

DISCLOSURE EFFECTS, CARBON EMISSIONS AND CORPORATE VALUE

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Abstract:

Purpose- The main objective of this study is to examine the impact of corporate carbon emissions and disclosure on corporate value, especially regarding whether disclosure helps to reduce uncertainty in valuation as predicted by carbon emissions using a unique data set on Japanese companies.

Design/methodology/approach- Empirical analysis of the relations between corporate carbon emissions using compulsory filing data to Japanese government covering more than 1,000 firms, corporate carbon management disclosure (CDP disclosure), and the market value of equity.

Findings- We find that (1) corporate carbon emissions have a negative relation with the market value of equity, (2) the disclosure of carbon management has a positive relation with the market value of equity, and (3) the positive relation between the disclosure of carbon management and the market value of equity is stronger with a larger volume of carbon emissions.

Practical implications- Our results may be an important when considering the inclusion of carbon disclosure as a component of nonfinancial disclosure. In addition, our findings encourage Japanese companies to reduce carbon emissions and to disclose their carbon management activities.

Originality/value- We provide the first empirical evidence of an interactive effect between the volume of carbon emissions and carbon management disclosure on the market value of equity. And, our results concerning the relation between environmental performance, disclosure, and market value are readily generalizable, especially as all companies emit carbon, either directly or indirectly. In addition, our results are arguably free of problems with sampling bias and endogeneity as we employ data obtained from the compulsory filing of carbon emissions information.

Keywords: Carbon emissions, Disclosure, Value relevance, Interactive effect

1. INTRODUCTION

The objective of this study is to examine the impact of carbon emissions and disclosure on corporate value, particularly whether disclosure helps to reduce uncertainty in valuation as predicted by carbon emissions. Global warming has been increasingly recognized as a high-priority issue worldwide, with the Intergovernmental Panel on Climate Change (2007) concluding that global warming is caused by human activity. Moreover, the external costs of environmental damage from human activity are already significant and increasing, and recently amounted to US\$6.6 trillion, equivalent to 11 per cent of world GDP (UNEP FI and PRI, 2011).

Because carbon emissions can have a significant impact on business activity and behaviour, several studies have analysed the relation between the carbon emissions and corporate value. For example, Aggarwal and Dow (2011), Matsumura *et al.* (2011), and Griffin *et al.* (2012) conclude there was a negative relation between the volume of carbon emissions and corporate value by using data on voluntarily disclosed carbon emissions. However, the use of voluntarily disclosed carbon emission data in analyses of this type presents a potential problem with endogeneity and sampling bias. In addition, analysis of this relation without consideration to discern the disclosure effects and the actual carbon emissions effects provides only superficial evidence.

From an information perspective, the notion that accounting is designed to provide information that tells us something should reduce *uncertainty* (Christensen and Demski, 2003). As there are no existing studies that we know of that analyse the impact of disclosure on corporate value conditional on carbon emissions, in this paper we use Japanese company data to investigate whether disclosure of carbon emissions helps to reduce uncertainty in valuation. This is important work as Japanese firms typically display a high level of carbon efficiency and the cost of marginal carbon reduction in Japan is higher than in many comparable countries (JRITE, 2008). Japan is also the site of the world's first mandatory greenhouse gases reporting scheme under its Law Concerning the Promotion of Measures to Cope with Global Warming enacted in 1998. Under this scheme, company-level greenhouse gas emission data became publicly available from the 2006 financial year onwards. The volume of carbon emissions accounts for 95 per cent of the total greenhouse gas emission.

In this study, we employ the carbon emission filing data to investigate (1) whether emissions have a negative relation with the market value of equity, (2) whether the disclosure of carbon management has a positive relation with the market value of equity, and (3) whether the positive relation between the disclosure of carbon management and the market value of equity is stronger with a larger volume of carbon emissions. Our empirical results support all three hypotheses.

The main contributions of this work are as follows. First, we provide the first empirical evidence of an interactive effect between the volume of carbon emissions and carbon management disclosure on the market value of equity. Second, our results concerning the relation between pollution, disclosure, and market value are readily generalizable, especially as all companies emit carbon, either directly or indirectly. Previous studies using data on environmental pollution other than carbon emissions, including sulphur dioxide (SO₂), chemical substances, and soil contamination, typically employ samples from a limited number or necessarily pollution-biased industries. In addition, our results are arguably free of problems with sampling bias and endogeneity as we employ data obtained from the compulsory filing of carbon emissions information. Finally, our findings encourage Japanese companies to reduce carbon emissions and to disclose their carbon management activities. Furthermore, our results for Japanese companies, which already have better energy efficiency

and a relatively high marginal carbon reduction cost, suggest that even stronger results concerning these relations may be obtained in countries outside Japan.

The remainder of this paper is organized as follows. Section 2 provides the background to the analysis and reviews the related research. Section 3 develops our hypotheses. Sections 4, 5, and 6 respectively describe the empirical models, samples, and results for our three hypotheses and supplementary analysis. Section 7 concludes.

2. BACKGROUND AND RELATED STUDIES

2.1. Japanese regulatory background

Although Japan experienced serious environmental pollution from the 1950s to the 1970s, the problem was substantially overcome through strict environmental protection legislation and the efforts of the industrial sector, including the development of new technologies and significant investment in pollution control. As a result, Japanese companies rank highest in carbon efficiency globally, with a marginal carbon reduction cost higher than those in many other countries (JRITE, 2008).

In the same year as the 1998 Kyoto Protocol, Japan enacted the Law Concerning the Promotion of Measures to Cope with Global Warming, the world's first law aimed at controlling global warming and providing a framework for global warming countermeasures. Subsequent amendment of the law introduced the world's first mandatory greenhouse gases reporting scheme. The main objective of this amendment was to encourage business to recognize its own emission status and promote voluntary actions to reduce emissions and to make data on company-level emissions transparent to the public. Under this scheme, from financial year 2006 onwards, those businesses with 21 or more employees generating in excess of 3,000 metric tons equivalent of carbon dioxide were obliged to report their greenhouse gas emissions within four months after a March fiscal year end to the Japanese Ministry of Economy, Trade and Industry and the Japanese Ministry of the Environment, who aggregate and publish the data.

With regard to the empirical literature on corporate social (including environmental) performance (CSP), there are three main areas of inquiry. These comprise studies concerning the relations between (1) CSP and corporate financial performance (CFP), (2) CSP disclosure and CFP, and (3) CSP, CFP, and disclosure. We now discuss each of these three areas in turn.

2.2. Relation between CSP and CFP

Numerous studies find that CSP is mostly tied with CFP, but with some showing non-significant and mixed results. For a summary of extant empirical studies, see Griffin and Mahon (1997), Margolis and Walsh (2003), Orlitzky *et al.* (2003), Allouche and Laroche (2005), and Beurden and Gössling (2008). While these studies address the same basic theme, one reason they provide such a range of results is that the relation between CSP and CFP is largely dependent upon the indicators used for the analysis (Ma, 2006; Garcia-Castro *et al.*, 2010).

In the literature, we recognize two main types of CSP indicators: (1) performance-based measures obtained from actual corporate environmental and social activity, such as the volume of chemical substances released and the volume of emissions, and (2) perception-based measures, including scores, ratings, lists, and indexes from Fortune's *The Most Admired Companies*, the Kinder Lydenberg Domini survey, the Dow Jones Sustainability Index, the Domini Social Index, the Investor Responsibility Research Centre, and Innovest. Two main types of CFP indicators are also generally employed: (1) market-based measures, such as stock prices and returns, and (2) accounting-based measures, such as the returns on assets and equity. Although there is some divergence in findings, some studies show that

perception-based CSP measures tend to have a greater positive relation with CFP than performance-based CSP measures (Wu, 2006), and other studies conclude that CFP, as measured by accounting performance, has relatively stronger explanatory power than stock market performance (Orlitzky *et al.*, 2003). Accordingly, in this study, we focus on corporate environmental performance, and employ a performance-based measure (the volume of carbon emissions) as a CSP indicator, primarily because this measure is objective and directly reflects company performance. For the CFP indicator, we use a market-based measure to investigate the effect of the volume of carbon emissions on corporate value.

There have been several studies showing the effect of environmental performance on the corporate value. Cormier and Magnan (1997) show that the level of water pollution has a significant negative impact on corporate value, and Konar and Cohen (2001) and King and Lenox (2002) demonstrate that toxic chemical releases have a significant negative impact on corporate value. Al-Tuwaijri *et al.* (2004) use toxic waste data and show the same result. With regard to the impact of soil pollution, Barth and McNichols (1994) indicate that site clean-up costs estimated by soil contamination data have a significant negative impact on corporate value. Similarly, Garber and Hammitt (1998) conclude that soil pollution leads to higher costs of capital and Bae and Sami (2005) suggest that it leads to lower earnings response coefficients. Together, these studies suggest that environmental pollution can have a negative impact on corporate value.

In terms of studies using emission data, Hughes (2000) finds that the SO₂ emission ratio exerted a significant negative impact on corporate value. However, in the case of SO₂, the firm sample is limited, and SO₂ is not listed as a greenhouse gas under the Kyoto Protocol. Greenhouse gases also have much broader global consequences than SO₂. Besides, corporate measures to reduce emissions differ because an end-of-pipe solution, such as the installation of scrubbers, is one option to reduce SO₂ emissions, but this is not applicable to carbon emissions (Johnston *et al.*, 2008).

Recent growth in carbon regulation and carbon markets have stimulated the study of carbon accounting and disclosure (Stanny and Ely, 2008; Prado-Lorenzo *et al.*, 2009; Bowen and Wittneben, 2011; Dawkins and Fraas, 2011; Milne and Grubnic, 2011; Rankin *et al.*, 2011; Ziegler *et al.* 2011; Haigh and Shapiro, 2012). With regard to the analysis of the relation between carbon emissions and corporate value, Chapple *et al.* (2011) find a market decrement for high carbon emitters under a national emissions trading scheme. Moreover, Aggarwal and Dow (2011), Matsumura *et al.* (2011) and Griffin *et al.* (2012) suggest that the volume of carbon emissions has a negative influence on corporate value. However, as these results are based on carbon data obtained from voluntary corporate disclosure, they may entail sampling bias and problems with endogeneity. In addition, analysis of this relation without consideration to discern the disclosure effects and the actual carbon emissions effects provides only superficial evidence.

2.3. Relation between CSP disclosure and CFP

Even when a company has existing exposure to environmental pollution, some studies have shown that such activity can lead to better financial performance if the company undertakes tangible activity to reduce the pollution. For example, capital investment is often associated with incremental corporate value (Clarkson *et al.*, 2004), and eco-efficient and proactive environmental strategies and activities have been found to lead to higher profitability and greater corporate value (King and Lenox, 2002; Burnett and Hansen, 2008; Sinkin *et al.*, 2008; Clarkson *et al.*, 2011; Nishitani and Kokubu, 2012; Oshika *et al.*, 2013). However, there are mixed results concerning the relation between the presence of environmental management systems and CFP (Christmann, 2000; Nakao *et al.*, 2007; Cañón-de-Francia and Garcés-Ayerbe, 2009; Henri and Journeault, 2010; Albelda, 2011; Hatakeda *et al.*, 2012).

Overall, these studies provide evidence that actual corporate action, beyond that merely establishing an environmental management system, leads to financial gains.

For the most part, capital market investors cannot recognize corporate environmental activity in the absence of corporate disclosure. Although voluntary disclosure is sometimes used when companies display poor environmental performance or have a poor environmental reputation (Milne and Patten, 2002; Clarkson *et al.*, 2008; Aerts and Cormier, 2009; Cho and Roberts, 2010; Villiers and Staden, 2011; Cho *et al.*, 2012), disclosure is based on actual corporate activity. For example, Magness (2006) shows that companies with a more active strategic posture generally undertake greater environmental disclosure.

Several existing studies conclude that there is a positive link between corporate financial performance and environmental disclosure in annual reports (Al-Tuwaijri *et al.*, 2004; Cox and Douthett, 2009; Moneva and Cuellar, 2009; Cho *et al.*, 2010), in sustainability reports (Dhaliwal *et al.*, 2011), and on corporate websites (Cho and Roberts, 2010). Moreover, Murray *et al.* (2006) find that there was a positive relation between the level of environmental/social disclosure and the consistency of financial returns, and Magness (2010) suggests investor reactions were more favourable to companies with prior environmental disclosure.

Together, these studies indicate that, although establishing an environmental management system does not entail a clear relation with corporate value, concrete environmental activities and disclosures can exert a positive effect on corporate value. In particular, while private climate change reporting is required for understanding corporate risk and risk management (Solomon *et al.*, 2011), some studies conclude that environmental disclosure was inadequate for investment decisions (Solomon and Solomon, 2006) and that the amount of disclosure on climate change was often inadequate (Cotter *et al.*, 2011).

Investors worldwide have recently begun to request carbon disclosure by companies. One major initiative is the Carbon Disclosure Project (CDP), the world's largest non-profit coalition of institutional investors. Every year since 2002, the CDP has sent leading global corporations a questionnaire on the risks and opportunities from climate change, greenhouse gas emissions, emission reduction plans, targets, and strategies, emission intensity, and corporate governance. By publishing the responses, the CDP is working to facilitate active communication between companies and investors. The CDP has clearly been very successful in terms of the number of reports published, and the backing received from prominent investment banks and pension funds and the institutionalization and process of global convergence (Kolk *et al.*, 2008).

Subsequently, several studies analyse the relations between company characteristics and their responses to the CDP questionnaire. For example, Stanny and Ely (2008) find that size, previous disclosure, and foreign sales were related to whether firms disclosed climate change information through the CDP. Dawkins and Fraas (2011) likewise find a positive relation between environmental performance and voluntary climate change disclosure via the CDP. Rankin *et al.* (2011) conclude that companies that voluntarily disclosed greenhouse gas emissions and publicly reported this to the CDP tended to be large companies operating in the energy, mining, and industrial sectors.

Finally, Aggarwal and Dow (2011), Matsumura *et al.* (2011), and Griffin *et al.* (2012) analyse the relation between the carbon emission data in the CDP responses and corporate value. However, the relation between disclosure and corporate value depends on the actual volume of corporate carbon emissions. Therefore, the relation between disclosure and corporate value should be analysed on the presumption that the volume of actual carbon emissions affects corporate value.

2.4. Relation between CSP, CFP and disclosure

When we consider the relation between CSP, CFP and disclosure together, we should control CSP to best discern the role of the disclosure. For example, some studies have suggested that companies with environmental pollution can actually alleviate the negative impact on corporate value through disclosure. As for the reason, Blacconiere and Northcut (1997) and Campbell *et al.* (1998, 2003) conclude that, through disclosure, the negative impact of potential environmental liabilities on corporate value is alleviated by reducing investor uncertainty. Carbon disclosure may also display this potential uncertainty-reducing role and likewise alleviate the negative impact of current carbon emissions on corporate value.

Previous studies employing environmental pollution, corporate value and disclosure faced the following challenges. First, previous analyses using information other than carbon emissions typically addressed a limited range of industries because they dealt with a defined set of data or a specific regulation. One outcome is that their results are not necessarily generalizable. Second, analysis using voluntarily disclosed carbon emission data involves sampling biases and an endogeneity problem. Finally, the interactive effect of the volume of carbon emissions and disclosure on corporate value is not made clear.

Therefore, in this study, we (1) investigate the relation between the volume of carbon emissions and corporate value using carbon emissions data mandatorily reported to government under law. As our data are free from sampling biases and endogeneity, we can then (2) investigate the relation between corporate carbon management disclosure (as proxied by company responses to the CDP questionnaire) and corporate value, and (3) investigate whether the positive relation between the disclosure of carbon management practices and the market value of equity is greater in companies with larger volumes of carbon emissions.

3. HYPOTHESES DEVELOPMENT

3.1. Relation between carbon emission and the market value of equity (Hypothesis 1)

As discussed in Section 2, Previous studies (Aggarwal and Dow, 2011; Matsumura *et al.*, 2011; Griffin *et al.*, 2012) conclude that there is a negative relation between carbon emissions and corporate value, with the Japan Accounting Association Special Committee (2009) evidencing the same relation in Japan. However, these studies have some limitations. First, the analyses in Aggarwal and Dow (2011), Matsumura *et al.*(2011) and Griffin *et al.*(2012) are based on the voluntarily reported volume of carbon emissions, and thus entail an endogeneity problem (i.e., companies that voluntarily disclose carbon emission data are likely to have a higher corporate value, irrespective of the volume of emissions). Second, the reliance on voluntarily disclosure necessarily decreases the sample size and thereby reduces the credibility of the reported values. Although the Japan Accounting Association Special Committee (2009) use mandatorily disclosed carbon emissions data, the data were restricted to a single year because of a lack of data availability and thus the results lack generality.

In this paper, we use mandatorily reported carbon emissions data over three years. In Japan, consistent emissions data covering all types of industry became available under law after the 2006 financial year (FY2006). Since then, companies have had to report their greenhouse gas emissions to government, and so the research challenges evident in previous studies are solved.

Hypothesis 1: The volume of carbon emissions displays a negative relation with the market value of equity.

At first impression, our analysis appears similar to the work by Aggarwal and Dow (2011), Matsumura *et al.*(2011) and Griffin *et al.*(2012), but it is worthwhile to find whether the empirical results hold (1) when we apply the same analysis to Japanese data, (2) when we

use mandatorily disclosed as against voluntary carbon emissions data, and (3) when we combine data over three years. Additionally, as the time period from FY2006 to FY2008 includes both economic upturns and downturns, we can be assured that our empirical results are unaffected by general economic conditions.

Hypothesis 1 attempts to capture the effect of different carbon emissions (between companies) on market capitalization. The business world often takes the view that investment undertaken to reduce carbon emissions will also reduce short-term profits and increase cash outflows. In this paper, we argue that a reduction in carbon emissions persistently improves medium- and long-term profits and cash inflows through the cost reductions made available by decreasing the use of raw materials and fuel and through enhancing the company's image for its stakeholders.

3.2. Relation between disclosure of carbon management and market value of equity (Hypothesis 2)

Most previous studies demonstrate the positive effects of company voluntary disclosure. For example, Botosan (1997) and Botosan and Plumlee (2001) show that companies with rich disclosure enjoy a lower cost of equity capital. In the context of voluntary disclosure on the environment, Dhaliwal *et al.* (2011) confirm that companies with environmental disclosure are associated with a lower cost of equity capital, while Guidry and Patten (2010) observe a positive reaction by the stock market when high-quality sustainability reports are issued. All other things being the same, a lower cost of equity capital should yield a higher market value of equity. It is thus obvious that rich disclosure improves the market value of equity.

In this paper, we use CDP response data as a proxy for disclosure of carbon management practices. Even though the volume of carbon emissions is made public, investors are sometimes unsure about the future (financial) consequences of the emissions, and other information will often assist investors to evaluate correctly its implications. As the CDP measure is investor oriented and has a common format, the disclosure of carbon management practices through the responses to the CDP questionnaire will assist the process of communication between companies and investors.

Hypothesis 2: Disclosure of carbon management practices through the responses to the CDP questionnaire has a positive relation with the market value of equity.

Although the ISO 14001 certification might be another proxy for carbon management practices, we employ the CDP response data. Because CDP is a non-profit coalition representing 655 investors with assets of US\$78 trillion, the CDP response data can be thought as being a more investor-oriented form of disclosure than the ISO 14001 certification [1].

3.3. Interactive effect between the volume of carbon emissions and the disclosure of carbon management practices on the market value of equity (Hypothesis 3)

Most existing analyses of the relation between CSP of any kind (e.g., the volume of carbon emissions) and CFP (e.g., the market value of equity) have not considered the implications of additional disclosure. Consequently, the findings can only be used to infer the static relation depicted in Panel A in Figure I. Conversely, most prior analyses of the relation between disclosure (e.g., responses to the CDP questionnaire) and corporate financial performance do not condition the relation for the original status of corporate social performance. Therefore, the results can inform us about a shift (or change in the magnitude) in the relation, but nothing about a change in the slope (or responsiveness) of the relation. As such, we are

unable to identify unambiguously which of the two potential shifts depicted in Panel B in Figure I has actually taken place.

In our empirical circumstances, even we observe the negative relation between the volume of carbon emissions and the market value of equity and confirm the positive relation between the disclosure of carbon management and the market value of equity. It remains unclear whether the degree of positive relation differs according to the volume of carbon emissions unless we can discern the interactive effect between the volume of carbon emissions and carbon management disclosure. For example, if the volume of carbon emissions for a given company is already low (high), the magnitude of the risk impact on future financial measures that CDP attempts to capture tends to be small (large). Thus, we need to analyse the effect of carbon management disclosure conditional on the volume of current carbon emissions.

Hypothesis 3: The positive relation between carbon management disclosure and the market value of equity is larger (smaller) if the volume of carbon emissions is higher (lower).

4. EMPIRICAL MODELS

4.1. Analysis of carbon emissions and carbon management disclosure (Hypotheses 1 and 2)

To conduct our empirical analysis, we employ the model in Ohlson (1995, 2001), primarily because this model is relatively robust with respect to management accounting discretions. In this model, even if management attempts to boost the current period's earnings through changes in accounting procedures (e.g., specifying a longer useful life for the depreciation of assets, switching from LIFO to FIFO for inventory accounting), the value of the company remains unchanged as the higher residual income in the current period is offset by lower residual income in future periods. In addition, unlike the original residual income model, the Ohlson model aims to measure the relation between current (residual) income and future (residual) incomes. Assuming market efficiency, we estimate the market value of equity (MVE) as follows:

$$\begin{aligned}
 MVE_t &\approx BVE_t + \sum_{i=1}^{\infty} x_t^a \\
 &= BVE_t + \sum_{i=1}^{\infty} \frac{NI_{t+i} - BVE_{t+i-1} \times r}{(1+r)^i} \\
 x_{t+1}^a &= \omega_1 x_t^a + \mu_t + \varepsilon_{1,t+1} \\
 \mu_{t+1} &= \omega_2 \mu_t + \varepsilon_{2,t+1}
 \end{aligned}$$

where

MVE_t = market value of equity at time t ,

BVE_t = book value of equity at time t ,

x_t^a = residual income for period t ,

NI_t = net income for period t ,

r = cost of equity capital,

μ_t = ‘new’ information that affects future residual income and is received at time t ,
 ω_1, ω_2 = parameters indicating the persistency of residual income and new information, respectively, and
 $\varepsilon_{1,t}, \varepsilon_{2,t}$ = error terms for residual income and new information, respectively, at time t .

Transforming the Ohlson model framework, we express the sum of the discounted present values of future residual earnings using four variables: namely, current-period residual earnings (NI_t), the persistence of current-period residual earnings (ω_1), other information affecting residual earnings in the next period (μ_t), and the persistence of other information affecting residual earnings in the next period (ω_2). As proxies for these variables, we respectively employ current earnings, forecast earnings for the next period, and carbon emissions per unit. In the case of Hypothesis 1, which aims to observe the relation between the volume of carbon emissions and the market value of equity, we estimate the following regression (1), such that Hypothesis 1 will be empirically supported if the sign of the estimated coefficient for β_4 is significantly negative. To deal with any differences in carbon emission behaviour across industries, we specify industry dummy variables using the Nikkei Industries Classification.

The current Japanese reporting scheme for carbon management practices requires companies to report their volume of carbon emissions on an individual company basis and not on a consolidated basis as in accounting. To address this, we multiply the volume of carbon emissions by the consolidation ratio, defined as the total assets of an individual company in the consolidated financial statements divided by the total assets of the company in the individual company financial statements [2].

$$MVE_t = \alpha + \beta_1 BVE_t + \beta_2 EARN_t + \beta_3 E_t[EARN_{t+1}] + \beta_4 Carbon_t + \varepsilon, \quad (1)$$

where

MVE_t = market value of equity at time t ,

BVE_t = book value of equity at time t ,

$EARN_t$ = earnings before extraordinary items in period t ,

$E_t[EARN_{t+1}]$ = forecast of earnings before extraordinary items for the next year at time t ,

$Carbon_t$ = volume of carbon emissions per unit of sales in period t , and

ε = error term.

To test Hypothesis 2, we use the company responses to the CDP questionnaire as a proxy for the disclosure of carbon management practices. We slightly modify Equation (1) to the form in Equation (2) to see if the Hypothesis 2 is empirically supported. Hypothesis 2 will be empirically supported if the sign of the estimated coefficient for β_4 is significantly positive.

$$MVE_t = \alpha + \beta_1 BVE_t + \beta_2 EARN_t + \beta_3 E_t[EARN_{t+1}] + \beta_4 Disclosure_t + \varepsilon, \quad (2)$$

where

$Disclosure_t$ = a dummy variable that takes a value of 1 if the company responded to the CDP questionnaire at time t , otherwise 0, and all other variables are as previously defined.

To cope with the small samples for non-respondents to the CDP questionnaire (i.e., companies that received but did not return the questionnaire), we treat these samples and those with non-receivers of the questionnaire (i.e., companies that did not receive the questionnaire in the first instance and thus had no opportunity to respond) in the same manner. We later conduct additional analysis of these sub-samples.

4.2. Analysis of the interactive effect of the volume of carbon emissions and carbon management disclosure (Hypothesis 3)

To discern the interactive effect of the volume of carbon emissions and carbon management disclosure, we run the regression detailed in Equation (3). Hypothesis 3 will be supported if the sign of the estimated coefficient for β_6 is positive and the signs of the estimated coefficients for β_4 and β_5 remain, respectively, negative and positive. We can use this regression equation to appreciate whether carbon management disclosure moderates the negative effect of carbon emissions on the market value of equity (i.e., the negative coefficient of β_4 is somewhat offset by the coefficient of β_6), by differentiating Equation (3) with respect to *Carbon* as against *Disclosure*.

$$MVE_t = \alpha + \beta_1 BVE_t + \beta_2 EARN_t + \beta_3 E_t[EARN_{t+1}] + \beta_4 Carbon_t + \beta_5 Disclosure_t + \beta_6 Carbon_t \times Disclosure_t + \varepsilon, \quad (3)$$

where all variables are as previously defined.

We also run a regression of Equation (3) without the interaction term to ensure that the positive (negative) relation we observe between the volume of carbon emissions (carbon management disclosure) and the market value of equity remains unchanged, even when both variables are specified in the same regression.

5. SAMPLE SELECTION AND DATA COLLECTION

We draw our carbon emission data from the information reported under the emissions reporting scheme. In 2006, 2007, and 2008, there were 1,085, 808, and 1,057 listed companies, respectively, that reported carbon emissions. As explained, we use the company consolidation ratio to address the problem of different measurement attributes when mixing carbon emissions data (reported on an individual company basis) and financial data (reported on a consolidated basis).

In terms of carbon management disclosure, we employ the list of companies responding to the CDP questionnaire. The CDP questionnaire includes questions concerning the perceived risks and opportunities relating to climate change and any details companies may have on plans for emission reductions, targets, and strategies. We use the respondent data for the “Carbon Disclosure Project Report: Japan 150”, for 2006, 2007 and 2008 (Carbon Disclosure Project (2006, 2007, 2008) sent to 150 Japanese companies, with 96, 111, and 111 companies responding to each questionnaire, respectively. We extract financial and stock price data from Nikkei NEEDS Financial Quest. Our sample consists of companies with a March fiscal year end (which represents 74 per cent of listed companies in Japan). We use stock prices at the end of May, as tentative financial statements are usually released at this time in Japan. We designate earnings before extraordinary items as our profit figure (current earnings and forecasted earnings for the next period) given its role as a proxy variable to explain future financial performance.

We limit our sample to the manufacturing sector using the Nikkei industry classification codes [3]. Note also that we deflate all financial variables (i.e., MVE_t , BVE_t , $EARN_t$, $E_t[EARN_{t+1}]$) by year-end total assets. To calculate carbon emissions per unit, we employ the following year’s sales as a proxy of the level of manufacturing. As the distributions of MVE_t , BVE_t , $EARN_t$, $E_t[EARN_{t+1}]$, and $Carbon_t$ all display a long tail on the right, we apply a logarithmic transformation and remove the top and bottom one per cent of observations as outliers.

We also removed companies from the sample that were missing variables required for the analysis. As a result, we included 1,094 observations of firms. Of these, 89 companies

represented CDP respondents, 16 companies were non-respondents, and the remaining 989 firms did not receive the questionnaire. Table I provides descriptive statistics for each variable and Table II includes the correlation coefficients.

Table I.

Descriptive statistics

Table II.

Correlation matrix

6. RESULTS OF THE ANALYSIS

6.1. Result concerning the relation between the volume of carbon emissions, carbon management disclosure, and the market value of equity (Hypotheses 1–3)

Table III presents the results of the analysis of Hypothesis 1. The estimated coefficient on carbon emissions per unit is significantly negative given net assets, earnings before extraordinary items, and forecasted earnings. This result supports the argument in Hypothesis 1 concerning the negative relation between the volume of carbon emissions and the market value of equity. It is also consistent with prior research including Matsumura *et al.* (2011) and Japan Accounting Association Special Committee (2009) of an observed negative relation between carbon emissions and the market value.

Table III.

Relation between the volume of carbon emissions and the market value of equity

The result concerning Hypothesis 2 is included in Table IV. The empirical result supports our hypothesis that carbon management disclosure is associated with a higher market value of equity. The estimated coefficient for carbon management disclosure is significantly positive given net assets, earnings before extraordinary items, and forecasted earnings. This finding is consistent with existing research (e.g., Cox and Douthett, 2009; Moneva and Cuellar, 2009; Cho *et al.*, 2010).

Table IV.

Relation between carbon management disclosure and the market value of equity

Table V provides the results concerning Hypothesis 3. In Hypothesis 3, we argued that the positive relation between carbon management disclosure and the market value of equity is stronger (weaker) for the companies with a high (low) volume of carbon emissions. We ran the regression with and without the interaction term, and the estimates are shown in the two lower and two upper rows, respectively, in Table V. The results are again consistent with our hypothesis. The sign of the coefficient for the interaction term is positive, though the statistical significance is not strong. The other estimated coefficients are as predicted and strongly significant.

We can interpret this result in two ways. To start with, if we differentiate equation (3) with respect to *Disclosure*, the estimated coefficient for the interaction term is the difference in the magnitude of the positive effect of carbon management disclosure given a change in the volume of carbon emissions. As the sign of the estimated coefficient for β_6 is positive, the larger the volume of carbon emissions, the greater the positive relation between carbon management and the market value of equity. Alternatively, if we differentiate equation (3) with respect to *Carbon*, the estimated coefficient for the interaction term is the difference in

the slope of the relation between companies with and without carbon management disclosure. Once again, the sign of the estimated coefficient is positive; thus, the negative slope is steeper for the companies without carbon management disclosure. Overall, our empirical results are consistent with all three hypotheses proposed [4].

Table V.

Interactive effect of the volume of carbon emissions and carbon management disclosure on the market value of equity

6.2. Supplementary analysis of the effect of carbon management disclosure on the market value of equity

Until now, we have treated companies that received but did not respond to the CDP questionnaire and those that did not receive the CDP questionnaire in the same manner. However, the stock market may react differently to this difference in behaviour. For example, the stock market may penalize companies that intentionally refused to respond to the questionnaire more than those that could not respond to the questionnaire because they did not receive it in the first instance. To reveal this difference, we categorized our sample into three groups: companies that received and responded to the questionnaire (Group 1), companies that did not receive the questionnaire (Group 2), and companies that received the questionnaire but did not respond (Group 3). We hypothesize that the negative relation between the volume of carbon emissions and the market value of equity is largest for companies in Group 3 and smallest for companies in Group 1. Table VI provides the results for the regressions of equation (1) for the three groups. We omitted the industry dummies given the small sample sizes, especially in Group 3. The relation of the estimated coefficients was as expected, but the difference is not statistically significant, most likely because of the small sample size. We intend to reanalyse this relation when more data become available.

Table VI.

Relation between the volume of carbon emissions and the market value of equity by carbon management disclosure group

7. SUMMARY AND CONCLUSION

The main objective of this study was to examine the impact of corporate carbon emissions and disclosure on corporate value, especially regarding whether disclosure helped to reduce the uncertainty in corporate valuation predicted by carbon emissions. Global warming is being increasingly recognized as a global priority and, as the issue of carbon emissions has a significant impact on business activity and behaviour, several studies analyse the relation between carbon emissions and corporate value (Aggarwal and Dow, 2011; Matsumura *et al.*, 2011; Griffin *et al.*, 2012). However, the empirical use of data on voluntarily disclosed carbon emissions involves an endogeneity problem, and not considering the effects of actual corporate carbon emissions and disclosure entails proof of a relation of only a superficial nature.

As no existing studies that we know of, analyse the impact of disclosure on corporate value conditional on actual carbon emissions, we investigated whether disclosure helps to reduce the uncertainty in corporate valuation predicted by carbon emissions using a unique data set on Japanese companies. In this study, we investigated (1) whether corporate carbon emissions have a negative relation with the market value of equity, (2) whether carbon management disclosure has a positive relation with the market value of equity, and (3) whether the positive relation between carbon management disclosure and the market value of

equity is larger (smaller) if the volume of carbon emission is higher (lower). Our empirical results support all three hypotheses.

Our contributions to the literature are as follows. First, we provide the first empirical evidence of an interactive effect between the volume of carbon emissions and carbon management disclosure on the market value of equity. Second, our results are readily generalizable concerning the relation between environmental performance, disclosure, and market value, especially as all companies emit carbon, either directly or indirectly. Existing studies using data on environmental pollution other than carbon emissions, including sulphur dioxide (SO₂) (Hughes, 2000; Johnston *et al.*, 2008; Lu, 2011), chemical substances (King and Lenox, 2002) and soil contamination (Barth and McNichols, 1994; Garber and Hammitt, 1998; Bae and Sami, 2005), typically employ samples from a limited number of or necessarily pollution-biased industries. In addition, our results are arguably free from problems with sampling bias and endogeneity as we employ data obtained from the compulsory filing of carbon emissions information. If we were instead to use voluntarily disclosed emissions data, we may potentially identify a false positive relation between carbon emissions and market value because of the endogeneity problem. Finally, our findings should encourage Japanese companies to reduce carbon emissions and to disclose their carbon management activities. Furthermore, our results for Japanese companies, which already demonstrate better energy efficiency and a relatively high marginal carbon reduction cost, suggest that even stronger results concerning these relations may be obtained in countries outside Japan.

Of course, our analysis involves some caveats. First, as we did not have access to the raw data underlying the responses to the CDP questionnaire, we were unable to confirm the veracity of the responses and the information given, and whether any differences would have affected our main findings. Access to these data would have been useful. Second, in terms of carbon emissions, although we assume that companies report faithfully because they are subject to fines if they fail to report or if they file a false report, we are unable to check the accuracy of the carbon emissions data obtained from the government. Further information would have been worthwhile. Finally, our analysis is based on data from a single country. It would therefore be useful to include data from outside Japan and see whether the results differ. Nevertheless, our results show that investors utilize carbon emission information and confirm the role of disclosure in reducing *uncertainty* (Christensen and Demski, 2003). This is an important result when considering the inclusion of carbon disclosure as a component of nonfinancial disclosure.

NOTE

1. Saka and Oshika (2011) observe the empirical result that ISO 14001 certification has a positive association with the market value of equity.
2. We also ran regressions using alternative consolidation ratios (e.g., total sales, earnings before extraordinary items, and net income). The results were similar.
3. The data from the Japanese Ministry of Environment show that firms in the manufacturing industry (steel, chemicals, ceramic products, pulp and paper, petroleum and coal products, electric parts, device and integrated circuit manufacturers, transportation machinery, food manufacturing, and other) account for approximately 80 per cent of total emissions.
4. We also divided our samples into three groups according to sample year. The results were similar.

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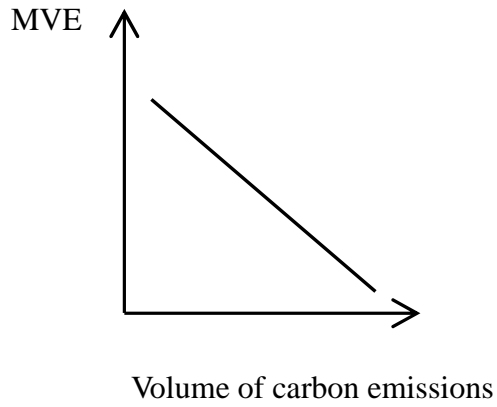
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Figure I.
Interactive effect

Panel A: Relation between volume of carbon emissions and market value of equity



Panel B: Interactive effect between volume of carbon emissions and disclosure on market value of equity

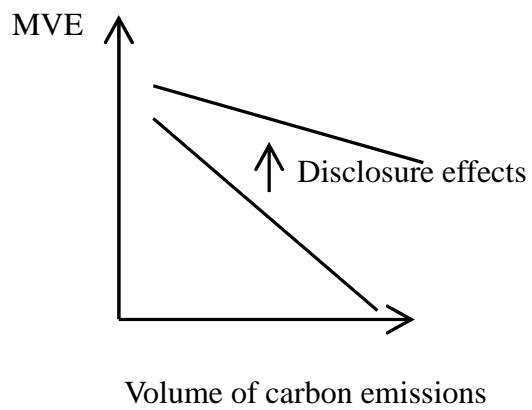
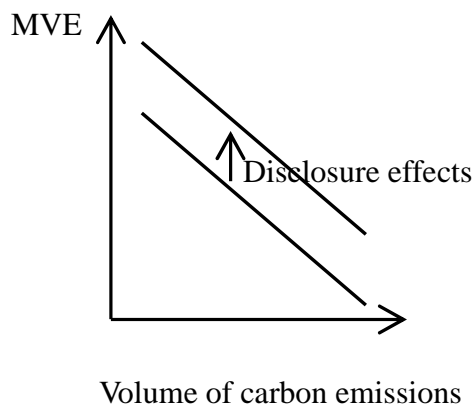


Table I.

Descriptive statistics

Variable	Mean	Std. dev.	Min.	Q1	Median	Q3	Max.
MVE_t	-0.639	0.624	-2.597	-1.055	-0.656	-0.208	1.073
BVE_t	-0.764	0.410	-2.305	-1.017	-0.716	-0.461	-0.093
$EARN_t$	-2.943	0.712	-5.833	-3.327	-2.861	-2.445	-0.760
$E_t[EARN_{t+1}]$	-3.220	0.851	-6.302	-3.724	-3.147	-2.568	-0.946
$Carbon_t$	-0.950	1.338	-5.088	-1.798	-1.058	-0.148	2.406

Notes: MVE_t is the market value of equity at time t . BVE_t is the book value of equity at time t . $EARN_t$ is reported earnings before extraordinary items in period t . $E_t[EARN_{t+1}]$ is forecasted earnings in period $t+1$ released at time t . $Carbon_t$ is the volume of carbon emissions in period t divided by sales in period t , and multiplied by the consolidation ratio, which is the multiple of total assets in the consolidated financial statement divided by total assets in the individual financial statement. We deflate MVE_t , BVE_t , $EARN_t$, and $E_t[EARN_{t+1}]$ by total assets at time t , apply a logarithmic transformation, and remove the top and bottom one per cent of observations as outliers.

Table II.

Correlation matrix

Variable	MVE_t	BVE_t	$EARN_t$	$E_t[EARN_{t+1}]$	$Carbon_t$
MVE_t	1	0.524	0.688	0.585	-0.284
BVE_t	0.522	1	0.358	0.235	-0.136
$EARN_t$	0.655	0.360	1	0.663	-0.107
$E_t[EARN_{t+1}]$	0.559	0.211	0.585	1	-0.081
$Carbon_t$	-0.262	-0.116	-0.072	-0.063	1

Notes: Figures below the diagonal are Pearson (product-moment) correlation coefficients, and figures above diagonal are Spearman (rank) correlation coefficients. MVE_t is market value of equity at time t . BVE_t is book value of equity at time t . $EARN_t$ is reported earnings before extraordinary items in period t . $E_t[EARN_{t+1}]$ is forecasted earnings in period $t+1$ released at time t . $Carbon_t$ is the volume of carbon emissions in period t divided by sales in period t , and multiplied by the consolidation ratio, which is the multiple of total assets in the consolidated financial statement divided by total assets in the individual financial statement. We deflate MVE_t , BVE_t , $EARN_t$, and $E_t[EARN_{t+1}]$ by total assets at time t , apply a logarithmic transformation, and remove the top and bottom one per cent of observations as outliers.

Table III.

Relation between the volume of carbon emissions and the market value of equity

N	Intercept	BVE_t	$EARN_t$	$E_t[EARN_{t+1}]$	$Carbon_t$	Industry dummies	Year dummies	Adj-R ²
1,094	0.985 (11.36)**	0.463 (14.75)**	0.330 (14.88)**	0.150 (8.50)**	-0.037 (-3.49)**	Yes	Yes	0.6632
1,094	1.032 (15.25)**	0.496 (15.87)**	0.325 (14.54)**	0.170 (9.25)**	-0.086 (-9.67)**	No	Yes	0.6109

Notes: The dependent variable is MVE_t , the market value of equity at time t . BVE_t is book value of equity at time t . $EARN_t$ is reported earnings before extraordinary items in period t . $E_t[EARN_{t+1}]$ is forecasted earnings in period $t+1$ released at time t . $Carbon_t$ is the volume of carbon emissions in period t divided by sales in period t , and multiplied by the consolidation ratio, which is the multiple of total assets in the consolidated financial statement divided by total assets in the individual financial statement. We deflate MVE_t , BVE_t , $EARN_t$, and $E_t[EARN_{t+1}]$ by total assets at time t , apply a logarithmic transformation, and remove the top and bottom one per cent of observations as outliers. Industry and year dummy variables included (results not shown). The figures in parenthesis are t -values. **, *, and * indicate that the coefficients are significant at the 1%, 5%, and 10% level, respectively.

Table IV.

Relation between carbon management disclosure and the market value of equity

N	Intercept	BVE_t	$EARN_t$	$E_t[EARN_{t+1}]$	$Disclosure_t$	Industry dummies	Year dummies	Adj-R ²
1,094	0.978 (11.72)**	0.485 (15.85)**	0.322 (14.85)**	0.145 (8.40)**	0.326 (8.10)**	Yes	Yes	0.6791
1,094	1.078 (16.19)**	0.539 (17.37)**	0.318 (14.27)**	0.166 (9.03)**	0.435 (10.09)**	No	Yes	0.6136

Notes: The dependent variable is MVE_t , the market value of equity at time t . BVE_t is book value of equity at time t . $EARN_t$ is reported earnings before extraordinary items in period t . $E_t[EARN_{t+1}]$ is forecasted earnings in period $t+1$ released at time t . $Carbon_t$ is the volume of carbon emissions in period t divided by sales in period t , and multiplied by the consolidation ratio, which is the multiple of total assets in the consolidated financial statement divided by total assets in the individual financial statement. $Disclosure_t$ is a dummy variable that takes a value of one if a company has responded to the CDP questionnaire at time t , otherwise zero. Thus, companies that have not responded to the CDP questionnaire and that did not receive the CDP questionnaire in the first instance are treated in the same way. We deflate MVE_t , BVE_t , $EARN_t$, and $E_t[EARN_{t+1}]$ by total assets at time t , apply a logarithmic transformation, and remove the top and bottom one per cent of observations as outliers. Industry and year dummy variables included (results not shown). The figures in parenthesis are t -values. **, *, and * indicate that the coefficients are significant at the 1%, 5%, and 10% level, respectively.

Table V.

Interactive effect of the volume of carbon emissions and carbon management disclosure on the market value of equity

N	Intercept	BVE_t	$EARN_t$	$E_t[EARN_{t+1}]$	$Carbon_t$	$Disclosure_t$	$Carbon_t \times Disclosure_t$	Industry dummies	Year dummies	Adj-R ²
1,094	0.914 (10.82)**	0.477 (15.65)**	0.325 (15.11)**	0.143 (8.32)**	-0.041 (-3.98)**	0.334 (8.33)**		Yes	Yes	0.6835
1,094	0.962 (14.75)**	0.511 (17.06)**	0.316 (14.77)**	0.162 (9.15)**	-0.081 (-9.53)**	0.413 (9.96)**		No	Yes	0.6431
1,094	0.924 (10.92)**	0.476 (15.63)**	0.326 (15.16)**	0.143 (8.34)**	-0.099 (-2.86)**	0.299 (6.69)**	0.031 (1.76)†	Yes	Yes	0.6841
1,094	0.965 (14.82)**	0.509 (16.97)**	0.318 (14.87)**	0.161 (9.10)**	-0.151 (-4.31)**	0.371 (8.03)**	0.037 (2.05)*	No	Yes	0.6442

Notes: The dependent variable is MVE_t , the market value of equity at time t . BVE_t is book value of equity at time t . $EARN_t$ is reported earnings before extraordinary items in period t . $E_t[EARN_{t+1}]$ is forecasted earnings for period $t+1$ released at time t . $Carbon_t$ is volume of carbon emissions in period t divided by sales in period t , and multiplied by the consolidation ratio, which is the multiple of total assets in the consolidated financial statement divided by total assets in the individual financial statement. $Disclosure_t$ is a dummy variable that takes a value of one if a company has responded to the CDP questionnaire at time t , otherwise zero. Thus, companies that have not responded to the CDP questionnaire and that did not receive the CDP questionnaire in the first instance are treated in the same way. $Carbon_t \times Disclosure_t$ is the interaction between $Carbon_t$ and $Disclosure_t$. We deflate MVE_t , BVE_t , $EARN_t$, and $E_t[EARN_{t+1}]$ by total assets at time t , apply a logarithmic transformation, and remove the top and bottom one per cent of observations as outliers. Industry and year dummy variables included (results not shown). The figures in parenthesis are t -values. **, *, and * indicate that the coefficients are significant at the 1%, 5%, and 10% level, respectively.

Table VI.

Relation between the volume of carbon emissions and the market value of equity by carbon management disclosure group

Group	N	Intercept	BVE_t	$EARN_t$	$E_t[EARN_{t+1}]$	$Carbon_t$	Industry dummies	Year dummies	Adj-R ²
1	89	1.687 (14.20)**	0.444 (6.36)**	0.246 (5.89)**	0.313 (7.90)**	-0.070 (-3.85)**	No	Yes	0.8836
2	989	0.929 (13.12)**	0.508 (15.87)**	0.316 (13.62)**	0.154 (8.17)**	-0.080 (-8.62)**	No	Yes	0.5992
3	16	1.474 (5.04)**	0.697 (4.39)**	0.535 (3.96)**	0.109 (1.04)	-0.090 (-2.28)*	No	Yes	0.8832

Notes: Group 1 contains companies that responded to the CDP questionnaire. Group 2 contains companies that did not receive the CDP questionnaire. Group 3 contains companies that received but did not respond to the CDP questionnaire. The dependent variable is MVE_t , the market value of equity at time t . BVE_t is book value of equity at time t . $EARN_t$ is reported earnings before extraordinary items in period t . $E_t[EARN_{t+1}]$ is forecasted earnings for period $t+1$ released at time t . $Carbon_t$ is volume of carbon emissions in period t divided by sales in period t , and multiplied by the consolidation ratio, which is the multiple of total assets in the consolidated financial statement divided by total assets in the individual financial statement. We deflate MVE_t , BVE_t , $EARN_t$, and $E_t[EARN_{t+1}]$ by total assets at time t , apply a logarithmic transformation, and remove the top and bottom one per cent of observations as outliers. Year dummy variables included (results not shown). Industry dummy variables not included because of small sample size. The figures in parenthesis are t -values. **, *, and * indicate that the coefficients are significant at the 1%, 5%, and 10% level, respectively.