# DO CARBON MANAGEMENT SYSTEM ADOPTION ANNOUNCEMENTS AFFECT MARKET VALUE?

*Research-in-Progress*

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## Abstract

*In this paper we conduct an event study to test the hypothesis that carbon management systems (CMS) are perceived by financial markets to be value-adding IS investments worth more than their costs. After populating a list of over 200 exchange-traded CMS adopters, we search newswires and specialty news outlets to identify 62 adoption announcements over a 10 year period. These are analyzed for a 3 day window starting with the announcement and we find that the mean cumulative abnormal returns (MCARs) from CMS announcements are 1.04%. A sub-analysis by firm size confirms earlier IS research results that smaller firms experience larger returns. Another sub-analysis by industry finds a potentially surprising result that lower-C02 emission industries accrue larger MCARs than high-emitting industries, though further research will be required to establish this conclusively.*

**Keywords:** Sustainability, Business value of IS/value of IS, Green IT/IS, Environmental sustainability, Enterprise software/systems, Information systems adoption, IS innovation, 09. Green IS and Sustainability

## Introduction and Literature Review

CEOs increasingly view environmental sustainability as important to their business' success (Lacy et al. 2010). However, it is difficult to manage what is not measured. Carbon management systems (CMS) are a new type of enterprise information system that digitize and allow the management of previously un- or under-tracked C02 emissions information. We define CMS as enterprise information systems for measuring, mitigating, and reporting carbon emissions (Melville 2012). CMS are being rapidly adopted by firms, but little is known about their impacts on business value.

This paper begins to fill in this knowledge gap by conducting an event study at the intersection of IS business value, environmental sustainability and financial markets and offering contributions to each of these three perspectives. The first is from an IS-specific viewpoint: what value, if any, does this new technology offer firms and what conditions and complements are necessary to realize this value? The information systems literature has examined the value of IS at the level of the firm (Brynjolfsson and Hitt 1996; Dos Santos et al. 1993), industry (Melville et al. 2007; Stiroh 1998), and country (Dewan and Kraemer 2000). This literature demonstrates that IS does add value (Kohli and Grover 2008; Mithas et al. 2012), but that value requires complementary resources and organization to be realized (Aral and Weill 2007; Bresnahan et al. 2002). There is also an established stream of research examining the value of specific types of IS that have investigated such diverse information systems innovations as ERP (Ranganathan and Brown 2006), e-commerce (Subramani and Walden 2001) and many others (see Roztocki and Weistroffer (2011) for a literature review). Some researchers have even investigated the value of a specific IS for sustainability (e.g. Shaft et al.'s (2001) case study on interorganizational information systems). However, we know of no empirical studies that investigate the value of carbon management systems.

Our study also contributes to the understanding of one part of environmental sustainability. Sustainability can be a highly contextual and controversial term (Moon 2007). For the purposes of this paper we adopt the broad definition of sustainability as integrating environmental thinking into social, political and economic activity (Elkington 1994), with public companies' adoption of CMS being a tangible outcome of this integration. Investigating this adoption by companies is important to the sustainability literature for two reasons. The first is because the financial results of overall corporate sustainability strategies have been varied with some authors finding positive returns (Bose and Pal 2012; Clarkson et al. 2011; Wahba 2008) and others finding mixed or no returns (Molina-Azorín et al. 2009; Surroca et al. 2010). One recent study even found negative returns associated with adopting a particular environmental standards certification (Paulraj and de Jong 2011). Further confusing the state of knowledge is the theoretical criticism that there may not be a direct link between environmental measures and traditional financial measures at all (Surroca et al. 2010). The current study adds to the body of evidence for positive financial returns associated with a particular type of sustainability effort. The second reason this is important to the sustainability literature is that its findings can aid managers that have already decided their company is going to pursue an environmental sustainability strategy in prioritizing which investments should be made. If waste and recycling are more concerning to supply chain managers than carbon emissions management as suggested by Bose and Pal (2012), then this study may either validate or correct that prioritization.

The third perspective's contribution is related to the efficiency with which financial markets metabolize information about firms' sustainability efforts and account for that information in a firm's stock price. For large, closely watched firms (even if they do not issue press releases in the traditional channels), market moving information is incorporated on the same day it becomes available (Jones 2010; McWilliams and Siegel 1997). However, markets are not always efficient (Gu and Hitt 2001; Valentine 2010) with size and the number of individual investors being two of the investigated causes of inefficiency. While institutional investors whose stated goals include investing in environmentally and socially responsible companies are an increasing part of the stock market in the US and globally (Ramchander et al. 2012), it is unclear whether this growth has resulted in announcements of environmental sustainability efforts being reflected in stock prices with uniform speed for all companies.

Two recent studies investigating market reaction related to carbon management have found mixed results. No statistically significant positive reaction was found by Keele & DeHart (2011) in their

investigation of 29 firms' announcements of joining the US EPA's Climate Leaders program. In contrast to the Climate Leaders' commitment to reduce carbon, the current study is of announcements of specific investments to enable the reaching of such goals and may be perceived by the markets differently than the announcements of the commitments themselves. Market reaction to announcements of IT adoption that supports environmental sustainability were found to be positive in another recent event study, though not for the category that includes CMS. That study examined 39 firms that announced 160 green IT initiatives, defined by the authors as "computing technologies that are energy-efficient and have minimal adverse impact on the environment" (Nishant et al. 2011). Interestingly, they found market reaction to IT to support decision making (a category defined by Corbett (2010) that includes CMS) to not be significant. The current study refines our growing understanding of financial markets and their reaction to IT to support environmental sustainability decision-making by separating out CMS for investigation alone.

The rest of the paper is as follows: we first develop hypotheses, describe methods and data, and then present and analyze results. We then conclude with a brief discussion of limitations and future extensions.

# Development of Hypotheses

## *Market Reaction to CMS Announcements*

Prior studies on IS investment announcements have shown that the market rewards firms that invest in innovative or platform technologies, while not rewarding typical or follow-on IT investments (Dos Santos et al. 1993; Im et al. 2001; Ranganathan and Brown 2006). Innovation is one of the links between environmental sustainability strategies and operating practices and improved financial performance (Surroca et al. 2010), and systems that allow the measurement, management and elimination of waste (which include CMS) can lead to innovations and profits (King and Lenox 2002). A recent empirical study (Mithas et al. 2012) shows that IT investments to solely reduce costs are not associated with increased firm profitability and a theorized reason is that cost-reducing innovations are sold by vendors and easier for competitors to implement, so any additional profits from cost reductions will be competed away. However, the study also finds that IT investments that increase revenue, perhaps through increased innovation, do have long term net financial benefits. A semi-strong efficient market hypothesis says that to the extent that market participants anticipate an investment will increase the present value of future cash flows a firm is expected to bring in, the stock price will rise (Fama 1970; Fama 1991). Thus if market participants believe a CMS investment will reduce costs and/or increase revenues by more than the initial outlay and discounted maintenance expenses, we expect to observe positive abnormal returns following its announcement. In summary, CMS can be considered innovative IS, and given prior positive business value findings concerning this type of IS, we hypothesize that carbon management systems will be perceived by investors as leading to improved future financial performance.

**H1:** *Abnormal stock market returns from CMS announcements will be positive.*

## *Determinants of Market Reaction: Firm Size, Announcement Timing & Industry*

The impact of a CMS investment on a firm's financial performance is anticipated to vary with the opportunities that the firm has to realize cost savings and revenue enhancements from the investment and with the amount of new-to-the-market information in the announcement. Im et al. (2001) argue that the larger the firm, the more likely it is that the information contained in a formal announcement will have already had opportunities to be disseminated, and that ceteris paribus, market reactions to announcements for larger firms will carry less novel informational content and be smaller and quicker than those for smaller firms. In this study we operationalized the concept of small and large firms as those with total assets below or above the mean of our sample, respectively. Based on the argument that announcements from small firms contain more new information[1] than those announcements from large firms we hypothesize:

**H2:** *The size of abnormal stock market returns from CMS announcements will be greater for smaller firms than it is for larger firms.*

[1] We thank an anonymous reviewer for pointing out that the information content of the announcements is the same for both size firms, but the amount of *new* information is what differs.

Another relevant issue that has been investigated is that of a time lag effect (Bose and Pal 2012; Im et al. 2001). The innovative nature of CMS implementations suggests there may be differing market reactions to CMS announcements over time. Because such announcements have increased over the last decade, they may be viewed by investors as increasingly commonplace, decreasing the expected financial benefits conferred by the uniqueness of the innovation. This would correspond to the argument in Mithas et al. (2012) that the financial benefits of cost-reducing information systems investments are competed away. Alternatively, markets may have grown more aware of the growth potential associated with sustainability disclosure and performance over time (Kangos et al. 2011) and may thus be more likely to react favorably to steps in that direction in later periods. The split between earlier and later adopters is operationalized in our sample as the five years (2002-2006) prior to 2007 (in which there were no announcements) and the four years following (2008-2011). On balance, we think the argument that markets are more likely to react favorably to mitigation steps in later periods holds more weight and thus hypothesize:

**H3:** *Market reaction to later adopters' announcements of CMS investments will be greater than that for earlier adopters.*

Differences in market reaction by industry is often either studied explicitly or included as a necessary control variable when using the event study methodology and should be included in the present analysis for completeness and comparability (Chatterjee et al. 2002; Dos Santos et al. 1993; Im et al. 2001; Ranganathan and Brown 2006). Beyond that rationale, however, industries also differ greatly in their carbon emissions[2] and the value to be realized from a carbon management system should also differ by industry. For example, we could contrast two industries. One may have high emissions from a smaller number of similar sources such as the electric power industry with a small set of power plant types (e.g. coal, natural gas, biofuel) which face regulations and other pressures to mitigate their carbon emissions. Another industry may have lower emissions from a larger number of widely dispersed and varying sources, such as consumer goods manufacturing. A CMS will give the electric power generator the data they need to comply with any forthcoming regulation and show changes in their emissions as efforts to reduce them are implemented. A consumer goods manufacturer may generate carbon emissions from many types of sources (e.g. factories, goods shipments, marketing activities), and while it may generate lower carbon emissions overall than power companies create, the greater number of sources creates more opportunity for a CMS to reduce the complexity and effort (relative to other methods such as manual entry on spreadsheets) associated with tracking carbon emissions through automation and information. Thus, as CMS may benefit both industries in different ways, we believe that investors will react differently to the CMS adoption announcements of firms in industries with high C02 emissions than those in industries with low C02 emissions:

**H4:** *Market reaction to announcements of CMS investments will differ between high C02-emission and low C02-emission industries[3].*

## Methods and Data

The event study method has been utilized in both the sustainability and IS literature[4]. This method is based on the assumption of a "relatively efficient capital market" (Dos Santos et al. 1993) which states that upon receiving news the market rapidly incorporates that new information into a firm's stock price, changing it by the amount that the investment is expected to contribute to the NPV of the firm. Srinivasan and Bharadwaj (2004) note that any event study will also test whether the stock market is efficient, and McWilliams and Siegel (1997) point out the importance of the event being unanticipated and the need for there not to be confounding events during the event window. The present study accounts for these concerns and the following subsections detail the process used to gather and screen the events as well as a description of the estimation method and its application.

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[2] See http://www.epa.gov/climatechange/emissions/usgginventory.html for illustrations

[3] Following established practice in professional carbon reporting (Kangos et al. 2011), we use the Global Industry Classification Standard (GICS) to classify industries. High C02 emission industries are defined as the materials, utilities and energy sectors of the GICS. The other 7 sectors are low emissions.

[4] See Konchitchki (2011) or Roztocki and Weistroffer (2011) for a literature review of information systems event studies.

### *Data Collection and Screening*

The data for this study were collected from three types of sources. First, financial data and stock market data were retrieved from the conventional archival sources COMPUSTAT and the Center for Research in Security Prices (CRSP). Second, event announcements were gathered primarily from the Factiva and Lexis-Nexis Academic databases (specifically PR Newswire, Business Wire, AP MediaNet Press Releases and ABN Newswire). These sources are consistent with other IS event studies and their use "limits information asymmetries and inconsistencies" (Konchitchki and O'Leary 2011). The third type of information sources are company and sustainability industry websites for the CMS vendor companies, adopter companies, carbon consulting ventures and sustainability news sites (e.g. http://www.greentechmedia.com). Because of their focus on the company, vendor or issue of carbon management, these sources sometimes offered additional information on adoption time or nature of the technology adopted beyond what was available in company press releases. In a few rare cases, these sites carried reporting of a company's adoption of a CMS that was not archived on a company's website or in the news databases.

Data collection was performed by compiling a list of CMS vendors and customers from the literature and popularly available sources, yielding over 240 organization/CMS vendor pairs. Sometimes called "Enterprise Energy and Carbon Accounting (EECA)" systems (Groom Energy and Greenbiz 2011), carbon management systems may be either stand-alone systems or modules of a larger ERP system, but are distinguished from software systems that only measure energy usage or the often-used spreadsheet-based carbon tracking system. Of all the adopters collected, only two had developed such systems in-house. The rest were commercially available. After eliminating organizations not traded on US exchanges (e.g. governments and privately held companies, as well as internationally-traded companies for whom data was not reliably available from our data sources), searches of newswire archives for the over 200 remaining companies and their CMS vendor name, CMS product name, and/or keywords specific to CMS adoptions[5] were performed. Careful examinations of CMS vendor and consultant websites and topic-specific third party news sites were conducted as well. In total, out of the 200 public company CMS adopters, these searches and examinations yielded a list of 68 CMS adoption announcements. After eliminating those for which an event date was not available (some announcements archived on company websites were not dated) and one additional announcement that a company made after changing vendors (so that only the first announcement is included in the study), there were 62 remaining events which are plotted in figure 1 with summary statistics presented in table 1.

**Table 1. Description of sample**

| CMS Adoption announcements (n= 62) | | | | | |
|---|---|---|---|---|---|
| Company Size | Min | Max | Mean | S.D. | Median |
| Total Assets ($ million) | 292.062 | 807,698.0 | 58,161.93 | 118,930.6 | 20,708.0 |

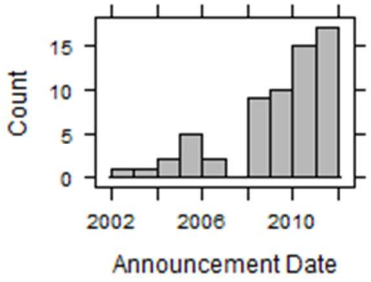


**Figure 1. Frequency of CMS adoption announcements, Jan 1 2002-Dec 31 2011**

[5] For example: the word "track" within 10 words of either "GHG", "carbon" or "greenhouse gas" AND containing (anywhere in the article) either "software" or "system".

## *Estimation method and tools*

The financial impact of CMS announcements is measured using the excess returns resulting from conventional event study methodology. While the general form of the method is fairly consistent across studies (Konchitchki and O'Leary 2011), the specific choices within that form (such as event window and estimation period) can vary. This study uses a 200 day estimation period with a 45 day buffer between the estimation period and the event window to reduce the contribution of variance from sampling error (MacKinlay 1997). We adopt the market model approach which is widely used in the IS literature (e.g.(Im et al. 2001; Ranganathan and Brown 2006)) with an equally weighted CRSP index. In this approach, the coefficients for estimating the relationship between the firm's returns and the market returns are calculated by using OLS to regress the daily returns for firm i on the daily market returns over the 200 day estimation period. Thus, the estimated normal returns are given by $R_{it}^{*}$ in the equation:

$$R_{it}^{*} = \alpha_i + \beta_i R_{mt} + \epsilon_{it} \quad (1)$$

where $\alpha_i$ is the Intercept term, $\beta_i$ is the systematic risk of i-th firm, $R_{mt}$ is the actual return of the market for time period t and $\epsilon_{it}$ is the error term with expected value = 0. Using the coefficients estimated in equation (1), the Abnormal Returns for firm i in time period t are calculated using the equation:

$$AR_{it} = R_{it} - R_{it}^{*} \quad (2)$$

where $AR_{it}$ is the Abnormal return of i-th firm for time period t, $R_{it}$ is the actual return of i-th firm for time period t and $R_{it}^{*}$ is the estimated normal returns for i-th firm for time period t (different from equation (1) in only that the time t used for estimation is now the event window, not the estimation period). After the abnormal returns have been calculated, they are summed for each event window, yielding the cumulative abnormal return (CAR) for firm i in that window. For the window [-1, 1], this would be given by equation;

$$CAR_i = \sum_{t=-1}^{t=1} AR_{it} \quad (3)$$

These cumulative average returns are then aggregated across firms and divided by the number of firms in the group to calculate the mean cumulative abnormal return (MCAR) for the group. Similar to prior studies (Nishant et al. 2011; Parameswaran et al. 2011), we use the *Eventus* event study tool (Cowan, 2005) for the calculation of these returns and testing for significance[6].

According to McWilliams and Siegel (1997), the most important decision in an event study is the event window. Because some events are announced after the close of markets for the day, the most conservative event windows often include the event day and one day after. Additionally, leakage of news that is about to be announced can occur in the days before a formal announcement, and so a common approach in IS event studies to account for this is to examine additional 1- and 2-day windows before and after the announcement date (Chatterjee et al. 2002; Ranganathan and Brown 2006). In this study we examine four event windows [0, 1], [-1, 1], [0, 2] and [-2, +2]. These will allow us to not only observe the presence and size of any abnormal returns in small windows of 2-5 days, but also note any differences in reaction speed between sub-samples of companies. If the market reacts similarly to CMS announcements for all companies, we would expect the most significant results to be in the two windows [0, 1] and [-1, +1].

An important issue when calculating MCARs is the assumption that no window for any firm in the sample overlaps with another firm in that same sample. Such overlap is known as clustering and it is avoided to allow the calculation of the aggregated cumulative abnormal returns without concern to the covariance between securities (these should be zero if the event windows do not overlap). In our full sample, the announcements of 21 firms were clustered. The violation of the assumption means that the underlying distributional assumptions that the parametric significance tests rely on may not hold. To account for this, we adopted the approach of excluding the clustered events from the results instead of other methods such as seemingly unrelated regression (Dewan and Ren 2007). Table 2 presents a frequency table of excluded and included events by relevant splits.

[6] Eventus version 9.0, hosted by the Wharton Research Data Services. Significance is tested with the parametric Patell Z-test and the non-parametric generalized sign test.

| Table 2. Event frequencies by attributes of interest | | | | | | | |
|---|---|---|---|---|---|---|---|
| | H1 | Split for H2 | | Split for H3 | | Split for H4 | |
| | Full | Large | Small | Earlier | Later | High | Low |
| Included Events | 41 | 23 | 22 | 11 | 30 | 18 | 29 |
| Excluded events because of clustering | 21 | 8 | 9 | 0 | 21 | 3 | 12 |
| This table shows that excluded events are all later adopters of CMS and are somewhat more likely to be from low C02-emitting industries than included events. Their size is not appreciably different from included events. | | | | | | | |

## Results[7] and Analysis

*H1: Positive market reaction to Carbon Management System adoption announcements: Supported*

Our results for the test of our first hypothesis are presented in table 3. In the full sample, the hypothesis is supported that announcing the adoption of a carbon management system results in positive cumulative abnormal returns for a firm. Specifically, the results indicate that for the whole sample of CMS announcements (and for all four event windows presented) there is evidence to both reject the Patell Z-test null hypothesis of no abnormal returns (e.g. p=.0335 for window [-1, +1]) and reject the null hypothesis of the generalized sign test that this fraction of positive returns is the same as would be expected without abnormal returns (e.g. p=.0655 for window [-1, +1]). When clustered events (i.e. overlapping event windows) were not corrected for, the results were only observed for two of the four event window specifications and they were weaker.

| Table 3. Overall impact of CMS announcements on stock price in different event windows, with and without correction for clustering | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Full Sample (n=41; after eliminating clustered announcements) | | | | Full Sample (n=62; clustering not accounted for) | | | |
| Event Window | [0, 1] | [-1, 1] | [0, 2] | [-2, 2] | [0, 1] | [-1, 1] | [0, 2] | [-2, 2] |
| Mean CAR | 0.49%** | 0.7%** | 1.04%*** | 1.34%*** | -0.02% | 0.20% | 0.35%* | 0.53%* |
| Z test p-value | 0.0617 | 0.0335 | 0.007 | 0.008 | 0.3244 | 0.1324 | 0.0652 | 0.0614 |
| Num. (+):(-) | 26:15** | 25:16* | 27:14** | 27:14** | 31:31 | 33:29 | 36:26* | 35:27 |
| Sign-test p-value | 0.0342 | 0.0655 | 0.0164 | 0.0164 | 0.4449 | 0.259 | 0.0795 | 0.1241 |
| | *, **, *** indicates significance at .10, .05 and .01 respectively | | | | | | | |

The remaining three hypotheses are tested by examining the panels of corresponding subsamples as displayed in Table 4. For brevity, only the results for window [0, 2] are shown

[7] Stock price source: CRSP, Center for Research in Security Prices. Graduate School of Business, The University of Chicago [2002-2011]. Used with permission. All rights reserved. www.crsp.uchicago.edu

| **Table 4. Mean cumulative abnormal returns (MCAR) of firms subsampled for hypothesis testing for the event window [0, 2]** | | | | | | |
|---|---|---|---|---|---|---|
| Characteristic | Panel A: Size of Firm | | Panel B: Time of Adoption | | Panel C: Industry C02 Emissions | |
| | Large | Small | Earlier | Later | High | Low |
| Sample size† | 23 | 22 | 11 | 30 | 18 | 29 |
| Mean CAR | 0.39% | 1.53%*** | 0.38% | 1.28%*** | 1.09%* | 0.99%** |
| Z test p-value | 0.2777 | 0.0037 | 0.3187 | 0.0048 | 0.0889 | 0.0135 |
| Num. (+):(-) | 12:11 | 16:6** | 8:3* | 19:11* | 13:5** | 18:11* |
| Sign-test p-value | 0.415 | 0.012 | 0.0647 | 0.0573 | 0.030 | 0.0716 |
| † Does not sum to 41 because when sample is split, clustering does not affect as many events<br>*, **, *** indicates significance at .10, .05 and .01 respectively | | | | | | |

*H2: Size Effect: Supported*

The results in the [0, 2] window support the hypothesis that smaller firms will show a greater abnormal return than larger firms. An additional analysis of other event windows (results not shown for brevity) indicates that large firms can show positive abnormal returns, but only for short windows that include the day *before* the announcement. This suggests potentially different market efficiency for incorporating sustainability information into stock prices in that the market may react faster for closely-watched large firms, while smaller firms may take a couple of days for the information to disseminate and be fully priced in. The faster reaction is also consistent with the theory that large firms may have more information leakage prior to the event (Im et al. 2001).

*H3: Later Adopter Effect: Not Supported*

Later adopters of carbon management systems are hypothesized to be rewarded as the market reacts rationally towards companies that are working to mitigate environmental risk. Both parametric and non-parametric tests provide evidence (in three and two of the windows respectively) for significant abnormal returns for later adopters. These indicate that the abnormal returns for later adopters are both present and positive. A significant limitation of this split, however, is the small sample of earlier adopters (n=11) which is below the acceptable threshold of 20 to interpret both the parametric and non-parametric tests, as well as the fact that all the announcements eliminated for clustering are later announcements. Thus, while we can conclude that later adopters are positively rewarded, we cannot conclude that earlier adopters were not similarly rewarded. Thus we cannot conclude that later adopters were rewarded greater than earlier adopters and the hypothesis of greater returns is not supported. That later adopters are rewarded at all is an interesting result in itself, however, as it seems to suggest a difference from (Bose and Pal 2012), implying that CMS may be perceived as substantively different from the green supply chain management initiatives that they investigated.

*H4: Type of Industry Emissions Effect: Not Supported*

The hypothesis that firms in industries with higher C02 emissions will react differently to CMS announcements is not supported. Instead, the results indicate that there is strong support showing that companies in low emitting industries enjoy positive abnormal returns (with significant abnormal returns and positive sign tests for three of the four windows), while there is only weak evidence that companies in high emitting industries may enjoy positive abnormal returns and those returns are close to the same size as those in low-emitting industries. Even weak evidence for abnormal returns cannot be established by this study, however, because the number of non-clustered events in high emitting industries is below the threshold of interpretability at n=18. Thus, the weakness of the evidence for no result in high emitting industries should be interpreted with caution as significance can be understated when n<20. With an n=29 in low emitting industries, the evidence for abnormal returns in low emitting industries is persuasive, but the difference between high and low emitting industries cannot be conclusively arrived at from this data set.

## Limitations and Future Directions

Sample size limitations have already been noted above. While only 62 announcements were able to be analyzed in this paper, the data collection process identified over 200 firms that adopted a carbon management system, representing a ~30% announcement rate of CMS adoptions. A future research direction could be to use a Heckman selection model to investigate if there might be selection on unobserved variables occurring with only certain types of firms choosing to make CMS announcements. Another extension would be to incorporate companies traded on non-US exchanges. We thank an anonymous reviewer for pointing out that this extension would be especially useful in the face of differing regulations related to carbon emissions, as regimes that regulate carbon would be expected to result in CMS announcements having no financial impact. Inference from the current study cannot be extended to such regulatory environments (e.g. the UK and EU), and it is the authors' intention to extend the research to explicitly examine international reaction. It is important to note that event studies that do this today typically estimate a different market model for each country. However, Park (2004) has found that such an approach overestimates the changes in firm value, and that a world market model is needed. This version of our study thus excludes non-US listed companies. Estimating a world market model using Park's methods would yield a more complete understanding of financial market reaction to carbon management systems world-wide. This will also increase our confidence in the estimates for large firms that are traded globally and who adopt carbon management systems. Other future directions include extending the analysis using the methods of Dewan and Ren (2007) to account for the clustering problem (instead of eliminating 1/3 of the announcements) and to investigate whether this innovation is perceived by the markets as increasing or reducing risk to shareholders. Combining this risk analysis with Kim and Mithas's (2011) investigation to see if debt holders are reacting in similar ways to shareholders would give us insights into whether the higher observed equity returns simply represent higher risk, driving returns to shareholders but making a firm's debt less attractive.

This study provides empirical evidence that the financial markets react positively to firms announcing the adoption of carbon management systems. While suggestive, this is only the beginning of demonstrating the business value of this new type of information system. Other approaches such as case studies would go far to validate whether firms are finding actual operation of these systems to be valuable, and further empirical studies investigating the mediating and complementary factors for both CMS and other types of Green IS should also be undertaken. Finally, as a Research-In-Progress study, enhancements to theory and analysis are ongoing. Through this study and others like it, in time we will hopefully gain a fuller picture of how carbon management systems and other types of Green IS bring value to businesses.

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