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Abstract

Why do for-profit firms take voluntary steps to improve the environment? Brand appeal to green consumers or investors, the ability to influence or avoid regulation, or the experience gained for future regulation, have all been suggested as possible reasons. The empirical evidence is decidedly mixed. This paper uses 19 years of monthly stock price returns to examine the profitability of participation in the world's largest voluntary greenhouse gas mitigation program: the Chicago Climate Exchange. After controlling for systemic market risk as well as industry-specific shocks, we find no statistically significant impact of announcing to join CCX on excess returns. However, the market appeared to be sensitive to changes in abatement costs implied by CCX membership. Most strikingly, the progress of proposed greenhouse gas legislation (the Waxman-Markey bill) had a positive impact on excess returns for CCX member firms, suggesting that the most profitable incentive for firms to join CCX is to prepare for future regulation. Our results imply that relying on voluntary approaches alone to combat climate change may not be enough.

JEL-Code: Q530, Q540.

Keywords: voluntary action, firm performance, climate change, permit markets.

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1 Introduction

The seductive idea of voluntary environmental action by firms has long held the imagination of the public and of politicians. If companies can reduce emissions of their own accord, the thinking goes, then government regulation will not be needed and consumers can consume guilt-free. There is an ongoing debate about whether this virtuous cycle of profitability and environmental responsibility exists. The debate is relevant because if voluntary approaches are successful, they can be used to relax or replace regulation, providing with firms the maximum amount of flexibility (Alberini and Segerson, 2002; Khanna, 2001).

US Climate policy forms a particularly important example of whether voluntary approaches can obviate regulation. At the time of this writing, the USA is the only industrialized country in the world that does not regulate greenhouse gas (GHG) emissions on a national level but instead relies on voluntary firm action.[1]

There are theoretical arguments both in favor and against the profitability of voluntary spending on environmental performance, and a growing empirical literature that examines the relationship between environmental and financial performance. Our paper contributes to this literature by studying the effect of membership in the Chicago Climate Exchange (CCX), the world's largest voluntary GHG cap-and-trade market.

CCX was established in 2003 to provide a formal market for firms to voluntarily, but verifiably, reduce GHG emissions. In contrast to other voluntary GHG programs, CCX includes both strict provisions and standards for the auditing of emissions reductions, and a formal market for the purchase of abatement credits. In that sense, the CCX is

[1] Although the EPA changed its policy and now includes CO_2 as an air pollutant, there are no federal standards, taxes or other regulation that puts a price on CO_2 emissions. Regional and local initiatives exist, however, such as the Regional Greenhouse Gas Initiative (RGGI) and California's Global Warming Solutions Act (AB 32).

the closest voluntary equivalent to a mandatory carbon market, the policy instrument of choice in most countries to reduce GHG emissions of industry. To our knowledge, this is the first attempt to examine the effect of CCX membership on firm performance. Our findings therefore have an immediate relevance for environmental regulation and policy.

The empirical literature about the profitability of voluntary environmental spending can be separated into two broad groups. The first compares financial performance of a ”green” portfolio with that of other portfolios over time, usually based on some environmental performance index.[2] The main challenges with this method are unobserved heterogeneity (Telle, 2006) and the identification of the effect of voluntary action. Even if an unbiased estimator of the effect is found, the direction of causation cannot be resolved: Are green firms more profitable because they are green, or are they green because they can afford to be?

The second thread of literature comprises studies that measure the effect of a discrete event in time (e.g. the discharge of toxic waste) on firm profits.[3] Studies of this type offer an advantage in identification and causation inference relative to the long-term comparison of portfolios, but suffer from the limitation that only environmental performance that is ”time stamped” can be investigated.

Our paper is in the spirit of an event study but also contains a long-term component. Our primary focus is on estimating the effect of discrete events on firm profits, such as announcements to join CCX and political information relevant for this market, particularly the passing ’Waxman-Markey’ bill in the US House of Representatives, which arguably raised the likelihood of a mandatory cap-and-trade system being instituted in

[2]E. g., Derwall et al. (2005); Dowell et al. (2000); Hart and Ahuja (1996); King and Lenox (2001); Russo and Fouts (1997); Yamashita et al. (1999); Ziegler et al. (2007).

[3]E. g. Dasgupta et al. (2001); Filbeck and Gorman (2004); Fisher-Vanden and Thorburn (1998); Gupta and Goldar (2005); Khanna et al. (1998); Konar and Cohen (1997, 2001); Muoghalu et al. (1995).

the medium term. We additionally include long-term information about marginal abatement costs implied by CCX membership, which we proxy with the CCX carbon price. Our sample covers 18 years of monthly data, a time-scale common to portfolio-type studies. By combining elements from both approaches we are able to identify the effect of membership while incorporating long-term information about marginal abatement costs and excess returns of CCX members compared to their industry rivals that chose not to participate.

We employ an extension of the Capital Asset Pricing Model (CAPM) to explore firm performance, as measured through excess share returns of US equities. We adjust CCX member returns for overall market risk, as well as for excess returns of industry rivals defined on the 4-digit SIC level, and include time dummies to mark discrete events. We find no significant effect of joining CCX, but member firm returns are negatively correlated with CCX carbon price changes over time, indicating that increased abatement costs have a negative impact on returns. Importantly, the passing of the Waxman-Markey climate bill led to positive and statistically significant excess returns for CCX member firms, implying that firms who had gained experience in the voluntary were believed to be better prepared for the possibly imminent mandatory market (the mandatory market has in fact not materialized to date).

The paper proceeds as follows. In the next section we provide background on the Chicago Climate Exchange, as well as a review of relevant literature. Section 3 presents our methodology and describes the data. In Section 4, we report and discuss our results, and Section 5 concludes.

2 Background

At the time of the Kyoto Protocol under the United Nations Framework Convention on Climate Change, the U.S. was the largest greenhouse gas emitter in the world, and therefore the most prominent non-participant. While that process ultimately resulted in a market for tradable carbon offsets in Europe, the lack of an agreement or legislation in the US meant that emission of greenhouse gases remained unregulated. In 2003, the Chicago Climate Exchange opened a trading exchange for voluntary greenhouse gas emissions reductions and offsets in North America and Brazil. CCX has been followed by a host of nonprofit and for-profit companies that seek to generate, finance, sell, and market emissions reductions and offsets.[4]

2.1 The Chicago Climate Exchange (CCX)

The Chicago Climate Exchange is by far the largest voluntary GHG market to date. Under CCX, member firms pay an annual membership fee and agree to voluntarily reduce their emissions of greenhouse gases. The fee ranges from $1,000 to $35,000 per year depending on the size of the firm and the type of membership. Although participation is voluntary, compliance with emission reduction objectives becomes legally binding once a member joins.

All emission baselines and annual emission reports receive independent verification.[5] Members commit to reduce their emissions by a fixed amount below the established baseline level. Firms who reduce beyond their target receive surplus allowances

[4] A review of the CCX and other voluntary programs can be found in Kollmuss et al. (2008).

[5] There are 3 classes of membership on CCX: Members, participant members, and associate members. Participant members establish a registry and get their emissions verified, but don't make any commitment on emissions reduction. Associate members have negligible direct emissions, but pledge to report and fully offset their indirect emissions. We focus here solely on full members.

to sell or bank; those who do not meet the targets comply by purchasing emissions allowances, called 'Carbon Financial Instrument' (CFI) contracts, which represent 100 metric tons of CO_2 equivalent (CO_2e). CFI contracts consist of exchanged allowances and offset credits. Offset projects are aggregated if less than 10,000 metric tonnes of CO_2e. A history of the CCX carbon price, the market price for allowances and the effective marginal abatement cost member firms, is given in Figure 1 below.

There are two distinct phases to the CCX membership program. During phase 1, from 2003 to 2006, members agreed to cut their emissions by 1% each year below their baseline average (1998 to 2001), thereby by achieving a reduction of 4% by the end of the fourth year . During phase 2, from 2007 to 2010, members have to further cut their annual emissions to achieve the target of 6% by 2010 . New members who did not participate in the first phase phase therefore had to reduce emissions by 1.5% per year to reach the new goal.

Qualifying projects for CCX can be located in any country except those listed in Annex 1 of the Kyoto protocol. However, projects developed under Kyoto's Clean Development Mechanisms (carried out in non-Annex 1 countries) can be traded under CCX, provided the project is approved.

2.2 Related literature

The literature about voluntary investments revolves around the question of whether non-mandated investments in environmental performance can be beneficial to firms and shareholders. Proposed answers range from a flat-out rejection of voluntary environmental investment (Friedman, 1970) to a belief that such investments will not only pay for themselves, but will generate a profit in most cases (Porter and van der Linde, 1995).

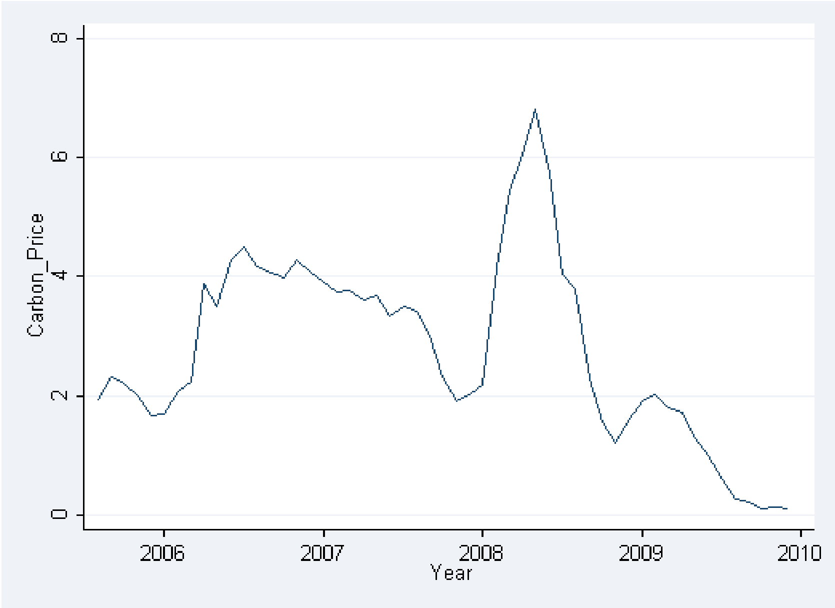

Figure 1: CCX carbon price (in US $ per t CO_2, 2004-2009)

A general discussion about when corporate social responsibility (CSR), of which voluntary environmental action constitutes a subgroup, can be found in Heal (2005). Khanna (2001) categorizes existing voluntary approaches and gives an excellent overview of the literature about firms' incentives to participate.

Arora and Gangopadhyay (1995) develop a theoretical model that leads firms to over-comply with environmental regulation. In their model, consumers all have green preferences but varying income levels, leading to a market segmentation based on willingness and ability to pay. An important assumption in the model is that firms are able to effectively and credibly communicate the "greenness" embedded in their product, a point also emphasized by Reinhardt (1999). More generally, voluntary green spending can be viewed as a form of advertising or marketing, allowing the firm to gain market share when environmental quality is valued by consumers. In an econometric study, Anton et al. (2004) find that consumer pressure is the dominant factor in explaining firm voluntary environmental investment.

Another rationale for voluntary environmental improvement comes from the investor side. Heinkel et al. (2001) construct a model where a subset of investors have green preferences and refuse to hold stock from ”dirty” firms. If the pool of green investors is large enough, equity from green firms will sell at a premium, leading to lower capital costs for these firms.

Nehrt (1996) examines timing and intensity of environmental investment, and finds that first movers profit more from investment. These ideas of getting a head start and forcing rivals to follow suit are closely related to the literature about ”raising rivals' costs”, where a dominant firms seeks to gain market share at the expense of its rivals by increasing (everyone's) costs (Hart and Tirole, 1990; Krattenmaker and Salop, 1986; Salop and Scheffman, 1983, 1987). This is a profitable strategy if the dominant firm's average cost increase is less than the marginal cost increase of its rivals. The cost increase can take many forms, including triggering new standards by over-complying with current regulation.

Another important advantage of voluntary investment is the experience gained in abatement, which may make it less costly to comply if regulation is later imposed. Klassen and McLaughlin (1996) propose several pathways for voluntary environmental investment, including the establishment of industry-wide guidelines. If these guidelines become regulation it will presumably be closer to the firm's needs than exogenously imposed rule. According to such thinking, firms may over-comply with environmental standards not to trigger, but to prevent, shape and/or prepare for future regulation. Khanna (2001) provides an extended discussion on this point. Our results suggest that this pathway could play an important role in voluntary participation in CCX.

Lastly, there may be strategic reasons to engage in voluntary action, because long-term firm profits depend on a range of different stakeholders, not only including consumers and investors but also workers, labor unions, municipalities, as well as different levels of government. Even though voluntary action may be costly in the short run, improved relations with stakeholders may more than recover the costs in the long-run (Barnett and Salomon, 2006; McWilliams et al., 2006).

Regardless of the particular motivation to participate in voluntary action, the underlying idea is always that the benefits outweigh the costs, with the consequence that voluntary action is profitable. This is the starting point for empirical studies, which aim to identify a link between environmental and financial performance. Most empirical papers have focused on local pollutants such as toxic waste. Konar and Cohen (1997), for instance, examines the efficacy of the Toxic Releases Inventory (TRI), a database which tracks releases of toxic pollutants, on stock market performance, and finds that firms with large releases were punished by the market. Other empirical papers find a positive relationship between environmental and financial performance[6] Dowell et al. (2000) find that multinational firms that adhere to a single stringent environmental standard worldwide, rather than adopting respective local standards, have a higher market valuation as measured by Tobin's q.

Other papers using local emissions data do not find a relationship between environmental and market performance (Filbeck and Gorman, 2004; King and Lenox, 2001; Telle, 2006). Derwall et al. (2005) provide evidence of substantially higher returns from a portfolio of 'socially responsible' firms from 1995-2003, but struggle with establishing causation: it could be the case that better-performing firms subsequently polish their social and environmental credentials as absolution, rather than as a means to prosper.

[6]see, for example, Hart and Ahuja (1996); Khanna et al. (1998); King and Lenox (2002); Konar and Cohen (2001); Muoghalu et al. (1995); Russo and Fouts (1997).

Voluntary emission reduction of a global stock pollutant (e.g. our case of voluntary GHG abatement) is different to reducing local pollution in several important ways. On the one hand, GHG emissions of any single firm are unlikely to yield a visible environmental impact. This means that consumers and investors have to be informed about climate change (and a firm's contribution of GHG) in order to prefer, and have increased willingness to pay for, products or equity in the GHG-reducing firm vis-à-vis their competitors. On the other hand, the global nature of GHG emissions can potentially send positive signals far beyond a local region. For example, Japanese consumers may value a reduction of GHG emissions by a US firm as much as American consumers, which is presumably not the case for a reduction in local pollution. Many of the CCX member firms are globally traded firms, and some also sell their products on the global market.

Oberndorfer (2009) finds that excess returns of EU electricity generators are positively related to the market price of carbon. Although the EU Emissions Trading Scheme is a mandatory market and therefore the question of the costs and participation are very different, to the context of voluntary action, there is a close relationship between Oberndorfer's paper and our study because of the focus on the link between firm profits and carbon prices, as well as the modeling approach.[7] The positive correlation between EU carbon prices and firms' returns may at first seem surprising, given that higher marginal abatement costs imply higher overall costs and thus lower profits. However, due to a combination of cost pass-through to consumers and a very generous free allocation policy, regulated firms actually received a windfall from the institution of the carbon market (Hintermann, 2011; Sijm et al., 2006). Furthermore, it is not clear that the EUA carbon price during that time actually reflected marginal abatement costs (Hintermann, 2010).

[7]Oberndorfer uses a CAPM that controls for market risk and other determinants such as fuel and electricity prices. The nature of the mandatory market does not allow for controlling for industry rival returns, because all rivals within the same SIC code are covered by the market as well.

Jacobs et al. (2010) find mixed evidence of voluntary action on firm performance: announcements of philanthropic gifts for environmental causes or ISO environmental standards certifications are associated with signicant positive market reaction, while voluntary emission produce a negative effect. While discrete actions may have some effect on the market valuation of a firm, simple sharing of information may not. Mallory (2009) examines the market performance of firms which voluntarily disclose their carbon emissions. Using a propensity score matching technique, she finds no statistical difference with firms that do not disclose emissions.

Amongst the literature that examines voluntary GHG action by firms, two papers are closely related to ours in terms of content and methodology. Fisher-Vanden and Thorburn (1998) carry out an event study among US firms that joined the voluntary programs Climate Leaders and Ceres, both of which aim to reduce GHG emissions. Matching daily stock data with firm announcements to join either of these programs, they find that announcement returns (measured as cumulative excess returns) were negative, both in absolute terms as well as relative to their industry rivals. When firms subsequently announced an emissions reduction goal, excess returns declined even more. Their results varied somewhat by industry as well as by the book-to-market ratio, but they conclude that for the firms in their sample, voluntary environmental action was not profitable.

Ziegler et al. (2009) compare the average stock performance of portfolios of US and European stock that differ in their climate-related policies, using a very similar methodology as our paper. Action taken by firms, such as announcing emission-reduction goals, or press releases relating to climate change, were seen to reduce average returns over the sample period (2001-2006) in all markets. While this was true for the US stock market over the entire sample period, in Europe the effect changed sign in 2003, when the EU adopted a more forceful approach to combating climate change.

3 Model and data

3.1 Model

To the extent that the stock market correctly prices securities, returns constitute a measure for (a change in) expected future profitability. Our goal is to identify the effect of joining CCX on returns in the spirit of an event study, while controlling for continuous variables such as abatement costs. The main difficulty is that stock returns are driven by a host of things, both observable and unobservable. In order to identify the impact of CCX membership we have to control for a series of factors.

We start with the Capital Asset Pricing Model (CAPM) originally developed by Sharpe (1964) and Lintner (1965); for a review of its history, see Fama and French (2004). According to the CAPM, risk-adjusted excess returns from holding a particular security are equal to overall market returns, or

$$\frac{E[r_i] - r_f}{\beta_i} = E[r_m] - r_f \qquad with \quad \beta_i \equiv \frac{Cov[R_i, R_m]}{Var[R_m]} \tag{1}$$

where $E[r_i]$ is the expected return on asset i (which can be a portfolio or an individual security, if the latter is to be added to a well-diversified portfolio), r_f is the risk-free rate of interest, and $E[r_m]$ is the expected rate of return of the stock market as a whole. The difference between the return from a risky asset and the risk-free rate of interest is known as the *excess return* or the *risk premium*.

The adjustment factor β_i measures the sensitivity of expected excess returns for a particular security to expected excess returns of the market. In particular, it adjusts for *market* or *systemic* risk, which is the part of overall risk that cannot be diversified away by combining a sufficiently large number of stocks into one portfolio. In the original

CAPM, this is the only variable (or ”factor”) that determines the average return of an asset. Because of this, it is also known as the 1-factor model and usually expressed by restating (1) in terms of excess returns:

$$E[r_i] - r_f = \beta_i(E[r_m] - r_f)$$

The associated empirical regression equation is derived by adding a time dimension, a constant, and replacing the expectations with an error term:

$$r_{it} - r_{ft} = \alpha_i + \beta_i(r_{mt} - r_{ft}) + \epsilon_{it} \tag{2}$$
$$E[\epsilon_{it}] = 0; \quad Var[\epsilon_{it}] = \sigma^2$$

The constant is known as Jensen’s alpha. Since a nonzero value for α_i indicates an over- or undervaluation of an asset which in an efficient market should be arbitraged away, the null hypothesis is always that $\alpha_i = 0$. The adjustment factor is unity for the market overall by construction. For an asset with a higher systemic risk than the market overall, $\beta_i > 1$, and vice versa.

To address some of the anomalies observed in stock markets (e.g. Banz (1981); De Bondt and Thaler (1985)), Fama and French (1992, 1993) extended the 1-factor model to adjust for price effects related to firm size and value. Carhart (1997); Jegadeesh and Titman (1993, 2001); Rouwenhorst (1998) added a fourth factor in order to address momentum trading strategies, leading to the following specification, sometimes called the ”4-factor” model:

$$r_{it} - r_{ft} = \alpha_i + \beta_{i1}(r_{mt} - r_{ft} + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}MOM_t + \epsilon_{it} \tag{3}$$

The variable or factor SMB_t stands for small-minus-large and is computed as the difference between the returns of a portfolio comprising small firms minus that of a portfolio of large firm stock. HML_t (high-minus-low) refers to the valuation of a stock relative to company assets and is the return of a portfolio of stocks with a high book-to-market ratio (growth stocks) minus a portfolio of stock where book-to-market is low (blue chips). Finally, MOM_t is known as the momentum factor and is calculated as the difference between the return of a portfolio comprised of winning stocks minus and return of a portfolio of losing stock. These factors are calculated on average returns from 6 different portfolios, characterized by firm size (market equity or the value of outstanding shares) and firm book-to-market equity.[8] Data for SMB_t, HML_t and MOM_t for the US stock market are available from Kenneth French's online data library.[9]

The 4-factor model has gained wide acceptance in the financial community and is the most common asset pricing model in applied work (e.g. Bollen and Busse (2005); L'Her et al. (2004); Ziegler et al. (2009)).

Non-systemic or idiosyncratic asset risk can be diversified away by including a sufficient number of imperfectly correlated assets into a single portfolio and is thus not reflected in average security prices according to equations (2) and (3), even though firm- or industry-level shocks naturally affect individual asset returns. While this is not a problem to price average stock or portfolio returns, excluding all firm-specific information would make no sense for our purpose. We therefore apply (3) to individual stocks rather than a portfolio in our main model[10] and extend it in the following way:

[8] Book equity captures a firm's total assets minus liabilities and is defined as the value of stockholders' equity plus the value of deferred taxes and investment tax credit, minus the value of preferred stock.

[9] $http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html$

[10] For a balanced panel with NxT observations, forming cross-section averages per time period and regressing them on common market factors in a time series regression with T observation yields the same point estimates as regressing individual stock returns on the same factors. In (our) case of an unbalanced panel, the point estimates will slightly differ because the portfolio approach equally weights

First, we include a dummy that marks CCX membership. Since the market incorporates information as soon as it becomes available (whether it does so fully and/or immediately is a matter of some dispute in the empirical literature), we use firm announcements to join CCX rather than the actual joining dates. We also account for market exits by firms leaving the system at the end of Phase I in 2003. No member firm has exited the system during the (current) second phase.

Second, because the likelihood of regulation is one of the justifications for joining a voluntary emissions reduction program such as CCX, we are interested in using a regulatory expectations proxy in our data. We restrict our attention to federal legislation because that is the level at which minimum compliance standards are set in the United States.[11] We focus our attention on the Waxman-Markey bill (the 'American Clean Energy and Security Act'), which sought to limit the emission of greenhouse gases and establish an emissions-trading scheme. We add a dummy for active CCX membership for June 2009, the month when the Waxman-Markey bill was passed in the US House of Representatives. The bill established the ground for a federal mandated cap-and-trade system. Our hypothesis is that this should have raised investors' assessment of the probability that a mandatory federal cap-and-trade system would be instituted in the medium term. In such a system, previous CCX membership is viewed as an advantage because these firms already have market experience.[12]

time averages, whereas the individual stock regression gives equal weight to all observations, implying a greater weight for months with more data. The interpretation of α and $\beta_1, ..., \beta_4$ remains unchanged.

[11] California has the unique ability among states to set even more stringent environmental regulations than federal law specifies, but it must meet the minimum. Other states can then adopt the California variant if they prefer.

[12] Prospects for a federal cap-and-trade system increased suddenly with the passing of the Waxman-Markey bill, but they faded out very slowly. Climate legislation passed the U.S. House of Representatives, but faced a deepening recession and declining support in the Senate. On February 1, 2010, Reuters reported that the Obama White House dropped any projected revenue from carbon auctions. Later in the same year, the bill was effectively tabled in the Senate, and at the time of writing no federal cap-and-trade system seems likely to gather congressional support in the foreseeable future.

Third, we incorporate information about the costs of emissions abatement implied by CCX membership. We proxy these costs by using the CCX carbon price, which, according to permit trading theory, should be equal to marginal abatement costs.[13] Even though we don't have information about total compliance costs (which depend on the total emissions reduction goal committed to by a particular firm as well as infra-marginal costs), marginal abatement costs are a useful proxy since we work with first differences rather than levels. A change in marginal abatement costs translates to a change in overall compliance costs, which in turn implies lower profitability and thus lower excess returns, all else equal.[14]

Lastly, we include excess returns from industry rivals defined by 4-digit SIC code, which are not CCX members. This ensures that shocks affecting the industry but not the market overall are not confounded with the effect of membership, the Waxman-Markey bill or the carbon price. In other words, a positive coefficient on the dummy for joining CCX cannot be due to a positive shock on the industry level in the same month, because this is already accounted for in industry excess returns. Because the inclusion of industry-specific returns alters the magnitude and interpretation of the β's in (2-3), we present our results separately with and without them.[15]

We use monthly data for our analysis. The signal-to-noise ratio of daily returns is

[13]The fact that the program is voluntary does not change the basic price mechanism of a permit market. Firms will abate emissions rather than buying offsets as long as it is cheaper to do so, i.e. up to the point where marginal abatement costs equal the CCX permit price.

[14]If firms are able to pass on all of the compliance costs to consumers, profits do not have to decrease necessarily. Consider, however, that CCX membership is not very widespread, such that most firms' industry rivals do not face any GHG compliance costs at all. Under these circumstances it is doubtful that member firms can fully pass on their costs.

[15]The common variation between industry returns and overall market returns is excluded from the regression when estimating the coefficients, reducing the absolute value of β_1 far below unity; however, it would be wrong to conclude from this coefficient that the non-diversifiable risk stock of CCX member stocks is particularly low. Although β_1 still correctly adjusts asset returns for whole market returns, the relationship between its value and unity is lost due to the inclusion of industry returns.

often very low. If the noise is orthogonal to the effect of joining (as proper noise should be), then monthly data could potentially reveal what daily data cannot. Using monthly data also mitigates the problem of how quickly markets assimilate new information. Fully efficient markets should do so immediately, but in practice there is often a delay. Using daily excess returns on the day of the announcement, or perhaps the day plus the two following days, risks missing any delayed effect, which is captured almost certainly with a monthly approach.

The other side of the medal when using monthly data is that too many days may be included. If a small effect is averaged over an entire month, it may become so small as not to be detectable.

3.2 Econometric specification

Because the CAPM is specified in (proportional) first differences, i.e. returns, we have to either explicitly or implicitly take first differences of all variables that we include in the model. This leads to the following regression equation:

$$\begin{aligned} r_{it} - r_{ft} =& \alpha + \beta_1(r_{mt} - r_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t \\ & + \gamma_1 JOIN_{it} + \gamma_2 WAX_{it} \cdot M_{it} + \gamma_3 \Delta C_t \cdot M_{it} + \gamma_4 (r_{it}^{sic} - r_{ft}) + \epsilon_{it} \end{aligned} \tag{4}$$

We set $JOIN_{it}$ = 1 in the month of the announcement, as well as for the following month if the announcement occurred in the second half of the month. This ensures that enough time is included to capture any excess returns due to joining, even if markets react with some delay. At a minimum, 16 calendar days are included in the announcement dummy (if the announcement falls on the 15th of a month), and a maximum of 46 calendar days (if the announcement falls on the 16th). We further set $JOIN_{it}$ = -1 when a firm leaves the system, and zero otherwise; it can be thought of the first difference of a dummy that is 1 during membership and zero otherwise.

WAX_{it} is a dummy equal to 1 in June and July 2009, and zero otherwise, consistent with the first difference of a dummy that is zero before the bill was passed, and one afterwards. The variable $\Delta C_t = C_t - C_{t-1}$ refers to the first difference of the CCX carbon price, and $(r_{it}^{sic} - r_{ft})$ refers to excess returns of industry rivals on the 4-digit SIC level.

The membership dummy M_{it} is one for firms that are active CCX members at time t, and zero otherwise. Multiplying ΔC_t by M_{it} is necessary because firms that are not CCX members face no price on emissions. Interacting M_{it} with WAX_{it} measures the effect of the Waxman-Markey bill only on current members. We estimate eq. (4) by OLS.

The first-differencing is more than just a technical detail, but it reflects a fundamental assumption underlying the CAPM. If markets are efficient, they incorporate information immediately. Stock prices are forward-looking in the sense that they reflect the present value of the expected stream of future dividends, a measure which includes all future expected profits. If joining CCX makes a firm more profitable (e.g. due to higher sales, lower costs, or any other pathway discussed above), arbitrage mandates that asset prices increase immediately to fully incorporate the newly updated expectations. Prices will remain high, but *returns* should adjust only once, assuming that investors are fully informed. Therefore, including a dummy that marks active membership rather than entry and exit into (4), or including the carbon price level rather than first differences, would contradict the assumption of efficient markets.

3.3 Data

Our data consists of monthly stock prices taken from the Center for Research in Security Prices (CRSP) for the years 1991 - 2009. The CRSP is a database of daily and monthly stock prices for publicly-listed firms in the United States going back to 1925.[16] We calculate our dependent variable, monthly excess return, by subtracting the risk-free rate of interest (RF) from the monthly average stock prices. The risk-free rate of interest is captured by using the effective federal funds rate of interest.[17]

We gathered data on CCX membership from the CCX website, which publishes a directory of current and former members. To find the specific date when firms announced their decision to join, we used financial news outlets such as Reuters, Lexus-Nexus, environmental news wires, general web searches, as well as companies own news releases. We believe that the date of announcement is the best representative date of membership because the stock price would react from the announcement rather than from the individual (potentially unpublicized) actions that were taken as conditions of membership.

A total of 109 entities are listed as members on the CCX exchange, of which 55 are firms that are listed on a US stock market (NASDAQ, NYSE or AMEX). The majority of the nonlisted entities are cities, states and universities. We were able to identify an announcement date to join CCX for 34 of the listed firms. Table 1 contains descriptive statistics of our sample. The sample size for the market variables *MEXRET, RF, HML, SMB* and *MOM* reflects the number of months in our sample period.

The 34 firms in our sample contain 24 different 4-digit SIC codes. Member firms

[16] CRSP is maintained at the University of Chicago, and is frequently used as a source of data for financial studies. For more information, see: http://www.crsp.com/.

[17] The effective federal funds rate is a weighted average of rates on brokered trades. Monthly figures include each calendar day in the month, and are annualized using a 360-day year or bank interest. Information and data are available at http://www.federalreserve.gov/econresdata/releases/statisticsdata.htm.

Table 1: Descriptive statistics in sample period (Jan. 1991-Dec. 2009)

	N	Mean	St. Dev	Min	Max
Market					
MEXRET	228	0.0055	0.0443	-0.1854	0.1104
RF	228	0.0030	0.0015	0	0.0056
HML	228	0.0008	0.0358	-0.2199	0.1380
SMB	228	0.0049	0.0340	-0.0989	0.1387
MOM	228	0.0055	0.0544	-0.3469	0.1835
CCX Members with announcement information (34 firms)					
RET	6'290	0.0098	0.1029	-0.8702	1.2235
CAP	6'290	20'657	42'287	4.2128	501'513
4-digit SIC-Rivals (19,144 firms)					
RET	106'103	0.0106	0.1833	-0.9641	13.4951
CAP	106'103	3'971	16'418	0.0089	489'845

MEXRET: Market return-RF (risk-free rate of interest); HML-MOM: Defined in text
RET: Return; CAP: Market capitalization (shares outstanding x price, in mio $)

tend to be larger on average than their industry rivals (nonmember firms sharing the same 4-digit SIC code), as membership in a carbon trading market makes no sense for very small firms. However, the average firm return *RET*[18] is statistically indistinguishable for members and non-member rivals.

4 Results

Coefficient estimates from OLS regression of (4) are given in Table 2. To test whether different industries have different intercepts (i.e. different α's), we also carried out a fixed effects (FE) regression based on 2-digit SIC classification but were not able to reject the null hypothesis that the industry intercepts were all identical, indicating that pooling the data and applying OLS is appropriate.

The first two columns show the results for the 1-factor and 4-factor versions of

[18]This variable is defined in the CRSP database as the simple monthly difference in stock price, here with the dividend payments stripped out for simplicity. See the CRSP data guide for more information.

our model without controlling for industry-specific returns (Models 1a-b). The results indicate that the systemic risk inherent in stock from CCX members is almost exactly that of the market ($\beta_1 \approx 1$), and Jensen's α is not significantly different from zero, implying that a stock index comprised of CCX members would track the overall stock market rather well. This reflects the wide variation of industries that CCX members belong to. The size, value and momentum factors are all highly significant.

The middle panel includes the industry adjustment (Model 2). Inclusion of excess returns from industry rivals renders the size factor insignificant in the 4-factor model, which may reflect a systematic firm size difference across industry codes. The other factors remain significant. The R squared and the Bayesian Information Criterion (BIC) indicate that the 4-factor model fits the data better and that adjusting for industry returns increases the explanatory power of the model.

The announcement to join CCX does not appear to have had an impact on excess returns in either model, neither positive nor negative. Adding a lagged version of the $JOIN$ dummy for all firms (not just those with an announcement date in the second half of the month, for which the $JOIN$ dummy already marks both the announcement as well as the follow-up month) or restricting the dummy to the month of the announcement only for all firms did not significantly change the results. This could indicate that investors had no strong belief whether joining CCX would lead to positive or negative net costs, or else that the effect is small enough that it disappears using monthly returns. Note that the estimated coefficient on the $JOIN$ dummy is positive in all specifications, although it never reaches statistical significance.

Investors reacted strongly to the passing of the Waxman-Markey bill, however. The coefficient on the WAX dummy is statistically significant in all specifications, indicating that the investors believed that these firms had gained an advantage over their rivals due to their experience in a carbon market (again, adding a lagged dummy did not change the results). The significant announcement effect of this bill indicates that preparing for regulation and thus gaining an advantage over rivals who have no experience may be important in CCX membership.

The market is also sensitive to emission abatement costs incurred by CCX members, as an increase in the carbon price significantly reduces excess returns. Presumably, the effect would be larger for firms that agreed to a greater level of abatement relative to their past emissions, but we cannot control for this because we lack the corresponding data. Controlling for emission intensity using 2-digit SIC coding (defining codes 10-14, 26, 28-29, 32-34 and 49 as emission-intensive industry groups) did not reveal a difference between emission-intensive and other firms in terms of the announcement effect and the sensitivity of returns to the carbon price.

The last panel in Table 2 contains the results of regressing a portfolio comprised of CCX members on the market factors as well as the Waxman dummy and carbon price changes. Naturally, controlling for industry rivals is not possible in a portfolio approach, and neither is the inclusion of firm-specific information such as announcement dates. On the other hand, creating a portfolio reduces the overall variation of returns (this is the point of diversification), which leads to a better model fit as evidenced in the higher R squared of the portfolio model. For the variables where such a comparison is possible, the portfolio model confirms the results of the individual-stock regressions: The passing of Waxman-Markey bill significantly increased returns of member firms, and returns are relatively correlated with carbon price changes.

5 Conclusions

The effect of voluntary investment in emissions abatement on firm profits, and by extension on their their stock returns, is ambiguous *ex ante*. On theoretical grounds, both an increase as well as a decrease in profitability are possible, rendering the question and empirical one.

We use monthly stock returns from 1991-2009 to test whether the announcement to join CCX, the largest voluntary cap-and-trade market worldwide, produced positive or negative excess returns for member firms. After controlling for systemic market risk as well as shocks on the 4-digit SIC industry level, we find that joining itself had no impact on excess returns. However, we find excess returns to be negatively associated with changes in the CCX carbon price, and thus with changes in marginal abatement costs. Since *not* joining CCX is associated with zero abatement costs, this result is an indication that CCX membership is not viewed as profitable from the market's perspective, even though the announcement itself had no significant effect (at least not one that we can detect using monthly data).

However, the market reacted positively to the passing of the Waxman-Markey bill in June 2009, which increased the likelihood of a federally mandated carbon market. This finding is robust to a series of alternative model specifications, including treating CCX firms as a portfolio and comparing them to the market overall. The positive excess returns upon passing of the Waxman-Markey bill suggest that the most likely incentive for firms to join CCX was to prepare for future regulation.

Our results do not back up the implications of corporate government theory, according to which investments into non-mandated emission reductions is a waste of shareholder money. By the same token, they also do not indicate that green investment pays.

In particular, they do not bode well for the hopes that voluntary GHG reductions may obviate the need for mandated programs, since it was precisely the (credible) threat of a mandated program that was the source the positive market signal. Therefore, our results suggest that relying on voluntary approaches alone to combat climate change may not be enough.

Table 2: Regression results

	Model 1a			Model 1b			Model 2a			Model 2b			Model 3a			Model 3b		
	coeff	t		coeff	t		coeff	t		coeff	t		coeff	t		coeff	t	
α	0.0002	0.20		0.0013	1.11		-0.0004	-0.37		0.0001	0.06		0.0005	0.37		0.0017	0.93	
MEXRET	0.9894	34.57	***	0.9997	37.64	***	0.6770	21.04	***	0.6436	21.26	***	0.9818	28.47	***	0.9857	24.48	***
SICEXRET							0.3366	19.31	***	0.3731	22.02	***						
SMB	0.1505	4.25	***				0.0284	0.81					0.1494	3.56	***			
HML	0.4088	10.76	***				0.2714	7.21	***				0.4026	8.85	***			
MOM	-0.1781	-7.84	***				-0.1340	-6.03	***				-0.1792	-6.59	***			
JOIN	0.0133	1.09		0.0097	0.78		0.0156	1.33		0.0136	1.14							
WAX	0.0789	4.20	***	0.0610	3.20	***	0.0585	3.19	***	0.0420	2.28	**	0.0634	3.01	***	0.0459	1.71	*
ΔCARBON	-0.0063	-1.39		-0.0109	-2.40	**	-0.0076	-1.74	*	-0.0107	-2.45	**	-0.0040	-0.86		-0.0072	-1.21	
N	6'290			6'290			6'285			6'285			228			228		
R2	0.2116			0.1851			0.2559			0.2435			0.8371			0.7294		
LL	6'130			6'025			6'305			6'253			562			504		
BIC	-12'189			-12'007			-12'531			-12'453			-1'086			-987		

MEXRET: Market excess return; SICEXRET: Excess return of 4-digit SIC rivals; SMB: size factor; HML: value factor; MOM: momentum factor

ΔCARBON: First difference of CCX carbon price; JOIN: Announcement dummy; WAX: Waxman-Markey dummy

*: p<0.1; **: p<0.05; ***: p<0.01

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