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The Added Value of a Climate Risk Premium in Business Valuation

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Contents

Abstract

Fama & French's research (1993) has shown that there are three relevant factors in predicting stock returns, namely a general market factor and factors related to company size and value. This paper examines whether a climate risk premium would be an addition to business valuation alongside the aforementioned factors. The climate premium covers the transitory risks of climate change and the increasing responsibility of companies regarding sustainability. A Fama-Macbeth analysis has been performed on the common stock of non-financial firms on the NASDAQ between 2008 and 2019. The results show that there are indications of the presence of Fama-French's factors and that the carbon risk premium (CARP) is significant. After applying winsorize, the climate risk premium (CLRP) and the emission intensity premium (EIP) are significant as well. The significance of CLRP is strongly influenced by its given weights. Thus, it can be observed that the results are sensitive to adjustments. In conclusion, this research

does not lead to indisputable evidence that the addition of a climate risk premium provides more information about the valuation of companies.

1. Introduction

The UN Climate Agreement in Paris in 2016 marked the moment when 195 countries intended to collectively limit global CO_2 emissions (NEA, 2017). In the Netherlands, this agreement led to the Climate Act where they set the goal of limiting CO_2 emissions by 95% by 2050 (Rijksoverheid, 2021). The climate goals set in the Paris Climate Agreement are forcing companies worldwide to make the transition towards CO_2-neutral emissions. The Intergovernmental Panel on Climate Change's (IPCC) special report estimates that investments regarding climate change should be around 2.5% of worldwide GDP between 2016 and 2035 to fulfill this goal (IPCC, 2018). For comparison, Europe currently spends 2% of its gross domestic product (GDP) on energy systems and corresponding infrastructure (European Commission, 2019). This percentage should increase to 2.8%, which translates to an increase of €520-575 billion. These investments will have profound implications for corporate profits, capital markets, and household wealth, mostly caused by carbon pricing, productivity barriers, and rising sea levels. At the current pace, global average temperatures are expected to have risen by 3 degrees Celsius at the end of this century, which is higher than the 1.5 degrees Celsius that has been agreed upon by world leaders (Cambio, 2021). To comply with these set goals, it is important to have uniform standards to monitor global emissions. A possibility to remedy this obstacle is using a climate risk premium when valuing organizations. For example, Bolton and Kacperczyka (2019) found that carbon emissions have a significant positive effect on stock returns, while emission intensity has no significant effect. They also found that for U.S. stock returns a carbon premium could not be explained by known risk factors. If it indeed turns out that the climate risk premium has an added value to the identified risk factors, this might form an incentive for stakeholders to act upon. Besides, postponing sustainability might form a risk for organizations. Early movers might experience more favorable circumstances since they have room to invest more evenly in sustainability. Therefore, if the climate risk premium proves to be economically relevant, its addition within the widely used valuation models may provide a more complete picture of the value of companies. This will update the relatively static models of business valuation, potentially causing a shift within the financial economic theory.

2. Theoretical Framework

The Capital Asset Pricing Model (CAPM) assumes that the risk profile of an organization is reflected by market risk. However, Fama & French (1993) found that there are other risk factors that influence an organization's returns, such as firm size and firm value. The Fama-Macbeth (FM) regression offers a way to test the relevance of a risk factor on asset pricing. Further, human fallacies and difficulties in measuring the costs of emissions contribute to a subjective perspective regarding asset pricing. This section will provide a more detailed explanation of these phenomena.

2.1 Related Literature

It is customary to arrive at the business valuation by discounting the cash flows against the Weighted Average Cost of Capital (WACC) (Brotherson et al., 2013). Within the WACC, equity and debt are weighted against each other. The cost of equity is usually estimated using the CAPM of Sharpe (1964) - Lintner (1965). CAPM states that investors demand a risk premium for the market risk that they endure. However, multiple studies show that market risk is not the only relevant risk factor and that there are large unexplained parts of the observed returns. For example, Banz (1981) found that a firm's size influences its expected returns, since low market cap firms are undervalued relative to their market beta. This is likely because small firms are assumed to be riskier. Recently Ciliberti et al. (2017) confirmed the existence of a size premium, when measuring in terms of dollar-turnover and by neutralizing β and low-volume. Using global data, they found that the biggest risks within the portfolios are large-cap companies.
Rosenberg, Reid & Lanstein (1985) found that the average return has a positive correlation with the book-to-market ratio. This is supported by Fama & French (1993), who found that value stocks perform better on average than growth stocks when looking at a firm’s returns.
An alternative to CAPM is Fama-French's (FF) Three-Factor Asset Pricing Model (Fama & French, 1992). In addition to the market risk premium, a size premium and a value premium are added.

These findings raise the question whether there are other relevant factors that have significant predictive power on firms' returns. Fama-Macbeth (1973) introduced an asset pricing method to answer this question. The FM regression examines whether a risk factor leads to a significant risk premium. This involves looking at the sensitivity of a portfolio's returns to a risk factor. This method assumes that investors are risk-averse, that portfolios are normally distributed and that estimated betas correspond to the true market betas. This last assumption influences the efficiency and consistency of the resulting estimates. To counter the complication, Fama-Macbeth form portfolios to increase the validity of these beta estimates.

2.2 Influence of Sustainability

Within financial theory, investors are often assumed to be transitive and rational. Examples of psychological factors such as biases and anchors seem to contradict this. Thus, this implies that market prices are influenced by the subjective patterns of investors. The most common psychological market pattern among these investors is the extrapolation bias (De Bondt, 1998). This bias indicates that investors base their price predictions on recent conditions and project them into the future. This is in line with what De Bondt found in 1993, that investors often base their sentiment on (at least) the past 100 days. Recent events and developments regarding sustainability will therefore weigh more heavily. Especially if sustainability and climate change are increasingly perceived as a social problem. Further, people frequently anchor on their most likely scenario or prediction (Tversky & Kahneman, 1974). This results in a narrow confidence interval for investors. Also, investors believe they can sell their equity on time in a bear market. According to Langer (1975), this sense of universal liquidity gives an unjustified sense of control. Concluding, investors do not always have sufficient knowledge of valuation techniques and are sensitive to human fallacies. This results in a reality where the value of organizations is influenced by popular valuation methods, (social) media, and financial advisors (Shiller, 1990). This implicates that a climate risk premium will become more relevant if climate change gets more attention among the aforementioned sources, of which the Paris Agreement is an ode. However, it is difficult to estimate the costs of climate change, such as the consequence of the temperature rises and extreme weather. According to Pindyck (2013) certain arbitrary inputs greatly affect the social cost of carbon and are not subject to theoretical or empirical foundation. However, it is clear that climate change will eventually lead to more physical risks like (extreme) weather and to rising temperatures. As a result, physical risk appeared to be seen as a common and central theme in the chosen strategies of companies (Cambio, 2021). Supplier risk also seems to form a climate risk. This type of risk represents the inability among suppliers to adapt to climate change. Examples are the failure of crop rotations, no price corrections or unsuccessful technological innovation. These situations make it more difficult for the suppliers to produce their products. Finally, regulatory risk is related to climate change. These risks represent changes in policies surrounding climate change and emissions, such as carbon pricing and emission trading schemes (ETS).

Since it is difficult to determine how an organization performs in the environmental field or to measure this against a specific standard, this can lead to psychological tendencies such as a focus on the short term without considering the negative effects in the long term. According to Slawinski & Bansal (2012), firms must therefore adopt an outward perspective to balance both short-term and long-term goals. This requires a business to open itself up to stakeholders and the broader environment. For companies, however, the question is whether adopting a sustainable vision or strategy contributes to their organization. Margolis et al. (2009) show that there is only a small positive correlation between social and financial performance of organizations. This correlation may be because shareholders can benefit from sustainable activities within an organization, as it limits the downside risk (Hoepner et al., 2018). Also, Hartzmark and Sussman (2018) found that sustainability is viewed as a measure of future performance, but that there are no signs that investment funds that invest specifically in sustainability outperform investment funds that do not. So, while investing in sustainability may not seem be particularly rewarding for firms in the short term, it may mean that companies would have to adjust their operations less abruptly in the future. According to Gros et al. (2016) a slow transition to the Paris Agreement will lead to costly consequences of climate change. However, adapting too fast will cause the prices of unsustainable products to rise sharply. The mid-term is not necessarily rosy either since sustainable finance strategies are more costly when firms emit more, leaving less profit to be distributed among shareholders (Alessi et al., 2019). It is possible that companies will therefore look for more sustainable alternatives, potentially leading to more sustainable, or carbon-free alternatives. Further, investors look at sustainability from a different angle. For them, an investment must outweigh the climate risk to be taken. According to Choi, Gao, and Jiang (2019) abnormally high local temperatures increase attention towards climate change. Then, looking at volume and returns, they found that retail investors are selling carbon-intensive stocks intensively during these events, and that these firms underperform firms with lower emissions. This is in line with the short-term focus as described by De Bondt (1993, 1998). However, institutional investors indicate that climate risk is already incorporated in the companies in which they invest, but that it does not yet fully cover it in some sectors (Krueger, Sautner, and Stark, 2020). Overall, to some extent it seems that investors already process their exposure to carbon risk.

2.3 Transparency

The suboptimal standardization and regulation of environmental practices can result into short-termism, which can lead to greenwashing. Greenwashing is the act of deliberately painting a distorted picture regarding company's environmental practices or its product. This form of deception is therefore a combination of inadequate environmental performance whilst communicating in a positive manner about this performance. According to Delmas & Burbano (2011) organizations are more likely to engage in greenwashing if it experiences high pressure from investors, consumers, and competitors. Also, companies will conform to companies that are comparable or located in the same sector. This unreliable reporting might eventually lead to distrust among consumers towards the current green products or firms. For firms, this might make it less attractive to perform in a more climate-friendly manner.

Since legislation and standardization differ per country or state, one can ask whether there is no need to standardize emission measures. There are international standards for self-declared environmental claims, but companies can generally voluntarily participate in these measures. Matsumura, Prakash, and Vera-Munoz (2014) found that these voluntary disclosures mitigate the negative effect of emissions on firm value. Further, in America it is not uniformly mandatory to disclose the environmental performance, apart from specific toxic substances. American companies are only obliged to state their CO2 emissions when this is above 25,000 metric tons (EPA, 2020). The reporting companies supposedly account for half of the U.S. emissions, which means that the other half is caused by small(er) emitters. This might explain the finding of Matsumura, Prakash, and Vera-Munoz (2014), that organizations that do not report emissions are usually smaller and less profitable. Also, there is some regulation of environmental marketing issues surrounding unfair or misleading displays in America. The Federal Trade Commission (FTC) can issue fines on this property, but enforcement thereof is limited since this legislation only applies on communication about a product or service. Also, definitions such as "biodegradable" and "all-natural" are vague and therefore leave room for interpretation (Delmas & Burbano, 2011). Finally, by disclosing emission data and having it checked by third parties, it will be become more difficult for firms to lie or exaggerate their environmental actions.

3. Data

Data from non-financial firms within the NASDAQ will be used in this research. Financial firms have been left out of consideration as these organizations often have a relatively high leverage, which does not have the same significance as under non-financial firms (Fama & French, 1992). The data will be collected from the Center for Research in Security Prices (CRSP) and the CRSP/Compustat merged annual industrial files of income statements and balance sheet data. The NASDAQ and stock returns are equal-weighted returns including dividends. In this paper, the Beta Suite of WRDS has been used to obtain the betas. The data concerning carbon emissions and emission scores are taken from Thomson Reuters, since this firm follows the measuring standards set by the Greenhouse Gas Protocol (n.d.). The ticker of the firms is used as an identification code since it is used in all datasets. Within these datasets, organizations do not always have the same fiscal year ending. Partly because of this, the gap between accounting data and the return among firms differs. According to Fama & French (1992), this gap leads to comparable results relative to the situation in which there is the same fiscal year ending. Finally, the term for this research spans from 2008 to 2019. It was decided to start after 2000 as the energy transition became more prevalent around this time (EIA, 2021). 2008 was specifically chosen as companies only started reporting sustainability information to a large extent since then. In addition, a conscious choice was made for no more recent data than 2019 as Covid-19 gives a distorted picture of regular reality.

Our control variables are defined in the following manner. Beta represents the market beta, obtained using a rolling window of 24 to 60 months of the market returns if available (see Formula 3). ME is the market value in billions ($) at the end of the fiscal year; BME is the book-to-market value at the end of the fiscal year; CARP consists of the CO_2 emissions in tonnes (kg) at the end of the fiscal year; EIP is the emission intensity at the end of the fiscal year; CLIM is the weighted average of the emission intensity (EIP) and the environmental score and the end of the fiscal year.

(3) $R_{i,t} - rf_t = \alpha_i + \beta_i * mktrf_t + \varepsilon_{i,t}$

Where

$R_{i,t}$ = stock I return during period t

$mktrf_t$ = Fama French Excess Return on the Market during period t

4. Methodology

Fama & French (1993) have shown that there are three relevant factors in predicting stock returns, namely a general market factor and factors related to company size and value. In this chapter, the steps will be described how to test whether a climate risk premium is of added value to these existing factors. A FM regression is used as an asset pricing test to test whether the three-factors are relevant in combination with a climate risk premium.

4.1 Climate Risk Premium

The climate risk premium consists of the physical, supplier and regulatory risks caused by climate change. Since Bolton and Kacperczyka (2019) found that carbon emissions have a significant positive effect on stock returns, while emission intensity does not, both options will be examined. This will be incorporated in the climate risk variable by looking at the total CO_2 emissions (CARP, see Formula 1) and the revenue-weighted emission intensity (EIP, see Formula

2). In addition, it can be to the advantage of an organization to participate in greenwashing or by limiting its operational information. This will make it necessary to consider the climate risk premium variable that reflects the transparency of organizations. For this purpose, the Thomson Reuters Environmental Score will be used, which will be referred to as the E-score. This is a measure of the transparency of an organization regarding its impact on the environment. Within this criterion a score is given between 0 and 100, where 0 represents companies that do not release environmental data and 100 represents companies that disclose detailed environmental information. It should be noted that this E-score represents the commitment of organizations regarding sustainability and thus indirectly represents transparency. This does not claim that companies that are non-transparent also immediately negatively affect the environment, but it seems reasonable that this reflects the benevolence of an organization. After these variables have been obtained, both variables will be weighted, resulting in the climate risk premium (CLRP, see Formula 3).

(1) $$Carbon\ Risk\ Premium\ (CARP) = CO2 - emissions$$

(2) $$Emission\ Intensity\ Premium\ (EIP) = \frac{CO2-emissions}{Revenue}$$

(3) $$Climate\ Risk\ Premium\ (CLRP) = x * \frac{CO2-emissions}{Revenue} + (1-x) * Escore$$

4.2 Fama-Macbeth Regression

Fama-Macbeth regressions are used as an asset pricing test to observe whether Fama & French's (1992) three-factors are relevant in combination with a climate risk premium. The monthly equal-weighted returns (ER) will therefore be regressed on the climate variables and market risk (β_{pre}), size (market equity (ME)) and value (book-to-market equity (BME)) are used as control variables. The process of the FM regression can be divided into two steps. The first step is to do a cross-section of returns on variables hypothesized to explain the expected returns (see Formula 4). The second step is to use the time-series means of these slopes to test whether the betas from period t-1 explain the returns of period t.

(4) $R_{it} = \alpha_i + b_1 * \beta_{i,t-1} + b_2 * \ln(ME)_{i,t-1} + b_3 * \ln(BME)_{i,t-1} + b_4 * \ln(Climate\ Premium)_{i,t-1} + \varepsilon_t$

5. Results

First, to investigate the reliability of the data, descriptive statistics of the variables will be examined in this chapter. This test will show whether the natural logarithm of certain variables should be used or whether certain unexplained extreme values should be removed. After these variables have been filtered, the mutual correlation will be looked at. Afterwards, a FM regression will be performed with varying weights for CLRP.

5.1 Informal Tests

As can be seen in Table 1, ME, BME and the climate variables have large standard deviations. That is not inexplicable when observing the outliers or by looking at the distance between the minima and the maxima of these variables. In the case of ME and BME, this can be caused by the high market value of companies in the US, also known as “super-sized” firms. Because of these differences, the natural logarithm is used for these variables. Similarly, the natural logarithm is used for the climate variables due to the variance and outliers. In addition, it should be noted that the climate variables have significantly fewer observations than the other control variables. This might be because it has recently become the norm to provide environmental data. Subsequently, the pairwise correlations of these filtered variables will be examined in Table 2. If the variables have a high mutual correlation, this can lead to a distorted picture of its effect on the dependent variable (multicollinearity). It is noticeable that ln(ME) has a high correlation with multiple variables. However, this correlation is not high enough to exclude these variables. Logically, there is also a high correlation between the climate variables. These variables will therefore not be included in combination in the subsequent regressions. Appendix I provides a more detailed description of the panel data used in this paper.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min	Max	Obs.
ER	0.0058	0.0503	-0.2052	0.1928	25417
β	1.297	.665	-2.125	5.523	24250
ME	24889.16	75155.118	24.957	1073390.5	19921
BME	.43	.989	-60.6	23.809	19920
ln(ME)	8.621	1.707	3.217	13.886	19921
ln(BME)	-1.116	.832	-4.773	3.17	19344
CARP	4257735.8	15923928	.11	1.482e+08	11358
EIP	371.419	1273.759	0	10263.158	11096
CLRP	217.24	637.276	5.35	5170.374	11072
ln(CARP)	12.51	2.333	-2.207	18.814	11358
ln(EIP)	3.723	1.844	-8.649	9.236	11096
ln(CLRP)	4.231	1.12	1.677	8.551	11072

The control variables will be examined for relevance by summarizing their characteristics. CARP, EIP and CLRP (x=0.5) have been used as the climate variables. From left to right: the mean, standard deviation (std. dev.), minimum (min), maximum (max) and the observations (obs).

The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables.

Table 2: Pairwise correlations using the climate variables (CARP, EIP and CLRP).

	β	ln(ME)	ln(BME)	ln(CARP)	ln(EIP)	ln(CLRP)
β	1.000					
ln(ME)	-0.297	1.000				
ln(BME)	0.174	-0.455	1.000			
ln(CARP)	-0.259	0.318	0.173	1.000		
ln(EIP)	-0.213	-0.113	0.287	0.810	1.000	
ln(CLRP)	-0.250	-0.027	0.248	0.759	0.869	1.000

The control variables will be examined for multicollinearity by testing the pairwise correlations of these filtered variables will be examined. CARP, EIP and CLRP (x=0.5) have been used as the climate variables.

The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables.

5.2 Fama-Macbeth Regression

The first step in the FM regression is to do a cross-section of returns on variables hypothesized to explain the expected returns. The time-series averages of these variables will be used in the second step of the FM regression. These values will be used to observe whether the betas from period t-1 explain the returns of period t. Table 3 shows the results of these FM regressions. As can be seen, the coefficient for the constant is similar between the regressions of the climate variables. That implies that the systematic risk of these tests is similar. The same can be observed after the two regressions that incorporate the Newey-West Standard Errors (NW SE), which act as a correction for autocorrelation. However, the significance of their systematic risk differs greatly, and it is even significant in NW SE-2. In addition, the number of significant variables increases sharply as more lags are added. Only in the case of the carbon premium (CARP) does the climate variable also appear to be significant. Furthermore, it seems that the market value becomes significant in the case of emission intensity based on the results of EIP and CLRP. However, no further pattern can be observed among the climate variables.

Table 3: Results of the Fama-Macbeth (FM) regression

Variable	Coefficient	p-value	p-value (NW SE)-1	p-value (NW SE)-2
$\beta_{, t-1}$	-9.39e-18	.237	.302	.235
$\ln(ME)_{t-1}$	-4.09e-18	.339	.394	.293
$\ln(BME)_{t-1}$	1.27e-17	.014*	.006*	.002*
$\ln(CARP)_{t-1}$	-5.27e-18	.075**	.105***	.035*
Constant	0.0059	.192	.233	.102***
Obs.	9387			
$\beta_{, t-1}$	-1.69e-17	.199	.232	.228
$\ln(ME)_{t-1}$	-8.65e-18	.159	.070**	.019*
$\ln(BME)_{t-1}$	3.15e-18	.415	.280	.251
$\ln(EIP)_{t-1}$	-3.06e-18	.334	.359	.332
Constant	0.0059	.192	.233	.102***
Obs.	9387			
β_{t-1}	-2.17e-17	.064**	.123***	.109***
$\ln(ME)_{t-1}$	-4.50e-18	.342	.222	.096**
$\ln(BME)_{t-1}$	-1.49e-18	.738	.744	.726
$\ln(CLRP)_{t-1}$	-1.56e-18	.708	.723	.724
Constant	0.0059	.192	.233	.102***
Obs.	9363			

The cross-sectional means of the returns of individual common stocks are regressed on variables hypothesized to explain the expected returns using time-series. All NASDAQ common stocks that have reported their carbon emissions in 2008 have been used in this regression. This table contains the results of this for January 2008 to January 2019. CARP, EIP and CLRP (x=0.5) have been used as the climate variables.
The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables.
The stars refer to the significance level (*P<0.05, **P<0.10, ***P<0.15). Significance is determined by both a regular p-value and two p-values after applying the Newey-West standard errors (NW SE). The optimal number of lags was determined using ivreg2-regression for two date variables. (1) represents a standard error with 18 lags and (2) 37 lags.

In the case of CLRP, the significance might be influenced by the chosen weighting of the underlying variables. To investigate this, it was decided to look at regressions with x=0.75 and x=0.25, respectively. As Table 4 shows, this adjustment of weights causes a large shift in the coefficients and their significance. However, the significance of the climate risk premium remains insignificant. Further research may be able to calculate an optimal value for this which might be significant, with or without the other variables.

Table 4: Results of the Fama-Macbeth (FM) regression: CLRP with x=0.25 and x=0.75

	Variable	**Coefficient**	**p-value**	**p-value (NW SE)-1**	**p-value (NW SE)-2**
(1)	$\beta_{, t-1}$	-3.61e-18	.682	.616	.603
	$\ln(ME)_{t-1}$	1.82e-18	.450	.401	.403
	$\ln(BME)_{t-1}$	-2.72e-18	.338	.335	.394
	$\ln(CLRP025)_{t-1}$	1.64e-18	.585	.569	.582
	Constant	.0059	.192	.233	.102***
	Obs.	9363			
(2)	$\beta_{, t-1}$	-4.57e-18	.670	.662	.601
	$\ln(ME)_{t-1}$	3.63e-18	.725	.687	.626
	$\ln(BME)_{t-1}$	-3.63e-18	.611	.646	.517
	$\ln(CLRP075)_{t-1}$	1.89e-18	1.000	1.000	1.000
	Constant	.0059	.192	.233	.102***
	Obs.	9363			

The cross-sectional means of the returns of individual common stocks are regressed on variables hypothesized to explain the expected returns using time-series. All NASDAQ common stocks that have reported their carbon emissions in 2008 have been used in this regression. This table contains the results of this regression for January 2008 to January 2019. CLRP has been used as the climate variable. The specific weighted variables are displayed in the following manner: (1) x=0.25; (2) x=0.75.

The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables.

The stars refer to the significance level (*P<0.05, **P<0.10, ***P<0.15). Significance is determined by both a regular p-value and two p-values after applying the Newey-West standard errors (NW SE). The optimal number of lags was determined using ivreg2-regression for two date variables. (1) represents a standard error with 18 lags and (2) 37 lags.

As mentioned in the introduction of this chapter, there is a disparity between the minima and maxima of certain variables resulting in a large standard deviation, in particular for ME and BME. This effect remains present even after the natural logarithms for these specific variables are used. To check whether these outliers give a distorted picture, ME, BME and a combination of both have been winsorized at 2.5% (see Appendix III). The combination of both the ME- and BME-winsorize leads to a significant climate variable for the carbon premium (CARP). Also, for EIP and CLRP there are large differences in both the coefficients and the significance. EIP is even significant after winsorizing BME, and the same is true for CLRP after winsorizing ME. This shows that those outliers strongly influence both the coefficients and their significance. In contrast to the other results, it even seems that beta is significant as a result when using winsorize for CLRP. Further in-depth research may reveal whether the distortion caused by outliers also applies to larger samples and other situations.

6. Conclusion

Climate change will eventually lead to more transitory risk such as regulatory risk, physical risks such as (extreme) weather and rising temperatures and supplier risk representing the inability among suppliers to adapt to climate change. Since investors base their sentiment on recent events (De Bondt, 1993), the risk of climate change is likely to be prized if one experiences the immediate and recent impacts of it. In addition, the value of organizations is severely influenced by popular valuation methods, (social) media, and financial advisors (Shiller, 1990). Since it is difficult to determine how an organization performs in the environmental field or to measure this against a specific standard, this can lead to psychological tendencies such as a focus on the short term. This can result in phenomena, such as greenwashing, that do not benefit the adoption of sustainable operations. By disclosing emission data and having it checked by third parties, it will be become more difficult to deceive stakeholders. Currently it seems that there mainly is a climate premium in certain intensive emission sectors. However, several studies have shown that emissions are increasingly being priced elsewhere. To uncover whether climate risk influences asset pricing within the NASDAQ between 2008 and 2019, multiple Fama-Macbeth (FM) regressions have been performed. These regressions include climate risk premiums and the common risk factors as described by Fama and French (1993). The results show that systematic risk is similar between the various regressions, while the significance differs among the climate variables. It is found that beta is significant for the climate premium (CLRP), and thus it is not ruled out that market risk is priced. In case of the size effect, smaller firms only seem to earn a significant higher return than larger firms after correcting for autocorrelation using Newey-West Standard Errors (NW SE). Further, only the carbon risk premium (CARP) is significant in the original model. Therefore, these untouched data seem to correlate with Bolton and Kacperczyka (2019), who found that carbon emissions (CARP) have a significant positive effect on stock returns, while emission intensity (EIP) does not. However, after applying winsorize, CLRP and EIP are also significant. For CLRP, this insignificance is influenced by the chosen weights of the underlying variables. In general, it can be observed that the results are sensitive to adjustments. Therefore, this research does not lead to conclusive evidence that the addition of a climate risk premium provides more information about the valuation of companies.

7. Recommendations

Further research should include the formation of portfolios based on the climate risk premiums, since Fama & Macbeth's (1973) assumption of true betas influences the efficiency and consistency of the resulting estimates. In addition, it is questionable whether market value is a good representation of a firm's size. Ciliberti et al. (2017) argued that the average daily volume of transactions is a better alternative, since market capitalization instigates biases, which might be caused by the "super-sized" firms in the US. Additionally, missing values seem to be more prevalent among smaller companies. This seems to be in line with Matsumura et al. (2014), who found that organizations that do not report emissions are usually smaller and less profitable. Going forward, this could be remedied by gathering more data from other markets than the NASDAQ or by imputing these missing values. Further, it is also striking that CO2 emissions are reported more often as we get closer to the present. This can possibly be explained by the increasing pressure from stakeholders or by the increasing awareness regarding global warming. Thus, it might be relevant to use a more recent timeframe to obtain more reliable results. Even if companies report their CO2 emissions, the question is to what extent they are honest about their CO2 emissions. As mentioned before, it is not mandatory in America to report on this when emitting less than 25,000 metric tons. This paper has attempted to counter this by adding an emissions score to the climate premium. However, scoring commitment and effectiveness in reducing environmental emission is subject to error-prone assessments. Reuters cannot look behind the scenes and will therefore have to base their score on imperfect information. Therefore, stricter regulation and standardization could be if value to support the energy transition.

Appendix I: Informal Tests (Continued)

Table I shows the detailed description of the panel data. Only the filtered variables are included that will also be included in the FM regression.

Table I: Panel data descriptive statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
ER	Overall	0.0058	0.0503	-0.2052	0.1928	N = 25417
	Between		0.0050	-0.0345	0.0188	n = 232
	Within		0.0503	-0.2084	0.2012	T-bar = 109.556
β	Overall	1.2967	0.6645	-2.1246	5.5228	N = 24250
	Between		0.5742	-0.5783	3.6249	n = 227
	Within		0.3818	-1.2269	4.7851	T-bar = 106.828
ln(ME)	Overall	8.6207	1.7070	3.2171	13.8863	N = 19921
	Between		1.6179	5.2062	13.2555	n = 190
	Within		0.5924	3.4887	10.7695	T-bar = 104.847
ln(BME)	Overall	-1.116	0.8321	-4.7730	3.1700	N = 19344
	Between		0.7332	-3.2605	1.0952	n = 190
	Within		0.4403	-4.2043	0.9586	T-bar = 101.811
ln(CARP)	Overall	12.5096	2.3326	-2.2073	18.8141	N = 25417
	Between		2.5534	-2.2073	18.5709	n = 232
	Within		0.3377	9.7782	14.5027	T-bar = 64.9029
ln(EIP)	Overall	3.7223	1.8440	-8.6485	9.2363	N = 11096
	Between		1.9991	-8.6485	8.9318	n = 172
	Within		0.3555	1.1379	5.6330	T-bar = 64.5116
ln(CLRP)	Overall	4.2309	1.1195	1.6771	8.5507	N = 11072
	Between		1.0984	2.3140	8.2474	n = 172
	Within		0.2079	3.1680	5.3176	T-bar = 64.3721

The control variables will be examined for relevance by summarizing their panel data characteristics. CARP, EIP and CLRP (x=0.5) have been used as the climate variables. From left to right: the mean, standard deviation (std. dev.), minimum (min), maximum (max) and the observations (obs).

The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables.

Overall refers to the overall variation; Between refers to between variation and describes the variation between IDs. The unit-level averages are calculated, after which its standard deviation is calculated; Within refers to within variation and describes the variation within an ID.

N refers to the total observations (IDs * months); n refers to the total IDs used; T-bar refers to the total months used.

Appendix II: Application of Winsorize

Table II to IV look at the results after applying the winsorize operation. In Table II the addition of BME both individually and in combination leads to the beta being significant. In Table III it is striking that the winsorizing of BME leads to the climate variable EIP being significant. However, it can be said that it is difficult to observe or confirm patterns. In any case, these interventions lead to major changes in the results.

Table II: Results of the Fama-Macbeth (FM) regression: winsorize ME and BME for 2.5% - CARP

	Variable	Coefficient	p-value	p-value (NW SE)-1	p-value (NW SE)-2
	$\beta_{, t-1}$	-1.02e-17	.165	.160	.158
(1)	$\ln(MEW)_{t-1}$	-2.61e-18	.638	.678	.593
	$\ln(BME)_{t-1}$	2.53e-17	.606	.665	.692
	$\ln(CARP)_{t-1}$	6.50e-19	.832	.720	.686
	Constant	0.0059	.192	.233	.102***
	Obs.	9387			
	$\beta_{, t-1}$	-1.79e-17**	.068**	.206	.144***
(2)	$\ln(ME)_{t-1}$	-2.33e-18	.555	.610	.460
	$\ln(BMEW)_{t-1}$	1.14e-17*	.021*	.001*	.000*
	$\ln(CARP)_{t-1}$	-1.41e-18	.605	.618	.556
	Constant	0.0059	.192	.233	.102***
	Obs.	9357			
	$\beta_{, t-1}$	-1.19e-17***	.132***	.047*	.051**
(3)	$\ln(MEW)_{t-1}$	-1.19e-17*	.035*	.044*	.020*
	$\ln(BMEW)_{t-1}$	3.55e-18	.467	.453	.434
	$\ln(CARP)_{t-1}$	2.24e-18	.378	.119***	.076**
	Constant	0.0059	.192	.233	.102***
	Obs.	9363			

The cross-sectional means of the returns of individual common stocks are regressed on variables hypothesized to explain the expected returns using time-series. All NASDAQ common stocks that have reported their carbon emissions in 2008 have been used in this regression. This table contains the results for the 2.5%-winsorized variables for January 2008 to January 2019. CARP has been used as the climate variable. The specific winsorized variables are displayed in the following manner: (1) the winsorized ME; (2) the winsorized BME; (3) combination of the winsorized ME and BME.

The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables. ln(MEW) and ln(BMEW) are the variables that have been winsorized for 2.5% at both ends.

The stars refer to the significance level (*P<0.05, **P<0.10, ***P<0.15). Significance is determined by both a regular p-value and two p-values after applying the Newey-West standard errors (NW SE). The optimal number of lags was determined using ivreg2-regression for two date variables. (1) represents a standard error with 18 lags and (2) 37 lags.

Table III: Results of the Fama-Macbeth (FM) regression: winsorize ME and BME for 2.5% - EIP

	Variable	Coefficient	p-value	p-value (NW SE)-1	p-value (NW SE)-2
	$\beta_{,\,t-1}$	1.62e-17**	.102***	.300	.343
(1)	$\ln(MEW)_{t-1}$	7.50e-18	.177	.237	.314
	$\ln(BME)_{t-1}$	1.91e-18	.593	.455	.391
	$\ln(EIP)_{t-1}$	4.91e-18	.146***	.274	.314
	Constant	0.0059	.192	.233	.102***
	Obs.	9363			
	$\beta_{,\,t-1}$	-1.10e-17***	.124***	.115***	.047*
(2)	$\ln(ME)_{t-1}$	-1.84e-18	.73	.594	.499
	$\ln(BMEW)_{t-1}$	1.90e-18	.619	.466	.305
	$\ln(EIP)_{t-1}$	-4.60e-18**	.079**	.056**	.043*
	Constant	0.0059	.192	.233	.102***
	Obs.	9363			
	$\beta_{,\,t-1}$	-6.90e-19	.933	.946	.937
(3)	$\ln(MEW)_{t-1}$	7.49e-18***	.148***	.152	.227
	$\ln(BMEW)_{t-1}$	2.23e-18	.528	.383	.288
	$\ln(EIP)_{t-1}$	9.34e-18	.692	.673	.670
	Constant	0.0059	.192	.233	.102***
	Obs.	9363			

The cross-sectional means of the returns of individual common stocks are regressed on variables hypothesized to explain the expected returns using time-series. All NASDAQ common stocks that have reported their carbon emissions in 2008 have been used in this regression. This table contains the results for the 2.5%-winsorized variables for January 2008 to January 2019. EIP has been used as the climate variable. The specific winsorized variables are displayed in the following manner: (1) the winsorized ME; (2) the winsorized BME; (3) combination of the winsorized ME and BME.

The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables. ln(MEW) and ln(BMEW) are the variables that have been winsorized for 2.5% at both ends.

The stars refer to the significance level (*P<0.05, **P<0.10, ***P<0.15). Significance is determined by both a regular p-value and two p-values after applying the Newey-West standard errors (NW SE). The optimal number of lags was determined using ivreg2-regression for two date variables. (1) represents a standard error with 18 lags and (2) 37 lags.

Table IV: Results of the Fama-Macbeth (FM) regression: winsorize ME and BME for 2.5% - CLRP

	Variable	Coefficient	p-value	p-value (NW SE)-1	p-value (NW SE)-2
(1)	$\beta_{, t-1}$	2.00e-17*	.015*	.141***	.198
	$\ln(MEW)_{t-1}$	2.68e-18	.572	.419	.372
	$\ln(BME)_{t-1}$	-8.44e-18**	.061**	.056**	.069**
	$\ln(CLRP)_{t-1}$	2.08e-18	.647	.639	.676
	Constant	0.0059	.192	.233	.102***
	Obs.	9363			
(2)	$\beta_{, t-1}$	-1.66e-17***	.109***	.116**	.080**
	$\ln(ME)_{t-1}$	-1.93e-18	.69	.666	.641
	$\ln(BMEW)_{t-1}$	-3.04e-18	.532	.536	.561
	$\ln(CLRP)_{t-1}$	-6.60e-19	.887	.866	.789
	Constant	0.0059	.192	.233	.102***
	Obs.	9363			
(3)	$\beta_{, t-1}$	2.47e-17*	.002*	.060**	.086**
	$\ln(MEW)_{t-1}$	1.26e-18	.786	.683	.567
	$\ln(BMEW)_{t-1}$	-3.26e-18	.479	.411	.282
	$\ln(CLRP)_{t-1}$	1.84e-18	.715	.670	.664
	Constant	0.0059	.192	.233	.102***
	Obs.	9363			

The cross-sectional means of the returns of individual common stocks are regressed on variables hypothesized to explain the expected returns using time-series. All NASDAQ common stocks that have reported their carbon emissions in 2008 have been used in this regression. This table contains the results for the 2.5%-winsorized variables for January 2008 to January 2019. CLRP (x=0.5) has been used as the climate variable. The specific winsorized variables are displayed in the following manner: (1) the winsorized ME; (2) the winsorized BME; (3) combination of the winsorized ME and BME.

The average return is the time-series average of the monthly equal-weighted stock returns, in percent. Beta is the time-series average of the calculated betas using the monthly equal-weighted stock returns. ln(ME), ln(BME), ln(CARP), ln(EIP) and ln(CLRP) are the time-series averages of the monthly average values of these variables. ln(MEW) and ln(BMEW) are the variables that have been winsorized for 2.5% at both ends.

The stars refer to the significance level (*P<0.05, **P<0.10, ***P<0.15). Significance is determined by both a regular p-value and two p-values after applying the Newey-West standard errors (NW SE). The optimal number of lags was determined using ivreg2-regression for two date variables. (1) represents a standard error with 18 lags and (2) 37 lags.

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