Environmental Disclosure and the Cost of Capital: Evidence from the Fukushima Nuclear Disaster*

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Abstract

We exploit the Fukushima nuclear disaster as a source of variation in the demand for environmental information to study the economic consequences of environmental disclosure. Using a large, hand-collected sample of Japanese firms, we find that firms that issue stand-alone environmental reports incur a less severe—although economically and statistically negligible—increase in the cost of capital after the disaster than non-disclosing firms. Most important, we document that, within disclosing firms, those reporting verifiable information on their expected environmental performance experience a lower increase in the cost of capital compared to both non-disclosing firms and to firms that do not report information on their expected performance. Finally, firms react to the disaster by increasing the disclosure of forward-looking information, with a larger effect for firms with histories of forward-looking guidance. Taken together, our results help to clarify the circumstances under which the disclosure of non-financial and unregulated information affects the cost of capital.

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1. Introduction

The number of firms that issue social and environmental reports has increased significantly since the 1990s (Simnett et al., 2009). While only about 500 firms published an environmental report in 1998, almost 6,000 did so in 2011 (Corporate Register, 2012). Extant literature argues that environmental reporting informs a broad range of stakeholders about the environmental impacts of corporate activities (Roberts, 1992; GRI, 2013). However, there is little empirical evidence on whether environmental reporting has economic consequences for investors. Even if environmental disclosure improves investor information and decreases uncertainty, which translates into a lower cost of capital (Diamond and Verrecchia, 1991; Easley and O'Hara, 2004; Lambert et al., 2007), the absence of regulatory guidance, verifiability, and penalties for misreporting raises credibility concerns (Cho and Patten, 2007; Dhaliwal et al. 2011) and questions about whether such disclosure affects a firm's information environment. Prior studies provide insights into how environmental disclosure affects the cost of capital (Richardson and Welker, 2001; Plumlee et al. 2010; Dhaliwal et al., 2011), but they rely on cross-sectional designs or do not consider how firms address credibility concerns within the unregulated setting of environmental disclosure.

In this paper, we use the Fukushima nuclear disaster (henceforth, "the disaster") as a source of variation in the demand for environmental information in order to study the effect of environmental disclosure on the firm's cost of capital. On March 11, 2011, following a major undersea earthquake, a tsunami disabled the power supply and cooling of three Fukushima Daiichi reactors owned by Tokyo Electric Power Co., causing the meltdown of all three cores in the following three days. In the aftermath of the disaster, a broad range of stakeholders has questioned the role environmental reports play in informing firm stakeholders about the environmental implications of corporate activities (CSRwire, 2011), and firms have become aware of the demand for information about how they manage issues related to the environment.

The underlying hypothesis of the study is that the disaster triggered a shift in the environmental disclosure equilibrium for all firms by raising concerns over how firms manage issues related to the environment. This change in the demand for information is expected to translate to an increase in firms' average cost of capital. However, given the largely voluntary nature of environmental reports (Blacconiere and Patten, 1994; Dhaliwal et al., 2011), we expect that the change in a firms' cost of capital differs according to the level of precision and credibility of their pre-disaster disclosures.

In the highly unregulated setting of environmental reporting, it is unclear how firms can provide credible information to investors. Theory predicts that firms can affect their information environment by committing ex ante to disclose information ex post, regardless of the nature of the information to be disclosed (Diamond and Verrecchia, 1991; Leuz and Verrechia, 2000; Leuz et al., 2007). Therefore, we define firms that report precise, forward-looking information on their environmental efforts (i.e., expected environmental performance) which is ex-post verifiable, as firms that provide credible environmental information.

A firm will start disclosing information about its expected environmental effort according to its current cost and benefit trade-off. However, once started, the disclosure is likely to be persistent and credible for at least three reasons. First, firms cannot lower the market penalty associated with the decision to stop disclosure by claiming to be uninformed, as once the firm starts disclosing, investors infer that the managers have the proprietary information and expect the disclosure to continue (Dye, 1985; Jung and Kwon, 1988).[1] Second, there is a trade-off between the benefits of stopping disclosure (e.g., because of bad performance) and the costs associated with lowering the credibility of future disclosure because the decision to stop disclosing is interpreted as a negative signal (Stocken, 2000; Einhorn and Ziv, 2008). Third, the disclosure of environmental performance is potentially highly proprietary (Li et al., 1997), and it bears political and regulatory costs (Blacconiere and Patten, 1994; Cho and Patten, 2007; Patten and Trompeter, 2003; Cormier and Magnan, 2003), so it is costly and potentially self-enforcing (Gigler, 1994). Accordingly, we expect that firms that continuously disclose their expected environmental performance (i.e., environmental targets) exhibit a credible commitment to disclosure and will experience a lower increase in the cost of capital after the disaster.

Our empirical strategy is akin to a difference-in-differences design in that we use the disaster as a source of time variation in the demand for environmental information, and heterogeneity in pre-disaster disclosure as a source of cross-sectional variation. This specification contrasts the change in the cost of capital around the disaster for non-disclosing and disclosing firms, allowing the coefficient for disclosing firms to vary with respect to the presence of information on environmental targets.

While the timing of the disaster is plausibly exogenous to firms' characteristics and underlying performance, identifying the role of environmental disclosure on firms' cost of capital is challenging for two reasons. First, the disaster likely triggered changes in the cost of capital through both a cash flow channel and an

[1] Investors are particularly likely to infer that the managers have the required information and expect the disclosures to continue in our setting, as the disclosure of expected environmental performance implies that the firm has put in place an environmental management system that can track the progress toward its goals (Darnall and Edwards, 2006).

estimation risk channel. Second, firms' pre-disaster disclosure strategy is likely to be associated with their specific characteristics (e.g., operating risk), which might play a role in explaining the heterogeneous changes in their cost of capital. We address these issues by employing firm fixed effects and a propensity score-matching design to minimize the degree of observable heterogeneity between disclosing and non-disclosing firms (Blundell and Costa-Dias, 2009). In addition, we employ ex-ante estimates of firms' implied cost of capital based on prices and analyst forecasts. Since the change in the cost of capital around the time of the disaster likely reflected concurrent changes in firms' expected cash flows, rather than changes in the demand for environmental information, the use of ex-ante estimates of firms' cost of capital allows us to control for revisions in firms' expected cash flows (Hail and Leuz, 2009).

We start the analysis by determining whether the disaster has led to an increase in concerns about how firms manage environmental risk. Because we cannot observe the demand for environmental information, we use the sensitivity of environmental performance to the cost of capital as a proxy for the importance that investors place on environmental information in discounting stock prices. While we find that the cost of capital was insensitive to environmental performance before the disaster, we observe a sharp increase in the cost of capital's sensitivity to environmental performance after the disaster. While this observation is only suggestive, it provides preliminary and descriptive evidence on how the disaster is associated with an increase in the importance placed on environmental information in assessing a firm's risk.

Next, we turn to examine whether firms that issue a stand-alone environmental report experience a less severe increase in the cost of capital after the disaster relative to firms that do not. While we document a significant average increase in the cost of capital for all firms, we find only a negligible and not significant difference in changes in the cost of capital between firms that issue a stand-alone report and those that do not. However, the absence of a statistical and economically significant difference between disclosing and non-disclosing firms masks substantial heterogeneity. Among disclosing firms, we find that firms that provide environmental targets experience a lower increase in the cost of capital relative to both non-disclosing firms and to disclosing firms that do not include such information.

Next, we carry out a battery of cross-sectional analyses to address alternative explanations. First, we examine whether our results are driven by heterogeneity in firms' environmental performance. One could argue that firms disclosing information about the expected environmental performance are more likely to report good environmental news, and, as a result, experience a less severe increase in the cost of capital around the disaster. We do not find evidence that heterogeneity in the pre-disaster environmental performance drives our results. Second, we consider other firms characteristics (i.e., operating risk, capital intensity, and cash flow revisions around the disaster), which might correlate with a firm's disclosure strategy and thus explain the different cost of capital reactions to the disaster. However, we do not find evidence that heterogeneity in these firm characteristics is the major driver of our results.

Finally, we examine changes in firms' environmental disclosure policy after the disaster. If the disaster has changed the cost-benefit trade-off that underlay firms' disclosure choices, then firms will adjust their disclosure policy to the new cost-benefit tradeoff. However, how firms change their disclosure after the disaster is an empirical question. On one hand, firms that do not disclose environmental targets experience a larger increase in the cost of capital than disclosing firms, thus a higher increase in the demand for environmental information, and are expected to react strongly. On the other hand, firms that disclose environmental targets are more likely to be timely in reacting to the change in the demand for environmental information. We find that firms that disclose environmental targets in the pre-disaster period react strongly to the disaster by increasing the number of pages and the degree of verifiable and forward-looking information in their environmental reports. While these firms experience a less intense increase in the cost of capital than other firms, so they should react less strongly to the disaster, they are also more likely to be timely in reacting to the change in the demand for environmental information after the disaster.

We make two primary contributions to the literature. First, we contribute to the literature on the economic consequences of CSR reporting. The limited regulatory guidance, non-comparability, and credibility concerns associated with firms' opportunistic behavior make the relationship between CSR disclosure and the cost of capital unclear theoretically and empirically challenging. We provide insights into how differences in credibility of CSR disclosure affect a firm's cost of capital, and, thus, highlight the importance of considering variation in disclosure characteristics driven by the underlying cost-benefit trade-off. Furthermore, our identification strategy tries to addresses endogeneity concerns by using a quasi-natural experiment that provides plausibly exogenous variation in the demand for environmental information.

Second, we contribute to the broad literature on the economic consequences of voluntary disclosure. We focus on a highly unregulated setting in which there is considerable variation in the information disclosed, and provide evidence on how differences in disclosure precision affect the cost of capital. Our focus on non-financial disclosure complements Leuz and Schrand's (2009) evidence on the relationship between mandatory financial disclosure and the cost of capital, and Balakrishan et al.'s (2014) findings on the effect of managerial forecasts on market liquidity.

The next section provides a review of prior literature. The research design is presented in section 3, while sections 4 and 5 present the data and main results, respectively. Sections 6 and 7 report additional analyses, and section 8 concludes.

2. Prior literature

Extant research documents a negative relationship between the level of disclosure and the cost of capital.[2] There are several possible explanations for also expecting a negative association between environmental disclosure and the cost of capital. In particular, we identify three mechanisms through which environmental disclosure is expected to affect a firm's information environment. First, a firm that provides information on its environmental programs and policies and their environmental impacts will also be able to respond quickly to new environmental regulation, thus lowering the risk associated with future compliance requirements (Blacconiere and Patten, 1994). Second, environmental disclosure serves as a source of information when investors estimate the role of environmental issues in driving competitive advantage (Richardson et al., 1999). Third, environmental disclosure might improve investors' information, which reduces firms' cost of capital, systemic risk, and expected returns (Diamond and Verrecchia, 1991; Easly and O'Hara, 2004; Lambert et al., 2007).

[2] In line with analytical models, disclosure transforms private information into public information. Easly and O'Hara (2004) show that, if the amount of private information about a firm is larger than that of other firms, its cost of capital is higher. However, Easly and O'Hara (2004) analyze a single-firm world, so it is not possible to infer whether the effect of disclosure will survive the forces of diversification. Lambert et al. (2007) demonstrate that the effect of disclosure on the cost of capital is not diversifiable, as it is related to the assessed covariance of the firm's cash flow with all the other firms' cash flows.

Although it is empirically challenging to document a causal relationship between disclosure and the cost of capital (Leuz and Schrand, 2009; Clinch and Verrecchia, 2015), previous studies provide insights into how non-financial, unregulated disclosure affects the cost of capital (Richardson and Welker, 2001; Plumlee et al., 2010; Dhaliwal et al., 2011; Clarkson et al., 2013). Richardson and Welker's (2001) examine the relationship between financial and social disclosure and the cost of capital, and document a negative association between financial disclosure and the cost of capital for firms with low analyst followings, but they also find that social disclosure and the cost of capital are significantly and positively related. Plumlee et al. (2010) examine how the quality of a firm's voluntary environmental disclosures is related to firm market value and find a positive association between environmental disclosure and firm value after controlling for environmental performance. Dhaliwal et al. (2011) investigate whether the initiation of stand-alone CSR reporting affects the cost of capital and find a negative relationship between the first-time issue of CSR reports and the subsequent cost of capital, but the result holds only for firms with above-the-median CSR performance. Clarkson et al. (2013) find no evidence that voluntary environmental disclosures affect firms' cost of capital.

These studies rely mainly on cross-sectional designs. In cross-section the relationship between disclosure and the cost of capital can be positive, negative, or null (Leuz and Schrand, 2009; Clinch and Verrecchia, 2015). Indeed, disclosure choices are based on reasons related to the information environment and the cost of capital. For example, a firm may start disclosing in reaction to a deteriorating information environment or to an increase in investors' uncertainty, either of which may lead to a positive cross-section association between disclosure and the cost of capital. Alternatively, firms may start disclosing after experiencing a growth shock, making it difficult to separate the effect on the cost of capital driven by the change in disclosure from that driven by the shock to the expected cash flow.

3. Research design and data

3.1 Empirical strategy

We examine the heterogeneous cost of capital changes after the Fukushima nuclear disaster in order to examine whether ex ante differences in the disclosure of environmental information are associated with the cost of capital. We consider the cost of capital for two reasons. First, theory predicts a link between disclosure and the cost of capital, and this relationship depends on the firm's commitment to transparency (Diamond and Verrecchia, 1991; Leuz and Verrecchia, 2000). Second, we consider the cost of capital instead of market returns or the earnings-to-price ratio in order to disentangle estimation-risk effects driven by increased environmental concerns from cash-flow effects that are due to revisions in expected cash flows.

In our baseline specification, we contrast the change in cost of capital around the disaster for non-disclosing and disclosing firms, allowing the coefficient for disclosing firms to vary with respect to the degree of disclosure precision in the pre-disaster period. Therefore, we propose the following general specification:

$$CoC_{i,t} = \alpha_i+\phi_t +\gamma D_t*\theta_{i,PRE}+\beta_1 X_{i,t}+\beta_2 D*X_{i,t}+ \varepsilon_{i,t}\ , \qquad (1)$$

where *CoC* stands for the implied cost of capital, α_i is a non-observable firm fixed effect, ϕ_t is a year fixed effect[3]. D_t is a binary variable marking years after the disaster.

[3] In alternative specifications, we replace the year fixed effects with industry-year fixed effects to control for industry-specific cost of capital time-trends (using the two-digit SIC code industry classification). In addition, we replace the firm-fixed effects structure with a lagged first- and second-order polynomial of cost of capital to address the concern that changes in the cost of capital may vary with pre-treatment cost-of-capital levels. Finally, we replace year fixed effects with a first- and second-order polynomial of a time-trend variable. We also include

In this model, we assume that the firm sets the environmental disclosure strategy in the pre-disaster period according to a cost and benefit trade-off that leads some firms to disclose environmental information and others not. However, among disclosing firms, the same economic trade-off leads some firms to disclose precise, forward-looking information while others do not, so the variable $\theta_{i,PRE}$ captures pre-disaster variation in environmental disclosure precision. Our underlying hypothesis is that environmental disclosure policy in the pre-disaster period moderates the impact of the disaster on the cost of capital, and that firms that disclose precise, forward-looking information experience a less severe change than those that do not.

The vector $X_{i,t}$ includes observable firm characteristics that are likely to be associated with the cost of capital and firms' disclosure strategy. To reduce unobservable heterogeneity between disclosing and non-disclosing firms further, we match each disclosing firm with a paired non-disclosing firm with a propensity score using the following variables: (1) size, measured as the natural logarithm of the firm's total assets at the beginning of its fiscal year; (2) financial leverage, measured as the ratio between the firm's total liabilities and the market value of its common equity at the beginning of its fiscal year; (3) return on assets, computed as the ratio between the firm's income before interest and taxes at the beginning of its fiscal year; (4) book-to-market ratio, measured as the ratio between the firm's book value of its common equity and the market value of the common equity at the beginning of its fiscal year; and (5) environmental performance, measured as the pillar score from Thomson Reuters ASSET4 ESG. We include industry fixed effects, using the two-digit SIC code industry classification. To alleviate measurement error, we take the firm-specific average of each of the five variables over the three years before the

differential time trends (in the first- and second order polynomial form) between disclosing and non-disclosing firms.

disaster. Then we match each disclosing firm with a non-disclosing firm with the closest estimated propensity score. We allow matching with replacement as long as only a small fraction of firms in our sample did not issue an environmental report.

However, the error term and the treatment of interest in equation (1) might still be correlated if, even after conditioning on firm fixed effects and the vector of observables, other factors that vary around the year of the shock and affect changes in the cost of capital correlate with firms' disclosure choices. For example, firms that experienced a lower increase in operating risk around the time of the disaster may have been more likely than others to disclose more precise environmental information to begin with. If this was the case, OLS estimates in equation (1) will still be biased if the change in operating risk correlates with changes in the firm's cost of capital and ex-ante disclosure choices. Therefore, we propose a flexible specification in which we allow the coefficients of the vector of the control variables to vary around the time of the disaster (i.e., $D*X_{i,t}$), to account for the extent to which these factors could co-vary with changes in the cost of capital.

We cluster standard errors at the firm level to allow any arbitrary within-firm correlation over time. In additional specifications we cluster standard errors at the industry level.

3.2 Implied cost of capital computation

We follow prior literature and rely on accounting-based valuation models to estimate the ex-ante cost of capital (Claus and Thomas, 2001; Gebhardt, Lee, and Swaminathan, 2001; Easton, 2004; Ohlson and Juettner-Nauroth, 2005; Hail and Leuz, 2006, 2009). These approaches build on discounted dividend models that are translated into a valuation equation based on residual income through the use of accounting identities. The underlying idea is to replace price and analysts' earnings forecasts in the valuation equations and obtain the cost of capital as the internal rate of return that equates actual share price and the time series of the expected residual income. To the extent that shocks to growth opportunities enter directly in the cost of capital estimation in terms of analysts' forecasts and long-term growth prospects, the use of these metrics allows us to control for concurrent cash flow effects around the time of the disaster. To address concerns over measurement error related to the use of a single measure, we use the yearly average of the four models as our proxy for the cost of capital. The details of the computation of the four metrics are reported in Appendix 1.

3.3 Environmental disclosure

The paper's underlying argument is that changes in the cost of capital around the time of the disaster are associated with ex-ante differences in disclosure strategies. To lay out this argument empirically, we first employ a dummy variable that is equal to one if a firm issue environmental reports at least since 2009 or earlier without stopping, and zero otherwise (i.e., *ER*). Data on firms' environmental disclosures are hand-collected from the Japanese Ministry of Economy, Trade and Industry[4] and corporate websites.

Next, we exploit cross-sectional variation in the disclosure precision by splitting the sub-sample of disclosing firms into non-overlapping groups according to whether they included information on carbon dioxide (CO_2) emissions targets at least since 2009. This choice is based on three reasons. First, because Fukushima is likely to have triggered a *general* increase in concern about how firms manage their environmental impact, the disclosure of CO_2 emissions targets is a good proxy with which to capture firms' commitment and effort in their environmental management of

[4] http://www.ecosearch.jp/en/

corporate activities (Ioannou et al., 2014). Second, a survey of market interest in nonfinancial information (Eccles et al., 2011) reveals that greenhouse gas emissions (and CO_2 emissions) receive the highest level of investors' interest among multiple environmental metrics because they are "easier to quantify and integrate into the valuation models" (p. 113) and represent a risk exposure to the company, including the potential for future regulatory costs. Third, using firms' disclosure of CO_2 target emissions is aligned with anecdotal evidence.[5] Therefore, we employ a dummy variable that equals one if the firm *continuously* provided a quantitative target for CO_2 emissions at least since 2009, and zero otherwise (i.e., *ER_Target*). The data are hand-collected from the corporate reports.

3.4 Control variables

We include control variables that are likely to vary systematically with the cost of capital and with firms' environmental-disclosure strategy. Following prior

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[5] Anecdotal evidence of corporate reactions to the disaster is found in environmentally sensitive industries, such as the energy one. For example, the CEO message in NOK Corp (an oil seal manufacturer) 2012 CSR report states as follows: "The earthquake and consequent nuclear accident made us drastically change the consciousness of all over the world how essential the stable energy resources are. We re-acknowledge how important to build the sustainable society, where we can effectively utilize the limited energies and other resources. After the nuclear accidents, Japan decided to reconsider the goal aiming to reduce greenhouse gas emissions by 25% and to pull out of Kyoto Protocol, which was extended beyond 2012. However, because global warming countermeasures are very important environmental challenges for the development of sustainable society, NOK will positively consider the challenges by balancing with the economy, even though it will be extremely difficult to achieve. NOK is implementing the 3–year plan form FY2011 setting its environmental policy as 'reduce the adverse environmental impacts and build up the information control system of environmental hazardous substances globally by promoting environmental management'. Because the adverse environmental impacts caused by human activities such as global warming, other climate change issues, resource exhaustion, environmental pollution and deterioration of biodiversity are becoming threats to the sustainable development of global economy, NOK positions the reduction of adverse environmental impacts as one of the priority issue that we shall focus on […]". Furthermore, such evidence can be tackled also in other industries such as in the food and health industry, as shown in the KIRIN group 2013 Sustainability report: "The Kirin Group has chosen to adopt a CSV [Creating shared value] approach because we wanted to transform the ways in which we do business. For years, we remained customer-focused and quality-focused to offer products and services that made customers happy. Then we asked ourselves, "Why not do more?". After the Great East Japan Earthquake in March 2011, we found people becoming more and more conscious about the social issues that they saw around them and we realized the tremendous expectations placed on us by society. It was not long before we determined that addressing social challenges as part of our business of providing products and services would benefit our business in the long run."

research (Fama and French, 1992, 1993; Hail and Leuz, 2006), we expect the cost of capital to be negatively associated with firm size and positively associated with the book-to-market ratio and beta. Therefore, we control for firm size (*SIZE*) using the log of the firm's total assets at the beginning of its fiscal year. The book-to-market ratio (*B_M*) is computed as the ratio of the firm's book value to market value of equity at the beginning of its fiscal year. We also consider traditional controls for risk (Hail and Leuz, 2006). Return variability (*RET_VAR*) is measured as the standard deviation of monthly stock returns over the previous twelve months. Firm leverage (*LEV*) is the ratio between the firm's beginning-of-year total liabilities and the beginning-of-year market value of equity. We also control for the firm's profitability (*ROA*) using return on assets, computed as the net income before interest and taxes over total assets. We consider proxies for the quality of financial reporting, as it is likely to be correlated with firms' environmental disclosure strategy and cost of capital. We include total accruals (*ACCRUALS*) as the difference between net income before extraordinary items and discontinued operations, and cash flow from operations, scaled by total assets at the beginning of the period. Analysts following is computed as the logarithm of the number of analysts that issued a forecast during the year (*FOLLOWING*). To address concerns that our results are mechanically driven by a change in forecast behavior around the disaster (e.g., it could be that, around the year of the disaster, analysts became more pessimistic about firms' prospects, biasing downward their cost-of-capital computation), we also control for forecast bias, computed as the mean one-year-ahead consensus forecast minus the actual earnings (*ERROR*). Appendix 2 lists the definition of all variables employed in this study.

4. Data and descriptive statistics

The sample is comprised of 3,756 firm-year observations from 445 unique firms during the period 2003-2011[6]. To be included in the sample, a firm has to be listed in the First Section of the Tokyo Stock Exchange for the period 2003-2011 and with data available to compute the implied cost of capital metrics, disclosures, proxies, and control variables. We do not require a firm to be continuously listed over the entire sample period, but a firm has to be listed from at least two years before the disaster and one year after. To compute the implied cost of capital, we collect financial data from Compustat Global and price information from Datastream and hand-collected information about analysts' forecasts from the "Tokyo KeizaiShinpo-Sha," which reports analysts' consensus outstanding on a monthly basis for all firms listed on the Tokyo Stock Exchange. To be included in the implied cost of capital computation, firms have to have analyst forecasts for one year ahead and two years ahead and either a three-years-ahead earnings forecast or a long-term growth forecast. Prices and analyst earnings forecast data points are measured as of seven months after the fiscal year end to guarantee that accounting data are publicly available and priced by the market at the time of the cost-of-capital computation. Finally, we delete the 1 percent at the top of the sample distribution of the yearly average of the four cost-of-capital models (Claus and Thomas, 2001; Gebhardt, Lee, and Swaminathan, 2001; Easton, 2004; Ohlson and Juettner-Nauroth, 2005).

Table 1 summarizes the sample selection process and provides breakdowns of the sample by year and by industry.

[Insert table 1 about here]

[6] The fiscal year of firms included in the sample ends on March 31.

Table 2 Panel A reports descriptive statistics of the variables used in the analyses. The mean (median) *CoC* estimate is 12.5 percent (11.1%). Table 2, panel B presents descriptive statistics of the control variables according to the firms' environmental disclosures. We report the descriptive of the cost-of-capital metrics and control variables separately for three groups of firms: those that issue a stand-alone report, those that do not issue a stand-alone report, and those that disclose environmental targets.

[Insert table 2 about here]

5. Results

We first explore whether the disaster triggered an increase in the sensitivity of the cost of capital to environmental performance. This evidence would be consistent with the idea that the disaster was an environmental-transparency shock, giving us the opportunity to examine how voluntary environmental disclosure affects the cost of capital. To undertake this, we regress firms' cost of capital on environmental performance and the set of control variables separately for the pre- and post-disaster. Information on environmental performance is collected from the Thomson Reuter ASSET4 ESG database. Figure 1 plots the coefficients of the environmental performance from these regressions. While the cost of capital was insensitive to environmental performance before the disaster, we observe a sharp increase in sensitivity of environmental performance to the cost of capital in the 12 months after the disaster. While only suggestive, this evidence is coherent with the idea that the disaster triggered concerns about how firms manage environment-related issues.

[Insert Figure 1 about here]

We next turn to examine whether firms that issue stand-alone environmental reports experience a less severe increase in the cost of capital relative to those that do not. We first estimate the average change in firms' cost of capital, irrespective of firms' disclosure choices,[7] and find that, on average, the disaster triggered an increase in the cost of capital (table 3, column 1). Then, we examine the heterogeneity in the changes in the cost of capital associated with differences in firms' disclosure choices. Our right-hand side variable of interest is the interaction between *POST* and *ER*, which captures the difference in changes in the cost of capital for disclosing and non-disclosing firms after the disaster. We find that firms that issue stand-alone reports experience a less severe but insignificant increase in their cost of capital relative to those that do not. This result holds across alternative model specifications. The estimated coefficient ranges from 0.01 in the model with firm fixed effects (column 2) to 0.014 in the flexible specification with firm fixed effects (column 4). Taken together, the results in Table 3 show weak evidence in support of a meaningful and statistically significant association between the cost of capital and environmental disclosures.

[Insert Table 3 around here]

The absence of a significant average association between environmental disclosure and the cost of capital might masks substantial heterogeneity if there are differences in the level of disclosure precision and credibility within disclosing firms. Therefore, we replace the interaction term between *POST* and *ER* with two non-overlapping interaction terms: (1) *POST_Er_Target*; (2) *POST_Er_NoTarget*, where the first interaction term captures the change in the cost of capital for firms that

[7] Given that there is no control group in this specification, we replace year-fixed effects with a time-trend variable.

disclose environmental targets relative to the change for non-disclosing firms, and the second interaction term captures the change for firms that do not disclose such targets (but do provide environmental reports) relative to the change for non-disclosing firms. Table 4 reports the estimation results. The coefficient on *POST*ER_Target* is negative and significant across the various model specifications. Importantly, the economic magnitude of the coefficient is also stable across the model specifications. On the other hand, the coefficient on *POST*ER_NoTarget* is negative but not statistically significant. Overall, evidence from Table 4 suggests that firms that disclose more precise and forward-looking information suffer a less intense shock in the cost of capital.

[Insert Table 4 about here]

6. Additional analyses

Previous analyses provide evidence about the association between the cost of capital and voluntary disclosure, but they might simply be picking up spurious associations between unobservable firm characteristics that correlate with environmental disclosures. Our empirical strategy, which is based on firm fixed effects, propensity score matching, and extensive interaction terms, address only partially this endogeneity concern. Indeed, environmental disclosures are likely to be bundled with several firm characteristics, such as environmental performance, operating risk, and energy-dependence that might explain why firms react differently to the disaster. Therefore, we carry out a battery of additional analyses to rule out alternative plausible explanations.

First, we consider firms' environmental performance. Firms with strong environmental performance may be more likely than other firms to commit to environmental disclosure because these firms are more likely to disclose good environmental news. To explore this possibility, we collect data on firms' environmental performance from Thomson Reuters ASSET4 ESG.[8] Then, we augment equation (1) with an environmental-performance partitioning variable and the interaction between this partitioning variable and *POST*, *POST*ER_Target,* and *POST*ER_NoTarget.* Table 5 reports the estimation results. We find that firms that disclose environmental targets experience a lower increase in their cost of capital after the disaster than do firms that issue only stand-alone reports, irrespective of the underlying environmental performance. In untabulated results, we run a similar test using firms' self-reported CO_2 emissions as an alternative proxy for environmental performance and obtain evidence consistent with that reported in Table 5.

[Insert Table 5 about here]

Another source of concern is that our evidence is driven by firms operating in environmentally sensitive industries, where concerns about environmental management and related risks are particularly prevalent. To address this concern, we rerun our main analyses, excluding the firms that operated in environmentally sensitive industries (ESI). Following Cho and Patten (2007), we define ESI firms as firms with a primary SIC code of 13 (oil exploration), 26 (paper), 28 (chemical and allied products), 29 (petroleum refining), 33 (metals), 10 (mining), or 49 (utilities). Table 6 reports the estimation results. The evidence is consistent with the main results, so implying that restricting the analysis to firms that operate in non-environmentally sensitive industries does not change our inferences. Moreover, the

[8] Sixty percent of the firm-years in our sample are not covered by ASSET4. Building on the argument that environmental performance tends to be homogenous within an industry, to increase the power of our tests we replace the missing values of the performance variables using industry-year means (using the two-digit SIC code industry classification).

magnitudes of the estimated coefficients are very similar to those in the main analyses over the entire sample, suggesting that the evidence is not driven by industry-specific shocks[9].

[Insert Table 6 about here]

Next, we address concerns related to other confounding factors that might drive the association between environmental disclosure and the cost of capital. Indeed, our proxy for commitment to disclosure may simply reflect unobservable firm characteristics that are likely to be observed with a given disclosure strategy. To account for this possibility, we augment equation (1) with partitioning variables that capture capital intensity (our proxy for energy dependency, measured as the standardized ratio of the gross property, plant, and equipment, and total assets) and operating risk (measured as the standard deviation of the firm's rolling five-year cash flow from operations; Liu and Wysocki, 2006). Columns (1) – (4) of Table 7 report the estimation results.[10] We do no evidence in support of the idea that our results are mostly driven by differences in capital intensity and operating risk, as none of the interactions between environmental disclosures and the partitioning variables are significant, regardless of the model specification.

We further account for another source of disturbance, which stems from heterogeneity in cash flow effects around the disaster. Indeed, the disaster is likely to have caused a downward revision in firms' expected cash flows. If this change in

[9] In un-tabulated analyses, we also rule out that our results are driven by specificities of the institutional setting. Our evidence is robust when we control for firms participating in the Japanese emission-trading scheme (in which participants adopt emission reduction targets and receive emission allowances) or greenhouse gas accounting system (according to which entities emitting above a defined threshold have to report their emissions to the government).

[10] For the sake of brevity, we report only two specifications (flexible with firm fixed effects and flexible with firm fixed effects for the PSM sample). Results remain consistent when the other specifications presented in the main analysis are used.

expected cash flow differs for disclosing and non-disclosing firms, and within disclosing firms according to the degree of disclosure precision, then our estimates are likely to be biased. To address this concern, we estimate our main model by including a partitioning variable that captures the magnitude of cash flow revisions around the disaster. We compute the magnitude of cash flow revisions using the standardized short- term growth (defined as the ratio of the difference between the one-year and one-year-ahead earning per share estimates over the one-year-ahead earnings per share estimate). The estimations results are presented in Table 7, columns (5) – (6). We do not find evidence consistent with the idea that our findings are driven by the correlation between differences in expected cash flow revisions and firms' environmental disclosure strategies.

Building on the same rationale, we exclude from our main sample firms headquartered close to the Fukushima nuclear plants, as these firms should have experienced the most severe damage from the disaster. In particular, we exclude firms located within 150, 300, and 400 km radius of the Fukushima nuclear plant. Table 7, columns (7) – (9) show that, as we exclude firms located close to the nuclear plant, the *POST*ER_Target* coefficient remains statistically significant. More important, the magnitudes remain similar to those in Table 4. For example, when we exclude firms within 150 km from the Fukushima nuclear plant, the coefficient on *POST*ER_Target* is -0.051, while in Table 4 the coefficient is -0.053. Excluding firms located within 300 or 400 km of the plants leads to lower magnitudes and higher standard errors. While the higher standard errors are mainly driven by a loss of power because of the lower sample size, the lower magnitudes are probably related to the fact that 40 percent of the target-disclosing firms are located within 350 km of the plants. Nevertheless, results from Table 7, columns (7)-(9) reassure us that our evidence is not primarily driven by cash flow effects.

[Insert Table 7 about here]

7. Disclosure reaction

If the disaster has led to a change in the demand for environmental information, we expect that firms will adjust their disclosure policy to the new cost-benefit tradeoff. Using the Enron scandal as a source of variation in the credibility of financial reporting, Leuz and Schrand (2009) document that firms react to the accounting scandal by increasing the amount of disclosure in mandatory reports. Balakrishnan et al. (2014) use brokerage house closures as a source of variation in the availability of public information and document that firms reacted to such information-related shocks by increasing the supply of voluntary disclosure. Ioannou and Serafeim (2014) investigate the effect of a shift in the demand for environmental social and governance issues (e.g., introduction of *mandatory* disclosure regulations) on firms' disclosure practices, and find that the disclosure of firms that have less extensive disclosures before the shift do not catch up to firms that have more extensive disclosure before the shift. Rather, disclosure differences widen as a result of the shift in demand.[11]

To explore how firms' disclosure change after the disaster, we collect the following environmental disclosure data from firms' environmental reports for the years 2009-2012 (Muslu et al., 2015): length of the reports (number of pages and

[11] This effect holds only for environmental and social disclosure. Firms that were laggards in governance disclosure increased their disclosure significantly, reaching levels of governance disclosure similar to those of the leaders. They explain their asymmetric response as being consistent with governance disclosures' being less costly to obtain and make available than environmental (or social) information. For example, information about environmental impacts is more difficult to obtain, aggregate and release than is information on board compensation.

number of words), degree of hardness of the disclosure (number of numerical words), and horizon content (number of references to future years and number of short-term and long-term horizon words). We focus only on firms that issue environmental reports both pre- and post-disaster, because only a few firms that did not issue environmental reports before the disaster do so afterward. Then we regress the change in the number of words and the change in a disclosure factor (based on all the disclosure attributes described above) on a dummy variable that marks firms that reported environmental target information before the disaster. We also include industry fixed effects and the full set of control variables, measured in the year before the disaster. Table 8 reports the estimation results. We find that firms that included information about their expected environmental performance increase the number of pages in their disclosures and the precision and forward-looking nature of the information disclosed relative to firms that did not include target information in their environmental reports before the disaster. By revealed preferences, this evidence suggests that, for firms that provided less precise and less forward-looking information before the nuclear disaster, the cost of increasing the precision of the environmental disclosure outweighs the relative benefit.

[Insert Table 8 about here]

8. Conclusions

We use a large, hand-collected sample of environmental information disclosed by Japanese firms over the period 2003-2011 to investigate whether heterogeneity in firms' pre-disaster environmental disclosure policy explain differences in the cost of capital changes after the Fukushima nuclear disaster. We document that firms that issue stand-alone environmental reports experience a smaller increase in the cost of capital than non-issuing firms. More important, we find that firms that provide more precise and verifiable environmental information on expected environmental performance experience a less severe increase in their cost of capital than di firms that do not disclose such information.

Despite the consistency of our results across the alternative specifications, our findings are subjected to several caveats. First, the absence of a control sample does not allow us to properly control for concurrent events that might affect the cost of capital around the disaster. However, to affect our results these potential confounders should be correlated with the timing of the shock as well as with firm environmental disclosure choices. Second, disclosure choice is endogenous, and we are unable to properly instrument it. We address this concern several ways, but recognize that these approaches do not allow us to identify the effect of environmental disclosure on cost capital. However for an omitted variable to affect our results it should be correlated with the timing of the shock, with firms' environmental disclosure strategy, and it should affect differentially disclosing and non-disclosing firms. These caveats should be considered when interpreting our evidence

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Appendix 1: Implied cost of capital computation

The computation of the implied cost of capital models requires the use of the following variables: p_0: current stock price, measured as of seven months after the fiscal year-end; bv_0: current book value of equity per share, measured as of fiscal year-end; e_t: expected future earnings per share for year t, computed as the mean analyst forecast earnings per share from I/B/E/S Summary Unadjusted file; d_t: expected future dividends per share for year t; bv_t: expected book value of equity per share for year t; g, r_{gst}, r_{glt}: expected perpetual, short-term, and long-term growth rate; k: average dividend payout ratio over the past three years. (k is required to be bounded between 0 and 1.) If k is missing for a given firm-year, we replace it with the industry-year median.

A.1 Claus and Thomas (2001)

$$p_0 = bv_0 + \frac{e_1 - r_{CT} \times bv_0}{(1+r_{CT})} + \frac{e_2 - r_{CT} \times bv_1}{(1+r_{CT})^2} + \frac{e_3 - r_{CT} \times bv_2}{(1+r_{CT})^3} + \frac{e_4 - r_{CT} \times bv_3}{(1+r_{CT})^4}$$

$$+ \frac{e_5 - r_{CT} \times bv_4}{(1+r_{CT})^5} + \frac{(e_5 - r_{CT} \times bv_4) \times (1+g)}{(r_{CT} - g)(1+r_{CT})^5} \qquad (A.1)$$

$$bv_t = bv_{t-1} + e_t - e_t \times k$$

If e_3, e_4, or e_5 are missing, they are replaced with $e_3 = e_2*(1+r_{glt})$, $e_4 = e_3*(1+r_{glt})$, $e_5 = e_4*(1+r_{glt})$, where r_{glt} is the analyst forecast for long-term growth rate. The inflation rate is used as a proxy for g.

A.2 Gebhardt, Lee, and Swaminathan (2001)

$$p_0 = bv_0 + \frac{e_1 - r_{GLS} \times bv_0}{(1+r_{GLS})} + \frac{e_2 - r_{GLS} \times bv_1}{(1+r_{GLS})^2} + \frac{e_3 - r_{GLS} \times bv_2}{(1+r_{GLS})^3}$$

$$+ \sum_{t=4}^{11} \frac{\overline{ROE}_t - r_{GLS}}{(1+r_{GLS})^t} \times bv_{t-1} + \frac{\overline{ROE}_{12} - r_{GLS}}{r_{GLS} \times (1+r_{GLS})^{12}} \times bv_{11} \qquad (A.2)$$

$$\overline{ROE}_t = \frac{1}{I} \sum_{i}^{I} \overline{ROE}_{t,i}$$

$$ROE_{t,i} = e_{t,i} / bv_{t,i}$$

$$bv_t = bv_{t-1} + e_t - e_t \times k$$

Beyond the explicit forecast period of three years, the residual income series is defined by linearly fading the forecasted accounting return on equity to the sector-specific average return. The industry-average return on equity is used for firms in a given year, using Campbell's (1996) industry classification.

A.3 Ohlson and Juettner-Nauroth (2005)

$$p_0 = \frac{e_1}{r_{OJ}} \times (g_{st} + \frac{r_{OJ} \times d_1}{e_1} - g_{lt})/(r_{OJ} - g_{lt}) \qquad \text{(A.3)}$$

$$g_{st} = (e_2 - e_1)/e_1$$

$$d_1 = k \times e_1$$

Short-term growth (r_{gst}) is as defined in Gode and Mohanram (2003). The inflation rate is used as a proxy for g.

A.4 Modified PEG ratio model by Easton (2004)

$$p_0 = (e_2 + r_{PEG} \times d_1 - e_1)/r_{PEG}^2 \qquad \text{(A.4)}$$

We use an iterative procedure to back out the internal rate of return. This program identifies the annual firm-specific discount rate that equates the left-hand-side price to the right-hand-side value. We start iterating the discount rate from 0 to 1 by 0.0001 each time and stop when the absolute difference is less than 0.1 percent of the left-hand-side price. If there is no solution, we relax the 0.1 percent restriction to 1 percent, 5 percent, and 10 percent maximum. We measure each cost of capital metric as of seven months after the fiscal year end. Thus, prices and analyst forecasts are collected that reflect the consensus outstanding for the fiscal year ending in two months for e_1, fourteen months for e_2, and so on, while the valuation model assumes discounting for the whole year. Following Hail and Leuz (2006), we move the prices for the seventh month after the fiscal year back to the beginning of the period using the implied cost of capital (i.e., $[1+r]^{-7/12}$) and then use the full year's discounting.

Appendix 2: Variable definition

ER	Time-invariant dummy variable that equals 1 if the company issued environmental reports at least since 2009 without stopping this disclosure, and 0 otherwise. This data was hand-collected from the web archive of the Japanese Ministry of Economy, Trade and Industry and corporate websites.
ER_Target	Time-invariant dummy variable for firms that have issued environmental targets at least since 2009 and that did not stop this disclosure. The data was hand-collected from corporate reports.
ER_NoTarget	Time-invariant dummy variable for firms that have issued environmental reports at least since 2009 and that did not stop this disclosure but did not include environmental targets. The data was hand-collected from corporate reports.
POST	Dummy variable that equals 1 for the fiscal year ending after the Fukushima nuclear disaster on March 11, 2011.
CC	Yearly average of four implied cost-of-capital metrics (Claus and Thomas, 2001; Gebhardt, Lee, and Swaminathan, 2001; Easton, 2004; Ohlson and Juettner-Nauroth, 2005).
SIZE	Natural logarithm of a firm's total assets at the beginning of its fiscal year.
B_M	Book value to market value of equity ratio at the beginning of the firm's fiscal year.
ROA	Return on assets, computed as the net income before interest and taxes over the beginning of the year total assets.
LEV	The ratio of the beginning-of-year total liabilities to the beginning-of-year market value of equity.
RET_VAR	The firm's return variability, computed as the standard deviation of monthly stock returns over the last twelve months.
FOLLOWING	Analysts following, computed as the logarithm of the number of analysts that issued a forecast during the year.
ACCRUALS	The difference between net income before extraordinary items and discontinued operations, and cash flow from operations, scaled by total assets at the beginning of the period.
ERROR	Forecast bias as the mean one-year-ahead consensus forecast, minus the actual earnings.
Environmental Performance	Environmental performance (pillar) score from Asset 4 - Thomson Reuters that reflects "how well a company uses management practices to avoid environmental risks and capitalize on environmental opportunities in order to generate long-term shareholder value" (ASSET4 ESG Glossary). The score is a relative measure of performance, normalized to distinguish values and position the score between 0 and 100 percent. Since this variable is missing for almost 70 percent of our sample, we replace it with the year-industry mean using the two-digit industry classification.
Capital intensity	Standardized ratio of the gross property, plant, and equipment to total assets.
Operating risk	Standard deviation of the firm's five-year rolling cash flow from operations.
Delta E[CFO]	Ratio of the difference between the one-year and one-year-ahead estimated earnings per share to the one-year-ahead estimated earnings per share.

Table 1
Sample characteristics

Panel A. Sample selection	
Japanese firms-years in the WORLDSCOPE universe (2002-2011)	5,404
Less firm-years in missing data to compute the implied cost of capital	954
Less firms-years non continuously listed between 2003 and 2011	694
Final sample	**3,756**

Panel B. Distribution of the number of times a given firm appears in the sample

No. of times	No. of firms	No. of obs.	%
4	1	4	0.11%
5	1	5	0.13%
6	8	48	1.28%
7	39	273	7.27%
8	138	1104	29.39%
9	258	2322	61.82%
Total	**445**	**3756**	**100%**

Panel C. Distribution of firm-year observations by year

Year	No. of obs.	%
2003	430	11.45
2004	436	11.61
2005	442	11.77
2006	439	11.69
2007	427	11.37
2008	422	11.24
2009	431	11.47
2010	429	11.42
2011	300	7.99
Total	**3,756**	**100**

Panel D. Distribution of firm-year observations by industry

Industry	No. of obs.	%
Petroleum	13	0.35
Consumer durables	960	25.56
Basic	629	16.75
Food/Tobacco	216	5.75
Construction	434	11.55
Capital goods	628	16.72
Transportation	165	4.39
Utilities	134	3.57
Textiles/trade	200	5.32
Services	222	5.91
Leisure	86	2.29
Real estate	69	1.84
Total	**3,756**	**100**

Table 2
Descriptive statistics

Panel A: Descriptive statistics - Overall sample

Variable	N	Mean	SD	p5	p25	p50	p75	p95
CC	3756	0.125	0.064	0.048	0.083	0.111	0.153	0.255
SIZE	3756	7.743	1.556	5.403	6.617	7.584	8.730	10.495
B_M	3756	0.972	0.530	0.339	0.606	0.877	1.221	1.942
ROA	3756	0.024	0.038	-0.027	0.010	0.024	0.040	0.077
LEV	3756	1.679	2.263	0.185	0.545	1.131	2.143	4.725
RET_VAR	3756	0.092	0.059	0.039	0.062	0.085	0.108	0.165
FOLLOWING	3756	4.051	2.144	0.000	2.833	4.754	5.787	6.358
ACCRUALS	3756	-3.984	4.803	-11.533	-6.527	-3.995	-1.512	3.604
ERROR	3756	0.343	1.956	0.008	0.048	0.120	0.270	1.095

Panel B: Descriptive statistics by environmental disclosure policy

ER = 1								
CC	3329	0.124	0.061	0.048	0.084	0.110	0.151	0.248
SIZE	3329	7.816	1.557	5.434	6.675	7.640	8.870	10.558
B_M	3329	0.975	0.525	0.348	0.610	0.878	1.221	1.961
ROA	3329	0.025	0.036	-0.023	0.011	0.024	0.040	0.077
LEV	3329	1.642	2.187	0.192	0.545	1.117	2.132	4.499
RET_VAR	3329	0.091	0.060	0.039	0.061	0.084	0.108	0.164
FOLLOWING	3329	4.136	2.126	0.000	2.944	4.875	5.829	6.373
ACCRUALS	3329	-3.914	4.749	-11.276	-6.517	-3.995	-1.468	3.604
ERROR	3329	0.338	2.016	0.008	0.046	0.120	0.265	1.000
ER = 0								
CC	427	0.137	0.078	0.046	0.079	0.116	0.183	0.302
SIZE	427	6.851	1.205	4.953	6.008	6.753	7.597	8.723
B_M	427	1.110	0.661	0.310	0.647	0.999	1.431	2.209
ROA	427	0.019	0.043	-0.052	0.008	0.022	0.039	0.073
LEV	427	2.130	2.792	0.177	0.630	1.353	2.560	6.835
RET_VAR	427	0.096	0.048	0.041	0.064	0.087	0.114	0.191
FOLLOWING	427	2.645	2.113	0.000	0.000	2.944	4.564	5.663
ACCRUALS	427	-3.924	5.100	-13.585	-6.270	-3.615	-1.260	3.598
ERROR	427	0.407	1.000	0.018	0.088	0.178	0.404	1.357
Target = 1								
CC	240	0.124	0.070	0.040	0.077	0.109	0.153	0.264
SIZE	240	8.083	1.440	5.827	7.108	8.012	8.838	10.779
B_M	240	0.990	0.501	0.339	0.614	0.909	1.245	1.869
ROA	240	0.018	0.036	-0.034	0.005	0.016	0.034	0.073
LEV	240	2.694	2.288	0.279	0.799	2.242	3.825	7.563
RET_VAR	240	0.097	0.060	0.049	0.067	0.087	0.110	0.166
FOLLOWING	240	3.939	2.133	0.000	2.602	4.766	5.762	6.246
ACCRUALS	240	-2.573	4.707	-9.134	-5.162	-2.481	-0.134	5.131
ERROR	240	0.435	1.768	0.008	0.049	0.125	0.285	1.404
Target = 0								
CC	3516	0.126	0.063	0.048	0.083	0.111	0.153	0.254
SIZE	3516	7.676	1.555	5.376	6.547	7.502	8.662	10.462
B_M	3516	0.991	0.548	0.341	0.612	0.888	1.246	2.020
ROA	3516	0.025	0.037	-0.026	0.011	0.024	0.040	0.077
LEV	3516	1.631	2.255	0.180	0.538	1.112	2.065	4.395
RET_VAR	3516	0.091	0.059	0.039	0.061	0.084	0.108	0.165
FOLLOWING	3516	3.962	2.181	0.000	2.639	4.644	5.753	6.360
ACCRUALS	3516	-4.008	4.783	-11.567	-6.587	-3.995	-1.522	3.341
ERROR	3516	0.340	1.935	0.008	0.050	0.128	0.277	1.021

Table 2 Panel A reports descriptive statistics on the variables used in the regression analyses Panel B presents the descriptive statistics splitting the sample with respect to disclosure choices

Table 3
Environmental disclosure and the cost of capital

	BASE	BASE	PSM	FLEXIBLE	FLEXIBLE & PSM
	(1)	(2)	(3)	(4)	(5)
POST	**0.020***** **[0.006]**	-	-	-	-
POST*ER	-	**-0.010** **[0.012]**	**-0.010** **[0.012]**	**-0.014** **[0.012]**	**-0.013** **[0.012]**
SIZE	0.010 [0.008]	0.010 [0.008]	0.009 [0.009]	0.011 [0.008]	0.009 [0.009]
B_M	0.024*** [0.006]	0.024*** [0.006]	0.023*** [0.006]	0.024*** [0.006]	0.023*** [0.007]
ROA	-0.221*** [0.055]	-0.219*** [0.055]	-0.245*** [0.057]	-0.208*** [0.055]	-0.235*** [0.056]
LEV	-0.003* [0.002]	-0.003* [0.002]	-0.003* [0.002]	-0.003** [0.002]	-0.003** [0.002]
RET_VAR	0.029 [0.018]	0.029 [0.018]	0.025 [0.018]	0.032 [0.021]	0.028 [0.020]
FOLLOWING	0.005*** [0.001]	0.005*** [0.001]	0.005*** [0.001]	0.005*** [0.002]	0.005*** [0.002]
ACCRUALS	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]
ERROR	0.001*** [0.000]	0.001*** [0.000]	0.001*** [0.000]	0.001*** [0.000]	0.001*** [0.000]
Constant	0.004 [0.060]	-0.002 [0.063]	0.007 [0.066]	-0.003 [0.063]	0.007 [0.065]
YEAR FE	No	Yes	Yes	Yes	Yes
FIRM FE	Yes	Yes	Yes	Yes	Yes
POST*CONTROLS	No	No	No	Yes	Yes
Observations	3,756	3,756	3,612	3,756	3,612
R-squared	0.418	0.418	0.426	0.423	0.430

Table 3, column (1) reports the results from regressing the yearly average of the four cost of capital metrics on an indicator variable marking years after the Fukushima Nuclear Disaster (*POST*). Columns (2)-(5) reports the results the regressing the yearly average of the four cost of capital metrics on the interaction between the indicator variable marking firms issuing an environmental stand-alone report at least since 2009 or earlier and that do never stop this disclosure in their history (*ER*) and *POST*, and control variables and fixed effects. The table reports OLS coefficient estimates and (in parentheses) robust standard errors that are clustered at firm-level.
***, ** and * denote significance at 1 percent, 5 percent and 10 percent levels (two-tailed), respectively

Table 4
Environmental target disclosure and the cost of capital

	BASE	PSM	FLEXIBLE	FLEXIBLE & PSM
	(1)	(2)	(3)	(4)
POST*ER_Target	**-0.046*** **	**-0.045*** **	**-0.053*** **	**-0.051*** **
	[0.017]	**[0.017]**	**[0.017]**	**[0.018]**
POST*ER_NoTarget	-0.007	-0.007	-0.010	-0.009
	[0.012]	[0.012]	[0.012]	[0.012]
F-test on coefficients				
POST*ER_Target = POST*ER_NoTarget	0.002	0.002	0.001	0.001
SIZE	0.007	0.006	0.008	0.007
	[0.008]	[0.009]	[0.008]	[0.009]
B_M	0.024***	0.023***	0.023***	0.023***
	[0.006]	[0.006]	[0.006]	[0.007]
ROA	-0.220***	-0.246***	-0.207***	-0.234***
	[0.055]	[0.057]	[0.055]	[0.057]
LEV	-0.003*	-0.003*	-0.003**	-0.003**
	[0.002]	[0.002]	[0.001]	[0.002]
RET_VAR	0.027	0.023	0.031	0.027
	[0.018]	[0.017]	[0.021]	[0.020]
FOLLOWING	0.005***	0.005***	0.005***	0.005***
	[0.001]	[0.001]	[0.002]	[0.002]
ACCRUALS	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
ERROR	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.020	0.031	0.017	0.017
	[0.062]	[0.065]	[0.063]	[0.063]
YEAR FE	Yes	Yes	Yes	Yes
FIRM FE	Yes	Yes	Yes	Yes
POST*CONTROLS	No	No	Yes	Yes
Observations	3,756	3,612	3,756	3,612
R-squared	0.422	0.430	0.427	0.434

Table 4 presents the result from regressing the yearly average of the four cost of capital metrics on the interaction between firms disclosing the target of environmental performances at least since 2009 or earlier and that do never stop this disclosure in their history (*ER_Target*) and *POST*, and the interaction between firms issuing an environmental stand-alone report at least since 2009 or earlier and that do never stop this disclosure in their history but not the target (*ER_NoTarget*) and *POST*. Control variables are included but not reported for brevity. The table reports OLS coefficient estimates and (in parentheses) on robust standard errors that are clustered by firm.
***, ** and * denote significance at 1 percent, 5 percent and 10 percent levels (two-tailed), respectively

Table 5
Environmental target disclosure and the cost of capital conditional on environmental performance

	BASE	PSM	FLEXIBLE	FLEXIBLE & PSM
	(1)	(2)	(3)	(4)
POST*ER_Target	**-0.042****	**-0.042****	**-0.049*****	**-0.048*****
	[0.018]	**[0.018]**	**[0.018]**	**[0.018]**
POST*ER_NoTarget	-0.004	-0.004	-0.006	-0.006
	[0.013]	[0.013]	[0.012]	[0.012]
POST*ER_Target*Environmental Performance	-0.009	-0.009	-0.017	-0.016
	[0.019]	[0.019]	[0.018]	[0.018]
POST*ER_NoTarget* Environmental Performance	-0.014	-0.013	-0.019	-0.018
	[0.016]	[0.015]	[0.014]	[0.014]
F-test on coefficients				
POST*ER_Target = POST*ER_NoTarget	0.003	0.003	0.001	0.002
Environmental performance	-0.002	-0.002	-0.002	-0.002
	[0.002]	[0.002]	[0.002]	[0.002]
POST*Environmental performance	0.016	0.015	0.020	0.019
	[0.016]	[0.015]	[0.014]	[0.014]
SIZE	0.007	0.006	0.008	0.007
	[0.008]	[0.009]	[0.008]	[0.009]
B_M	0.024***	0.023***	0.024***	0.023***
	[0.006]	[0.006]	[0.006]	[0.007]
ROA	-0.220***	-0.246***	-0.208***	-0.236***
	[0.055]	[0.057]	[0.055]	[0.057]
LEV	-0.003*	-0.003*	-0.003**	-0.003**
	[0.002]	[0.002]	[0.001]	[0.002]
BETA	0.027	0.024	0.032	0.028
	[0.018]	[0.017]	[0.021]	[0.020]
FOLLOWING	0.005***	0.005***	0.005***	0.005***
	[0.001]	[0.001]	[0.002]	[0.002]
ACCRUALS	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
ERROR	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.020	0.030	0.016	0.025
	[0.062]	[0.065]	[0.063]	[0.065]
YEAR FE	Yes	Yes	Yes	Yes
FIRM FE	Yes	Yes	Yes	Yes
POST*CONTROLS	No	No	Yes	Yes
Observations	3,756	3,612	3,756	3,612
R-squared	0.423	0.431	0.428	0.435

Table 5 presents the result from regressing the yearly average of the four cost of capital metrics on the interaction between firms disclosing the target of environmental performances at least since 2009 or earlier and that do never stop this disclosure in their history (*ER_Target*) and POST, and the interaction between firms issuing an environmental stand-alone report at least since 2009 or earlier and that do never stop this disclosure in their history but not the target (ER_NoTarget) and *POST*. We include an environmental performance score from ASSET4, and the relative interactions. The table reports OLS coefficient estimates and (in parentheses) robust standard errors that are clustered by firm.
***, ** and * denote significance at 1 percent, 5 percent and 10 percent levels (two-tailed), respectively

Table 6
Environmental target disclosure and the cost of capital: non-environmentally sensitive industries

	BASE	PSM	FLEXIBLE	FLEXIBLE & PSM
	(1)	(2)	(3)	(4)
POST*ER_Target	**-0.047*** **	**-0.046*** **	**-0.053*** **	**-0.052*** **
	[0.017]	**[0.017]**	**[0.017]**	**[0.018]**
POST*ER_NoTarget	-0.007	-0.006	-0.011	-0.010
	[0.012]	[0.013]	[0.012]	[0.012]
F-test on coefficients				
POST*ER_Target = POST*ER_NoTarget	0.001	0.001	0.001	0.001
SIZE	0.009	0.008	0.009	0.008
	[0.009]	[0.010]	[0.009]	[0.010]
B_M	0.024***	0.023***	0.024***	0.023***
	[0.006]	[0.006]	[0.007]	[0.007]
ROA	-0.221***	-0.251***	-0.208***	-0.239***
	[0.060]	[0.062]	[0.059]	[0.062]
LEV	-0.003**	-0.003**	-0.003**	-0.003**
	[0.001]	[0.002]	[0.001]	[0.002]
RET_VAR	0.028	0.024	0.026	0.021
	[0.020]	[0.019]	[0.023]	[0.023]
FOLLOWING	0.005***	0.005***	0.005***	0.005***
	[0.001]	[0.001]	[0.002]	[0.002]
ACCRUALS	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
ERROR	0.001***	0.001***	0.001***	0.001**
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.014	0.022	0.016	0.024
	[0.068]	[0.071]	[0.069]	[0.071]
YEAR FE	Yes	Yes	Yes	Yes
FIRM FE	Yes	Yes	Yes	Yes
POST*CONTROLS	No	No	Yes	Yes
Observations	3,041	2,917	3,041	2,917
R-squared	0.402	0.411	0.405	0.414

Table 6 presents the result from regressing the yearly average of the four cost of capital metrics on the interaction between indicator variables marking firms disclosing the target of environmental performances at least since 2009 or earlier and that do never stop this disclosure in their history (*ER_Target*) and the years after the Fukushima nuclear disaster *(POST)*, and the interaction between firms issuing an environmental stand-alone report at least since 2009 or earlier and that do never stop this disclosure in their history but not the target (*ER_NoTarget*) and *POST*. The estimation sample includes only firms in non-environmental sensitive industries. The table reports OLS coefficient estimates and (in parentheses) robust standard errors that are clustered by firm.
***, ** and * denote significance at 1 percent, 5 percent and 10 percent levels (two-tailed), respectively.

Table 7
Environmental target disclosure and cost of capital - Controlling for confounders

	Capital intensity		Operating risk		Delta E[CFO]		Distance from Fukushima > 150 Radius	Distance from Fukushima > 300 Radius	Distance from Fukushima > 400 Radius
	FLEXIBLE	FLEXIBLE & PSM	FLEXIBLE	FLEXIBLE & PSM	FLEXIBLE	FLEXIBLE & PSM	FLEXIBLE & PSM	FLEXIBLE & PSM	FLEXIBLE & PSM
	(1)	(2)	(3)	(3)	(5)	(6)	(7)	(8)	(9)
POST*ER_Target	**-0.050*** **	**-0.048*** **	**-0.066*** **	**-0.066*** **	**-0.042** **	**-0.042** **	**-0.051*** **	**-0.040* **	**-0.037* **
	[0.016]	**[0.016]**	**[0.024]**	**[0.024]**	**[0.017]**	**[0.018]**	**[0.017]**	**[0.021]**	**[0.021]**
POST*ER_NoTarget	-0.005	-0.005	-0.025	-0.025	0.002	0.002	-0.010	0.006	0.009
	[0.010]	[0.011]	[0.020]	[0.020]	[0.013]	[0.013]	[0.012]	[0.017]	[0.018]
POST*ER_Target*Partitioning variable	-0.023	-0.021	-0.075	-0.078	-0.034	-0.031	-	-	-
	[0.022]	[0.022]	[0.069]	[0.068]	[0.022]	[0.021]			
POST*ER_NoTarget*Partitioning variable	-0.006	-0.005	-0.072	-0.076	-0.040*	-0.037*	-	-	-
	[0.015]	[0.015]	[0.068]	[0.067]	[0.022]	[0.022]			
F-test on coefficients									
POST*ER_Target = POST*ER_NoTarget	0.000	0.000	0.002	0.002	0.000	0.001	0.001	0.001	0.001
CONTROLS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
POST*CONTROLS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
YEAR FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FIRM FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,678	3,534	3,756	3,612	3,749	3,606	3,579	1,476	1,383
R-squared	0.424	0.432	0.425	0.432	0.430	0.437	0.430	0.439	0.445

Table 7 presents the result from regressing the yearly average of the four cost of capital metrics on the interaction between firms disclosing the target of environmental performances at least since 2009 or earlier and that do never stop this disclosure in their history (*ER_Target*) and *POST*, and the interaction between firms issuing an environmental stand-alone report at least since 2009 or earlier and that do never stop this disclosure in their history but not the target (*ER_NoTarget*) and *POST*. We include continuous partitioning variables for capital intensity (models 1 and 2), operating risk (models 3 and 4), and expected change in cash flow (models 5 and 6), and the relative interactions. We subsequently exclude (models 7, 8 and 9) from the estimation sample firms incorporated in towns within a radius of 150, 300, 400 km Control variables are included but not reported for brevity. The table reports OLS coefficient estimates and (in parentheses robust standard errors that are clustered by firm.
***, ** and * denote significance at 1 percent, 5 percent and percent levels (two-tailed), respectively.

Table 8
Disclosure reaction

	Δ Pages			Δ Disclosure factor		
	(1)	(2)	(3)	(4)	(5)	(6)
ER_target	13.001**	11.590*	13.197**	0.410**	0.430**	0.464**
	[5.510]	[5.889]	[6.264]	[0.161]	[0.168]	[0.179]
$SIZE_{pre}$		2.526*	2.539		0.018	0.009
		[1.313]	[1.627]		[0.041]	[0.071]
B_M_{pre}		-1.969	-1.528		0.201	0.184
		[3.152]	[3.169]		[0.134]	[0.152]
LEV_{pre}		-0.256	-0.436		0.002	-1.231
		[0.760]	[0.729]		[0.040]	[3.199]
ROA_{pre}			25.474			0.002
			[27.565]			[0.041]
RET_VAR_{pre}			3.245			0.211
			[42.912]			[0.565]
$FOLLOWING_{pre}$			-0.180			-0.001
			[0.693]			[0.086]
$ACCRUALS_{pre}$			-0.079			0.035
			[0.403]			[0.027]
$ERROR_{pre}$			-1.861***			-0.071**
			[0.548]			[0.034]
Constant	17.000	-6.981	-6.899	-0.029***	-0.480	-0.237
	[.]	[15.168]	[17.032]	[0.000]	[0.444]	[0.492]
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	280	280	280	280	280	280
R-squared	0.063	0.100	0.111	0.041	0.049	0.063

Table 9, columns (1) – (3) report the results from regressions of the delta of the number of pages between the 2010 and 2011 on an indicator variables marking whether firms disclosed information on the expected environmental performance in the period before the accident. Columns (4) – (6) report the results from regressions of the delta of a disclosure factor between the 2010 and 2011 on an indicator variables marking whether firms disclosed information on the expected environmental performance in the period before the accident.
***, ** and * denote significance at 1 percent, 5 percent and 10 percent levels (two-tailed), respectively.

Figure 1
Cost of capital Sensitivity to Environmental Performance