which goes long in the ‘both corporate responses’ portfolio and short in the ‘no corporate response’ portfolio.

Regarding the entire observation period from 2001 to 2006, the first four tables of the estimation results (i.e. Table 2, Table 3, Table 4, Table 5) report some significant abnormal returns. According to Table 2 and Table 3, for example, the portfolio including corporations which make no clear statement that they believe that climate change can represent commercial risks and/or opportunities outperforms the stock market both in Europe and in the USA at least at the 5% significance level. Furthermore, Table 4 and Table 5 show that also the 'carbon reduction measures' portfolio outperforms the stock market in both regions at the 5% significance level. However, it should be emphasized that these results (in the same way as the significantly positive abnormal return for the 'no carbon reduction measures' portfolio in Europe according to Table 4) only apply in the one-factor model based on the CAPM. In contrast, all these apparently significantly risk-adjusted returns become insignificant in the multifactor model. Since the size, book-to-market equity, and momentum factors (besides the excess returns of the market) often have significant effects on the excess returns r_{it}-r_{ft} of stock portfolios in both regions, these estimation results support the high relevance and stronger reliability of the application of the Carhart four-factor model compared with the restricted one-factor model based on the CAPM. As a consequence, the results of our portfolio analysis cannot confirm Hypothesis 1b and Hypothesis 2b due to the generally insignificant relationships between the individual corporate responses to climate change and financial performance, respectively.

In contrast, Table 6 and Table 7 report significantly negative abnormal returns for the 'both corporate responses' stock portfolio in Europe and for the "long-short" strategy in both regions in the Carhart four-factor model, respectively. Therefore, a trading strategy, which bought stocks of corporations that made a clear statement that climate change can represent commercial risks and/or opportunities and additionally reported initiatives or new production techniques regarding CO_2 and sold stocks of corporations with none of these activities, led to negative abnormal returns over the entire observation period from 2001 to 2006. According to this, our estimation results provide some evidence to support Hypothesis 1a and to reject Hypothesis 2a due to the rather negative relationship between corporate responses to climate change and financial performance. Regarding the comparison between both regions, the estimated four-factor alpha is clearly more negative for the European than for the US stock market (and additionally statistically more robust based on the underlying 5% and 10% significance levels). While the estimated average monthly risk-adjusted return amounts to -1.20% in Europe, the corresponding value amounts to only -0.44% in the USA. As a consequence, Hypothesis 3 must generally be rejected according to these results.

However, the estimation results for the European stock market strongly change over time. According to Table 6, the 'both corporate responses' portfolio underperforms the stock market and – as indicated by the "long-short" strategy – also the 'no corporate climate response' portfolio in the first sub-period from 2001 to 2003, but outperforms them in the second sub-period from 2004 to 2006 at least at the 5% significance level in the Carhart four-factor model, respectively. Considering the individual corporate activities to address climate change, Table 2 and Table 4 show that these significant risk-adjusted returns especially stem from the respective returns with respect to the carbon reduction measures. While Table 2 reports that the four-factor alphas for the "long-short" strategy with respect to a clear statement that climate change can represent commercial risks and/or opportunities are not significantly different from zero, Table 4 shows that these abnormal returns are negative in the sub-period from 2001 to 2003 and positive in the sub-period from 2004 to 2006 and additionally differ from zero at the 10% significance level, respectively, for reported initiatives or new production techniques regarding CO_2. Due to this development over time, our estimation results support Hypothesis 4.

In this respect, it should be noted that some significant abnormal returns in the one-factor model based on the CAPM become – similar to the entire observation period from 2001 to 2006 as discussed above – insignificant in the Carhart four-factor model, while at the same time several factors have significant effects on the excess returns r_{it}-r_{ft}. This result also holds for the two sub-periods in the USA according to Table 3 and Table 5, which strengthens the importance of the application of this multifactor model. Regarding the first sub-period from 2001 to 2003, Table 3, Table 5, and Table 7 report no significant abnormal returns for the US stock market in the multifactor model. In contrast, Table 3 shows that the ‘no climate impact statement’ portfolio outperforms the stock market at the 1% significance level and – as indicated by the “long-short” strategy – the ‘climate impact statement’ portfolio at the 10% significance level in the second sub-period from 2004 to 2006. Furthermore, the ‘both corporate responses’ portfolio underperforms the stock market at the 10% significance level and – again as indicated by the “long-short” strategy – the ‘no corporate responses’ portfolio at the 1% significance level in this period according to Table 7. As a consequence, our estimation results provide some evidence to support Hypothesis 3 if only the sub-period from 2004 to 2006 was examined, although the general rejection of this hypothesis for the entire observation period from 2001 to 2006 as discussed above persists.

5. Conclusions

Our portfolio analysis implies that a trading strategy, which bought stocks of corporations with both considered responses to climate change and sold stocks of corporations with no responses to climate change over the entire observation period from 2001 to 2006, led to estimated losses in the average monthly risk-adjusted returns in the amount of 0.44% for the US stock market and in the amount of 1.20% for the European stock market. According to this, such specific “green investments” were penalized by the stock markets. Due to this negative relationship, additional activities to address climate change do not seem to be specific factors for firms to become economically more successful. In this respect, sceptics such as Friedman (1970), who argues that there is no role for corporate environmental activities or CSR beyond profit-maximizing actions, are supported. Furthermore, our empirical analysis does not encourage advocates of information-based environmental or climate policy instead of other market based instruments – such as green taxes – or mandatory command and control regulations because we cannot support a positive relationship between corporate responses to climate change and financial performance.

However, the main result of our portfolio analysis refers to the role of the underlying climate policy regime. While we do not directly analyze the effects of climate policy, for example, measured by pollution abatement expenditures (e.g., Brunnermeier and Cohen, 2003), on corporate financial performance, we contribute to the discussion of the impact of environmental policy on the relationship between corporate environmental and financial performance with the separated consideration of the US and European stock markets and the additional examination of different sub-periods. For Europe we find that a trading strategy, which bought stocks of corporations with both examined responses to climate change and sold stocks of corporations with no responses to climate change, indeed led to negative abnormal returns in the period from 2001 to 2003, but to positive abnormal returns in the period from 2004 to 2006. In contrast, such a trading strategy produced negative abnormal returns for the US stock market in the latter period.

According to this, the financial performance of firms with a higher level of responses to climate change is clearly more positive in regions and periods – such as Europe since 2004 – with stringent climate policy than in regions and periods – such as the USA from 2004 to 2006 – with weak climate policy. Regarding the investor perspective, these results suggest investing in corporations with a higher level of responses to climate change especially in regions with more ambitious climate policy regimes. Since the stringency of climate policy can be expected to further increase in Europe, but especially in the USA due to the announcements of the new administration under President Obama, such investments could generally become more attractive in the future. Based on this, it can also be expected that corresponding corporate activities become worthwhile. Regarding policy itself, the aforementioned criticism on advocates of information-based climate policy is strengthened as only a stringent climate policy regime, for example, based on ambitious emission trading systems, leads to positive relationships between corporate activities to address climate change and financial performance.

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Appendix

Table 1: Descriptive statistics

	Europe		**USA**	
	Climate impact statement	**No climate impact statement**	**Climate impact statement**	**No climate impact statement**
Numbers of corporations in the stock portfolios				
2001	14	171	17	142
2002	17	210	17	179
2003	40	355	23	294
2004	42	402	33	334
2005	60	431	36	424
2006	89	410	62	453
Average monthly returns of the stock portfolios				
2001-2006	0.03%	0.67%	0.23%	0.36%
2001-2003	-1.13%	-0.07%	-0.06%	0.06%
2004-2006	1.43%	1.57%	0.56%	0.71%
	Carbon reduction measures	**No carbon reduc-tion measures**	**Carbon reduction measures**	**No carbon reduc-tion measures**
Numbers of corporations in the stock portfolios				
2001	44	87	31	90
2002	51	114	32	115
2003	43	249	29	213
2004	69	259	34	240
2005	85	282	43	300
2006	115	273	59	330
Average monthly returns of the stock portfolios				
2001-2006	0.59%	0.76%	0.55%	0.32%
2001-2003	-0.31%	0.12%	0.08%	0.07%
2004-2006	1.68%	1.54%	1.12%	0.61%
	Both corporate responses	**No corporate responses**	**Both corporate responses**	**No corporate responses**
Numbers of corporations in the stock portfolios				
2001	6	84	9	83
2002	7	110	9	108
2003	11	230	16	205
2004	15	238	20	227
2005	29	262	24	265
2006	41	242	30	274
Average monthly returns in the stock portfolios				
2001-2006	-0.34%	0.76%	-0.08%	0.32%
2001-2003	-1.81%	0.11%	-0.44%	0.04%
2004-2006	1.46%	1.54%	0.35%	0.66%

Table 2: Parameter estimates (z-statistics) for the European stock market, portfolios according to climate impact statement

	Alpha	$\mathbf{r_{mt} - r_{it}}$	$\mathbf{SMB_t}$	$\mathbf{HML_t}$	$\mathbf{MOM_t}$	$\mathbf{R^2}$
2001-2006						
Climate impact statement	-0.13	1.22***	--	--	--	0.92
	(-0.59)	(17.59)	(--)	(--)	(--)	
	-0.20	1.04***	0.12	0.21	-0.20***	0.96
	(-0.89)	(22.22)	(1.44)	(1.38)	(-5.47)	
No climate impact statement	0.50***	1.12***	--	--	--	0.94
	(2.87)	(22.02)	(--)	(--)	(--)	
	0.06	1.05***	0.44***	0.17***	-0.09***	0.98
	(0.50)	(46.92)	(10.75)	(3.23)	(-3.75)	
Long-short	-0.64***	0.11	--	--	--	0.07
	(-2.64)	(1.57)	(--)	(--)	(--)	
	-0.26	-0.00	-0.32***	0.04	-0.15***	0.36
	(-0.98)	(-0.07)	(-3.43)	(0.24)	(-3.11)	
2001-2003						
Climate impact statement	-0.28	1.24***	--	--	--	0.92
	(-0.76)	(15.19)	(--)	(--)	(--)	
	-0.41	0.98***	0.10	0.20	-0.28***	0.96
	(-1.19)	(12.36)	(1.14)	(1.03)	(-5.13)	
No climate impact statement	0.66**	1.12***	--	--	--	0.94
	(2.42)	(18.63)	(--)	(--)	(--)	
	0.13	1.03***	0.41***	0.17**	-0.10***	0.98
	(0.64)	(31.98)	(8.71)	(2.41)	(-3.40)	
Long-short	-0.94**	0.12	--	--	--	0.09
	(-2.46)	(1.53)	(--)	(--)	(--)	
	-0.55	-0.06	-0.31***	0.03	-0.18***	0.37
	(-1.25)	(-0.61)	(-2.82)	(0.16)	(-2.76)	
2004-2006						
Climate impact statement	0.18	1.11***	--	--	--	0.95
	(1.19)	(29.34)	(--)	(--)	(--)	
	0.03	1.09***	0.14	0.15	-0.11	0.95
	(0.18)	(17.09)	(0.76)	(0.88)	(-1.37)	
No climate impact statement	0.27*	1.16***	--	--	--	0.95
	(1.69)	(28.17)	(--)	(--)	(--)	
	-0.04	1.05***	0.58***	0.13**	-0.05	0.99
	(-0.75)	(42.99)	(9.65)	(2.36)	(-1.57)	
Long-short	-0.09	-0.05	--	--	--	0.02
	(-0.52)	(-0.98)	(--)	(--)	(--)	
	0.07	0.05	-0.43**	0.01	-0.05	0.34
	(0.49)	(0.77)	(-2.07)	(0.07)	(-0.71)	

Note:
* (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 3: Parameter estimates (z-statistics) for the US stock market, portfolios according to climate impact statement

	Alpha	$\mathbf{r_{mt} - r_{it}}$	$\mathbf{SMB_t}$	$\mathbf{HML_t}$	$\mathbf{MOM_t}$	$\mathbf{R^2}$
2001-2006						
Climate impact statement	0.19 (0.74)	0.87*** (10.38)	-- (--)	-- (--)	-- (--)	0.78
	-0.22 (-1.06)	0.97*** (12.32)	0.01 (0.11)	0.50*** (6.58)	-0.08 (-0.99)	0.86
No climate impact statement	0.30** (2.36)	0.93*** (20.61)	-- (--)	-- (--)	-- (--)	0.94
	0.05 (0.43)	1.00*** (31.77)	0.07** (2.06)	0.23*** (4.20)	0.01 (0.42)	0.96
Long-short	-0.11 (-0.55)	-0.05 (-0.95)	-- (--)	-- (--)	-- (--)	0.02
	-0.27 (-1.38)	-0.03 (-0.44)	-0.06 (-0.95)	0.27*** (3.39)	-0.09 (-1.31)	0.19
2001-2003						
Climate impact statement	0.29 (0.93)	0.88*** (8.99)	-- (--)	-- (--)	-- (--)	0.78
	-0.17 (-0.46)	0.99*** (8.66)	0.03 (0.30)	0.53*** (5.62)	-0.07 (-0.60)	0.87
No climate impact statement	0.38* (1.84)	0.91*** (17.65)	-- (--)	-- (--)	-- (--)	0.94
	0.09 (0.47)	1.00*** (23.94)	0.06 (1.18)	0.30*** (5.83)	-0.00 (-0.05)	0.98
Long-short	-0.10 (-0.32)	-0.03 (-0.44)	-- (--)	-- (--)	-- (--)	0.01
	-0.25 (-0.77)	-0.02 (-0.20)	-0.03 (-0.36)	0.23** (2.51)	-0.07 (-0.67)	0.13
2004-2006						
Climate impact statement	0.09 (0.40)	0.86*** (9.94)	-- (--)	-- (--)	-- (--)	0.77
	-0.20 (-0.76)	1.02*** (7.18)	-0.14 (-1.18)	0.30** (2.16)	-0.03 (-0.37)	0.81
No climate impact statement	0.12 (1.29)	1.06*** (30.99)	-- (--)	-- (--)	-- (--)	0.97
	0.30*** (3.53)	0.95*** (17.57)	0.12** (2.03)	-0.16*** (-3.96)	-0.02 (-0.49)	0.98
Long-short	-0.03 (-0.13)	-0.20** (-2.10)	-- (--)	-- (--)	-- (--)	0.14
	-0.50* (-1.94)	0.07 (0.56)	-0.25** (-2.34)	0.46*** (3.50)	-0.01 (-0.11)	0.48

Note:
* (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 4: Parameter estimates (z-statistics) for the European stock market, portfolios according to carbon reduction measures

2001-2006						
	Alpha	**$r_{mt} - r_{it}$**	**SMB_t**	**HML_t**	**MOM_t**	**R^2**
Carbon reduction measures	0.43^{**} (2.27)	1.04^{***} (15.00)	-- (--)	-- (--)	-- (--)	0.93
	-0.06 (-0.36)	1.00^{***} (29.70)	0.38^{***} (8.58)	0.26^{**} (2.09)	-0.05 (-1.32)	0.97
No carbon reduction measures	0.60^{***} (3.09)	1.02^{***} (20.73)	-- (--)	-- (--)	-- (--)	0.92
	0.16 (1.22)	0.97^{***} (43.52)	0.53^{***} (12.58)	0.05 (0.88)	-0.06^{**} (-2.18)	0.98
Long-short	-0.17 (-1.03)	0.02 (0.29)	-- (--)	-- (--)	-- (--)	0.00
	-0.22 (-0.99)	0.03 (0.68)	-0.15^{***} (-2.86)	0.21 (1.50)	0.00 (0.08)	0.16
2001-2003						
	Alpha	**$r_{mt} - r_{it}$**	**SMB_t**	**HML_t**	**MOM_t**	**R^2**
Carbon reduction measures	0.36 (1.24)	1.03^{***} (12.79)	-- (--)	-- (--)	-- (--)	0.92
	-0.29 (-1.07)	1.03^{***} (21.69)	0.40^{***} (8.44)	0.29^{**} (2.02)	-0.03 (-0.78)	0.97
No carbon reduction measures	0.75^{**} (2.55)	1.00^{***} (17.61)	-- (--)	-- (--)	-- (--)	0.92
	0.27 (1.41)	0.92^{***} (38.39)	0.49^{***} (12.11)	0.01 (0.13)	-0.09^{***} (-2.84)	0.98
Long-short	-0.40 (-1.61)	0.03 (0.51)	-- (--)	-- (--)	-- (--)	0.02
	-0.56^{*} (-1.88)	0.11^{**} (2.20)	-0.08^{*} (-1.88)	0.28^{*} (1.89)	0.06 (1.42)	0.30
2004-2006						
	Alpha	**$r_{mt} - r_{it}$**	**SMB_t**	**HML_t**	**MOM_t**	**R^2**
Carbon reduction measures	0.51^{***} (2.91)	1.04^{***} (20.31)	-- (--)	-- (--)	-- (--)	0.95
	0.23^{*} (1.85)	1.00^{***} (23.37)	0.40^{***} (4.47)	0.17^{*} (1.82)	-0.21^{***} (-3.10)	0.98
No carbon reduction measures	0.24 (1.25)	1.16^{***} (22.68)	-- (--)	-- (--)	-- (--)	0.93
	-0.08 (-0.81)	1.03^{***} (27.86)	0.65^{***} (8.88)	0.09 (1.05)	-0.03 (-0.50)	0.98
Long-short	0.27 (1.58)	-0.12^{***} (-2.82)	-- (--)	-- (--)	-- (--)	0.17
	0.31^{*} (1.83)	-0.04 (-0.60)	-0.25^{**} (-2.15)	0.07 (0.65)	-0.18^{**} (-2.12)	0.40

Note:
* (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 5: Parameter estimates (z-statistics) for the US stock market, portfolios according to carbon reduction measures

	Alpha	$r_{mt} - r_{it}$	SMB_t	HML_t	MOM_t	R^2
2001-2006						
Carbon reduction measures	0.51** (2.12)	0.87*** (10.63)	-- (--)	-- (--)	-- (--)	0.79
	0.20 (0.95)	0.96*** (12.11)	-0.07 (-0.92)	0.46*** (4.93)	-0.08 (-1.25)	0.87
No carbon reduction measures	0.27 (1.62)	0.92*** (17.06)	-- (--)	-- (--)	-- (--)	0.90
	-0.08 (-0.52)	0.98*** (26.94)	0.14*** (2.77)	0.27*** (4.70)	0.01 (0.30)	0.94
Long-short	0.24 (1.10)	-0.05 (-0.77)	-- (--)	-- (--)	-- (--)	0.01
	0.28 (1.32)	-0.02 (-0.23)	-0.22** (-2.52)	0.19** (2.04)	-0.09 (-1.44)	0.22
2001-2003						
Carbon reduction measures	0.41 (1.05)	0.86*** (9.18)	-- (--)	-- (--)	-- (--)	0.80
	0.18 (0.53)	0.90*** (7.62)	-0.13 (-1.26)	0.48*** (4.35)	-0.14 (-1.23)	0.88
No carbon reduction measures	0.40 (1.50)	0.89*** (14.43)	-- (--)	-- (--)	-- (--)	0.90
	-0.04 (-0.17)	0.99*** (22.18)	0.13* (1.76)	0.35*** (5.86)	-0.01 (-0.28)	0.96
Long-short	0.01 (0.02)	-0.03 (-0.40)	-- (--)	-- (--)	-- (--)	0.01
	0.22 (0.62)	-0.09 (-0.85)	-0.25** (-2.30)	0.13 (1.10)	-0.13 (-1.21)	0.20
2004-2006						
Carbon reduction measures	0.63** (2.44)	0.89*** (8.44)	-- (--)	-- (--)	-- (--)	0.74
	0.24 (0.74)	0.99*** (6.75)	-0.01 (-0.07)	0.45*** (2.89)	-0.05 (-0.51)	0.80
No carbon reduction measures	0.00 (0.02)	1.10*** (18.89)	-- (--)	-- (--)	-- (--)	0.92
	0.18 (1.06)	0.95*** (9.37)	0.17* (1.79)	-0.16* (-1.71)	-0.00 (-0.06)	0.94
Long-short	0.62** (2.55)	-0.21** (-1.99)	-- (--)	-- (--)	-- (--)	0.14
	0.05 (0.26)	0.05 (0.44)	-0.18 (-1.44)	0.62*** (5.73)	-0.04 (-0.46)	0.61

Note:
* (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 6: Parameter estimates (z-statistics) for the European stock market, portfolios according to both corporate responses to climate change (i.e. climate impact statement and carbon reduction measures)

	Alpha	$r_{mt} - r_{it}$	SMB_t	HML_t	MOM_t	R^2
2001-2006						
Both corporate responses	-0.43	1.23***	--	--	--	0.73
	(-0.95)	(8.35)	(--)	(--)	(--)	
	-1.04**	1.01***	0.80***	0.20	-0.30***	0.86
	(-2.07)	(11.41)	(5.65)	(0.76)	(-3.00)	
No corporate responses	0.59***	1.02***	--	--	--	0.92
	(3.02)	(20.83)	(--)	(--)	(--)	
	0.17	0.97***	0.53***	0.03	-0.07***	0.98
	(1.32)	(40.98)	(12.78)	(0.60)	(-2.62)	
Long-short	-1.03**	0.21	--	--	--	0.09
	(-2.46)	(1.59)	(--)	(--)	(--)	
	-1.20**	0.04	0.27*	0.16	-0.23**	0.21
	(-2.14)	(0.39)	(1.71)	(0.57)	(-2.10)	
2001-2003						
Both corporate responses	-0.83	1.27***	--	--	--	0.72
	(-1.01)	(7.22)	(--)	(--)	(--)	
	-2.00***	1.03***	0.97***	0.32	-0.28**	0.86
	(-2.61)	(8.11)	(6.22)	(1.12)	(-2.48)	
No corporate responses	0.75**	1.01***	--	--	--	0.92
	(2.48)	(17.75)	(--)	(--)	(--)	
	0.28	0.91***	0.49***	-0.01	-0.10***	0.98
	(1.46)	(35.55)	(12.33)	(-0.11)	(-3.25)	
Long-short	-1.57**	0.26*	--	--	--	0.13
	(-2.20)	(1.69)	(--)	(--)	(--)	
	-2.27***	0.11	0.49***	0.33	-0.18	0.31
	(-2.69)	(0.85)	(2.88)	(1.06)	(-1.46)	
2004-2006						
Both corporate responses	0.37*	0.97***	--	--	--	0.89
	(1.80)	(21.10)	(--)	(--)	(--)	
	0.47**	1.03***	-0.22	-0.03	-0.06	0.90
	(2.48)	(12.74)	(-0.83)	(-0.19)	(-0.45)	
No corporate responses	0.26	1.15***	--	--	--	0.93
	(1.30)	(22.02)	(--)	(--)	(--)	
	-0.06	1.02***	0.66***	0.08	-0.02	0.98
	(-0.58)	(27.09)	(7.93)	(0.74)	(-0.34)	
Long-short	0.11	-0.18***	--	--	--	0.11
	(0.37)	(-2.59)	(--)	(--)	(--)	
	0.53**	0.01	-0.88***	-0.11	-0.04	0.54
	(2.35)	(0.11)	(-3.05)	(-0.64)	(-0.32)	

Note:
* (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 7: Parameter estimates (z-statistics) for the US stock market, portfolios according to both corporate responses to climate change (i.e. climate impact statement and carbon reduction measures)

	Alpha	$r_{mt} - r_{it}$	SMB_t	HML_t	MOM_t	R^2
2001-2006						
Both corporate responses	-0.09	1.01***	--	--	--	0.71
	(-0.26)	(9.26)	(--)	(--)	(--)	
	-0.47	0.93***	0.02	0.56***	-0.29***	0.79
	(-1.58)	(9.92)	(0.17)	(4.49)	(-3.32)	
No corporate responses	0.27*	0.95***	--	--	--	0.91
	(1.70)	(18.32)	(--)	(--)	(--)	
	-0.03	0.99***	0.14**	0.23***	-0.00	0.94
	(-0.20)	(26.35)	(2.51)	(3.97)	(-0.05)	
Long-short	-0.37	0.06	--	--	--	0.01
	(-1.13)	(0.67)	(--)	(--)	(--)	
	-0.44*	-0.06	-0.12	0.33***	-0.28***	0.24
	(-1.65)	(-0.69)	(-1.31)	(2.69)	(-3.29)	
2001-2003						
Both corporate responses	0.02	1.04***	--	--	--	0.72
	(0.03)	(8.33)	(--)	(--)	(--)	
	-0.45	0.87***	-0.01	0.58***	-0.34**	0.80
	(-0.80)	(5.71)	(-0.08)	(3.73)	(-2.38)	
No corporate responses	0.38	0.93***	--	--	--	0.92
	(1.51)	(15.68)	(--)	(--)	(--)	
	-0.01	0.99***	0.12	0.31***	-0.02	0.95
	(-0.05)	(20.95)	(1.50)	(5.01)	(-0.86)	
Long-short	-0.36	0.12	--	--	--	0.04
	(-0.69)	(1.17)	(--)	(--)	(--)	
	-0.43	-0.12	-0.13	0.27*	-0.31**	0.21
	(-0.89)	(-0.85)	(-1.10)	(1.89)	(-2.20)	
2004-2006						
Both corporate responses	-0.10	0.82***	--	--	--	0.65
	(-0.34)	(7.03)	(--)	(--)	(--)	
	-0.56*	1.08***	-0.14	0.53***	-0.17**	0.74
	(-1.68)	(6.61)	(-0.82)	(3.24)	(-2.00)	
No corporate responses	0.05	1.11***	--	--	--	0.92
	(0.29)	(17.32)	(--)	(--)	(--)	
	0.24	0.95***	0.18*	-0.17	-0.01	0.93
	(1.27)	(8.98)	(1.93)	(-1.54)	(-0.14)	
Long-short	-0.15	-0.29**	--	--	--	0.17
	(-0.49)	(-2.56)	(--)	(--)	(--)	
	-0.80***	0.14	-0.32**	0.70***	-0.16*	0.57
	(-3.31)	(1.34)	(-2.39)	(6.06)	(-1.80)	

Note:
* (**, ***) means that the appropriate parameter is different from zero at the 10% (5%, 1%) significance level, respectively.