M&SOM MANUFACTURING & SERVICE OPERATIONS MANAGEMENT

Articles in Advance, pp. 1–19
ISSN 1523-4614 (print) | ISSN 1526-5498 (online)

informs

http://dx.doi.org/10.1287/msom.1120.0420

Engaging Supply Chains in Climate Change

Chonnikarn (Fern) Jira, Michael W. Toffel
Harvard Business School, Harvard University, Boston, Massachusetts 02163
{cjira@hbs.edu, mtoffel@hbs.edu}

Suppliers are increasingly being asked to share information about their vulnerability to climate change and their strategies to reduce greenhouse gas emissions. Their responses vary widely. We theorize and empirically identify several factors associated with suppliers being especially willing to share this information with buyers, focusing on attributes of the buyers seeking this information and of the suppliers being asked to provide it. We test our hypotheses using data from the Carbon Disclosure Project's Supply Chain Program, a collaboration of multinational corporations requesting such information from thousands of suppliers in 49 countries. We find evidence that suppliers are more likely to share this information when requests from buyers are more prevalent, when buyers appear committed to using the information, when suppliers belong to more profitable industries, and when suppliers are located in countries with greenhouse gas regulations. We find evidence that these factors also influence the comprehensiveness of the information suppliers share and their willingness to share the information publicly.

Key words: econometric analysis; empirical research; environmental operations; sustainable operations; quality management; supply chain management; risk management
History: Received: October 13, 2011; accepted: October 20, 2012. Published online in *Articles in Advance*.

1. Introduction

A growing number of firms are responding to climate change by attempting to mitigate greenhouse gas (GHG) emissions in their operations and supply chains. Reducing the carbon footprint of companies' operations provides an enormous opportunity. The 2,500 largest global corporations account for more than 20% of global GHG emissions, yet emissions resulting from corporate operations are typically *exceeded* by those associated with their supply chains (Carbon Disclosure Project 2011a). There is a growing awareness of the vulnerabilities of supply chains to risks and potential costs associated with the physical and regulatory threats related to global climate change (Van Bergen et al. 2008, Gunther 2010, Halldórsson and Kovács 2010). Suppliers are vulnerable to climate change to the extent that their business activities are likely to be adversely affected by physical changes and regulations related to climate change (Intergovernmental Panel on Climate Change 2007, Schneider et al. 2007). On the upside, managing greenhouse gas emissions has also been shown to enhance brand and market value in some circumstances (Hopkins 2010, Kim and Lyon 2011). This combination of managing risks and pursuing opportunities has led many managers to try to better understand supply chain management in conjunction with climate change.

Gathering information from suppliers about their climate change vulnerabilities and GHG emissions enables buyers to benchmark and to identify cost- and risk-reduction opportunities. In addition, information about supplier vulnerabilities to climate change can help companies make better decisions to mitigate risks associated with GHG regulation and with climate change's forecasted physical effects (U.S. General Services Administration 2010). Information about supply chain GHG emissions is also being used by companies such as PepsiCo to develop carbon-footprint product labels, with the hope of differentiating products and increasing sales.

But such efforts by buyers are thwarted by severe data limitations because few companies report their emissions (U.S. General Services Administration 2010). A few initiatives have recently emerged to address this data gap. One of the first large-scale requests for supply chain GHG emissions data was by Walmart, in a program launched in 2007 to assess the sustainability of its supply chain. The United States federal government followed suit in 2009, when a new presidential executive order required federal agencies to set reduction targets and track the reduction of GHG emissions, including those associated with their supply chains (Obama 2009), which led to the launch in 2010 of the Federal Supplier Greenhouse Gas Emissions Inventory Pilot that is expected to run through 2013 (U.S. Environmental Protection Agency 2012a). In 2010, the U.S. Securities and Exchange Commission (2010) began requiring that the financial annual reports of publicly traded companies include

the business, physical, and regulatory risks posed by climate change.

Little is known about the circumstances that might encourage or deter suppliers from sharing with their buyers information about (a) their vulnerability to the physical manifestations of and regulatory responses to climate change, (b) their GHG emission levels, and (c) their GHG reduction strategies. In operations management, information sharing has been used to manage supply chain risks, but most research on information sharing in supply chains has focused on sharing operational parameters such as demand forecasts and inventory levels to mitigate supply chain disruptions (Lee and Whang 2000, Chen 2003). The scant research on the use of shared information to manage other types of risk, such as reputational damage and accidents, has largely focused on management system standards such as ISO 9001 and ISO 14001 (e.g., Corbett 2006, Naveh and Marcus 2007, Levine and Toffel 2010) and on codes of conduct governing workplace conditions (e.g., Locke et al. 2007, Weil and Mallo 2007, Toffel et al. 2012). Despite the growing interest of managers and policy makers in addressing climate change and an emerging awareness of the potential role of supply chain management, no prior research of which we are aware has examined the conditions under which suppliers and buyers are particularly likely to coordinate efforts to address climate change. We begin to address this opportunity by theorizing circumstances in which suppliers are especially likely to share climate change information with their buyers. We focus on attributes of both the buyers seeking this information and of the suppliers being asked to provide it. We test our hypotheses using proprietary data from the Carbon Disclosure Project's (CDP) Supply Chain Program, a collaboration of multinational corporations that request information about their key suppliers' GHG emissions as well as their vulnerabilities and opportunities associated with climate change. This empirical context provides an unusual opportunity to examine how a variety of suppliers respond to a simultaneous request from various buyers.

We identify several buyer and supplier attributes associated with suppliers' decisions of whether to share climate change information with their buyers and, if so, how much. Specifically, suppliers are more likely to share this information when they face more buyers requesting it and when their buyers convey a commitment to use it in their future procurement decisions. Suppliers operating in more profitable industries or located in countries with GHG emissions regulations are also more likely to share climate information with buyers. We find that these factors are also associated with suppliers sharing more comprehensive information, sharing key pieces of information, and sharing the requested information with the public.

We find no evidence that the GHG intensity of a supplier's industry directly affects the supplier's propensity to share climate change information, but we do find that GHG intensity moderates the influence of buyer requests on sharing such information. Suppliers in more GHG-intensive industries that do share climate change information are also especially likely to share GHG emissions data, owing perhaps to their greater likelihood of having already conducted a GHG inventory.

2. Related Literature

Our examination of the circumstances under which suppliers are particularly likely to share environmental information with their buyers builds on three streams of literature, as described below.

2.1. Organizational Adoption of Practices and Standards

Several studies have examined how buyers have sought to cascade their social and environmental values through their supply chains by pressuring suppliers to adopt particular environmental and labor management practices, codes of conduct governing working conditions, and process standards such as the ISO 14001 Environmental Management System standard. These studies found that the diffusion of such practices and standards was promoted by particular organizational, national, and supply chain characteristics. The adoption of environmental practices is more likely among suppliers that are larger, that are more environmentally aware, and that have slack resources and specialized assets (Locke et al. 2007, Lee 2008, Delmas and Montiel 2009). These studies also indicate that adoption is also more likely in countries with more stringent regulations, stronger legal institutions, and regulatory requirements to disclose pollution data. Suppliers are also more willing to adopt practices advocated by buyers that provide technical assistance and training, that engage in joint problem solving, that share best practices, and with whom they have collaborative, cooperative, and longer relationships (Locke et al. 2007). Anecdotal evidence suggests that buyers with market power can also more effectively motivate their suppliers to adopt particular management practices (Barrientos and Smith 2006).

Although a good deal is known about factors associated with suppliers adopting environmental and labor practices, it remains unclear whether these factors also apply to suppliers deciding whether to share environmental information with their buyers. The nature of the action requested of suppliers differs substantially: Buyer requests that suppliers share climate change information are based on the notion

of encouraging transparency rather than demanding conformity. Whereas the costs to a supplier of adopting prescribed operational practices can often be readily forecasted, sharing climate change information involves not only measurement cost but also great uncertainty as to how the buyer will interpret and use the information. Whether the buyer files the information away or uses it to benchmark and then demand significant GHG emission reductions can impose dramatically different costs on the supplier. The challenge of such unclear benefits and costs enables us to develop novel theory and hypotheses to better understand the factors that motivate suppliers to share such information with their buyers.

2.2. Information Sharing in the Supply Chain

Our work also relates to studies of how buyers and suppliers can promote supply chain coordination, improve production-planning decisions, and reduce risk by sharing production parameters such as inventory levels and demand forecasts. Whereas this literature focuses on assessing the value of information sharing, designing information-sharing mechanisms, and developing optimal information-sharing strategies (e.g., Cachon and Fisher 2000, Chen 2003, Özer et al. 2011, Kurtuluş et al. 2012), several works study the circumstances that promote information sharing between supply chain partners. Greater willingness to share has been associated with firms that are particularly dependent on new products and that engage in more innovation in their organizational processes (Zhou and Benton 2007). Supply chain partners are also more likely to share information the more longstanding their relationship, and the more it is characterized by trust and a shared vision, relationship-specific investments, and an agreement not to share the information with other supply chain partners (Lee and Whang 2000, Li 2002, Li and Lin 2006, Li and Zhang 2008). Other empirical work has focused on buyers sharing information with suppliers (Terwiesch et al. 2004, Schloetzer 2012).

Although this literature highlights the importance of mutual trust and cooperation, very few studies specifically motivate *suppliers* to share information with *buyers*. Moreover, the information-sharing literature has focused on operational metrics to the exclusion of increasingly important environmental and social information. Also, whereas sharing operational parameters typically involves information that one party already has available, such as inventory and demand forecasts, sharing climate change information often requires investment in areas quite outside the firm's core competency.

2.3. Corporate Environmental Disclosure

The literature on corporate environmental disclosure focuses on information disclosed to regulators, investors, and the public through financial and sustainability reports. Greater disclosure has been found among firms that are larger and more profitable or are more dependent on capital markets and foreign sales (Patten 1991, Cormier and Magnan 2003, Stanny and Ely 2008). Disclosure propensity differs by industries and by region (Patten 1991, Cormier and Magnan 2003). Firms also tend to disclose more and higher-quality environmental information when faced with heightened scrutiny by investors (Stanny and Ely 2008, Reid and Toffel 2009), regulators (Short and Toffel 2008), and the media (Brown and Deegan 1998, Cormier and Magnan 2003).

This literature stream examines disclosure to regulators, investors, and the public, but not—to the best of our knowledge—supply chain partners. It is unclear the extent to which this literature's findings apply to suppliers' decisions to share environmental information with their buyers in a business-to-business context (rather than with consumers).

3. Theory and Hypotheses

Voluntary information disclosure has long been studied as an information asymmetry problem featuring adverse selection, where the agent possesses private information that is unknown to the principal (e.g., Akerlof 1970). Although there are many variants of this setting, the fundamental decision by the agent is to maximize its payoff by deciding whether or not to disclose the desired information, given the expected response by the principal (Verrecchia 2001). In this context, the supplier's decision to disclose is based on trade-offs between the costs and benefits of disclosure.

In our context, a supplier must weigh the necessary investments against the implications for its competitive position. Disclosing climate change information can require an investment to analyze how climate change and GHG regulations are likely to affect the organization, to identify all of the various sources of GHG emissions, to collect GHG emissions data, and to develop and maintain a GHG reporting system. Firms engaging in these efforts also bear the opportunity cost of the required capital and personnel time. Suppliers weigh these investments against the potential impact on their competitive position, such as whether they will be better positioned to win or retain contracts, whether these tasks can help them develop capabilities that can differentiate them from competitors, and whether responding will help them avoid penalties that might arise from not responding.

Although some of the costs are relatively easy to quantify, the newness of this context and the rapidly changing public and political views regarding climate change render other costs and benefits highly uncertain. For example, because there is no established

benchmark for an acceptable level of suppliers' GHG emissions, a supplier might not know whether the information it shares will be viewed by its buyers as acceptable or unacceptable and whether sharing information will bring new business or new and costly requirements. The uncertainty about whatever carbon costs would result from GHG emissions regulations and the uncertainty over changing consumer preferences for less carbon-intensive products and services challenge suppliers to anticipate what—if any—strategic benefits might be achieved by sharing climate change information with their buyers.

We propose a framework that describes the factors that affect a supplier's perceived costs and benefits of sharing information with its buyers. We categorize these factors into two groups: characteristics of the buyer seeking the information and characteristics of the supplier from whom the information is being sought. From the buyers' side, we hypothesize that the *breadth* and the *depth* of buyer pressure will affect the suppliers' decisions whether or not to comply with buyers' requests to provide climate change information. From the suppliers' side, we hypothesize that their profitability, their vulnerability to stakeholder scrutiny, and the relative investment required for them to share information all contribute to their decision whether or not to share climate change information with buyers.

3.1. Characteristics of Demand for Information Sharing

Suppliers, already occupied with running their businesses, receive many information requests from buyers and other stakeholders (Chatterji and Levine 2006). Because gathering information to respond to such requests is costly (Delmas 2002), we theorize that suppliers will prioritize more salient requests, and that requests acquire salience when (a) they appear to be part of a growing trend rather than idiosyncratic and (b) suppliers face buyers who appear more committed to using the shared information. In other words, we argue that suppliers will be influenced by the *breadth* and *depth* of the pressure they face from buyers.

3.1.1. The Breadth of Buyer Pressure. Upon receiving a buyer's request for a novel type of information, such as climate change vulnerability, suppliers face the challenge of determining whether the request is idiosyncratic or whether it signals a new social movement that represents a broad shift in attitudes and increasingly institutionalized norms (Davis et al. 2005). Although most research based on social movement theory concentrates on how activist groups use media campaigns, shareholder resolutions, strikes, and boycotts to try to pressure organizations to adopt new norms (Davis et al. 2005, Reid and Toffel 2009), we assert that social movements can also be driven by organizations leveraging their procurement activities. When suppliers see the request as part of a new trend rather than idiosyncratic, they will anticipate greater benefits from sharing the information, because the cost of fulfilling the request can be seen as a smaller investment to be allocated across the current and future requests. They may also see a refusal to share the information as a risk to their legitimacy and to future orders. More buyers requesting the same information indicates greater breadth of pressure—a greater likelihood that the request is part of a trend and worth a response. We therefore propose:

Hypothesis 1 (H1). *Sharing climate change information with buyers is more likely among suppliers facing more buyers requesting this information.*

3.1.2. The Depth of Buyer Pressure. Research has found that buyers' mandating that their suppliers adopt particular management standards leads to the diffusion of those standards throughout the supply chain (Anderson et al. 1999, Delmas and Toffel 2008, Delmas and Montiel 2009). In our context, however, buyer requests for information are not mandates, and the penalties—if any—of not responding are very unclear. Buyers requesting climate change information from their suppliers exhibit different levels of commitment to using this information. Our interviews with sustainability officers at some buyers requesting climate change information from their suppliers indicated that they had no current plans to use the information but thought that the data might eventually be useful and that seeking it was virtually costless. In another example, a Fortune 500 manufacturer that was asked to complete the CDP Supply Chain Program questionnaire was unable to find anyone at the requesting buying organization who could explain how the responses would be used (Baier 2012).

Some companies have expanded their supplier scorecards to include suppliers' willingness to share GHG information, modified their standard request for proposals (RFP) to include climate change information sharing, and added sustainability language to their supplier agreements (Baxter International 2009, Vodafone 2009, Baier 2012). For example, climate change management is an element of one of Vodafone's six "pillars" by which supplier performance is measured (Vodafone 2009). In another example, Dell, in requesting its suppliers to respond to the CDP Supply Chain Program questionnaire, stated: "Failure to meet these requirements can impact your [supplier] ranking and potentially diminish your ability to compete for Dell's business" (Way 2010), although, even in this case, the cautious phrasing ("can," "potentially") conveys uncertainty about how important the information really is to future procurement decisions.

Suppliers are likely to perceive more intense pressure from those buyers that do plan to use the requested information in their criteria for supplier selection (or retention) and/or as part of procurement contract terms. Indeed, our interviews indicated that buyers often found it difficult to obtain information from suppliers unless the supplier perceived the request to be relationship-critical. Conveying a commitment to use suppliers' climate change information is more likely to lead suppliers to anticipate greater benefits from sharing that information and greater costs of refusing to do so. We therefore propose:

Hypothesis 2A (H2A). *Suppliers are more likely to share climate change information with buyers that appear committed to using this information in future procurement decisions*.

Alternatively, suppliers might be especially deterred from sharing information with buyers committed to using it. Because "appropriate" levels of climate change management attention and GHG emissions performance have yet to be well established, suppliers risk sharing information that a buyer might judge to be poor when benchmarked against other suppliers. For example, Walmart's senior director of sustainability and strategy acknowledged that the sustainability information Walmart requests from its suppliers, including GHG emissions levels and reduction targets, will "help us recognize who's leading and who's lagging" (Denend and Plambeck 2010, p. 3). This reasoning was supported by Verrecchia (2001), who stated that a reason for withholding information when disclosure is voluntary is the uncertainty concerning the types of player involved. In our context, the uncertainty concerns both the buyer's type (how the buyer will react to the disclosed information) and the supplier's own type (how the supplier compares with other suppliers). For example, when a supplier requests a price increase due to rising energy costs, few would expect the buyer to consult the energy and climate risk management information that the supplier shared via the CDP Supply Chain Program, but this is what Imperial Tobacco Group has done (Carbon Disclosure Project 2011a). In addition, sharing data with buyers could lead them to ask suppliers to incur additional costs, as implied by Dell's stated intention to "work with suppliers on emissions reduction strategies once data is collected" (Newton 2007). Such concerns would make suppliers *less* likely to disclose climate change information to buyers that appear especially committed to using it. We therefore propose:

Hypothesis 2B (H2B). *Suppliers are less likely to share climate change information with buyers that appear committed to using this information in future procurement decisions*.

3.2. Characteristics of Information Providers

Beyond buyer attributes, a supplier's competitive and institutional context will influence its propensity to share climate change information with a buyer. We focus on the profitability of a supplier's industry, the supplier's vulnerability to scrutiny from stakeholders regarding climate change, and the extent to which the investment required for it to share climate change information is reduced through operating in a domain featuring GHG emissions regulations.

3.2.1. Profitability. Firms often provide their highest-quality service to attract and retain the most profitable customers. Airlines offer first-class customers special treatment, some customer call centers prioritize the most profitable customers (Klungle and Maluchnik 1997), and some companies deprioritize the quality of service to their least-profitable customers (Wagner 2006). Theory indicates that bouts of extremely high service quality enhance customer retention (Bolton et al. 2006) and empirical research reveals high returns on investing in the loyalty of high-value customers (Reichheld 1996). Literature on newsvendor stocking quantities also indicates that firms maintain a higher service level for more profitable customers (Porteus 1990). We argue that, in this regard, agreeing to a buyer's requests for information can be treated as high-quality service. Suppliers in highly profitable industries are more likely to agree to such requests than those in less profitable industries such as commodities, where competition is based on price rather than service. Suppliers in more profitable industries (a) face higher opportunity costs of losing buyers and thus have greater incentives to retain them and (b) are more likely to be able to afford to invest in gathering the requested information, for example, by developing a GHG inventory. We therefore propose:

Hypothesis 3 (H3). *Sharing climate change information with buyers is more likely among suppliers operating in more profitable industries*.

3.2.2. Vulnerability to Stakeholder Scrutiny. Suppliers in GHG-intensive industries are more likely to face public scrutiny and pressure from nongovernmental organizations (NGOs) regarding climate change (Patten 1991), and are more likely to be targeted or threatened by GHG regulations. Similarly, they are more likely to be prioritized for scrutiny by buyers and investors seeking to manage their climate change vulnerabilities and to reduce GHG emissions. Those that refuse to share climate change information are likely to be targets of even greater NGO scrutiny (Stanny 2013), which can increase their costs. Research has shown that firms seek to avoid the costs and risks associated with being scrutinized (Short and Toffel 2008) and that sharing environmental information is one way to bolster legitimacy and alleviate scrutiny

on environmental matters (Neu et al. 1998). We therefore propose:

Hypothesis 4 (H4). *Sharing climate change information with buyers is more likely among suppliers operating in GHG-intensive industries.*

3.2.3. Investment Required for Information Sharing. Different suppliers would need to make different investments to share information with buyers. One important factor is whether regulations already require the company to gather related information. In our context, suppliers in countries where regulations already call for at least some of the requested information or similar information will require less investment to gather and analyze the data necessary to share climate change information with their buyers. For example, suppliers already subject to regulations requiring them to identify and calculate their GHG emissions and to develop a reporting system will require little additional investment to share this information with buyers.

Even suppliers in countries where GHG regulations target companies in other industries but not their own are likely to require lower investments to calculate their GHG emissions than suppliers in unregulated countries will require. GHG emissions regulations create a market of service providers to support the development of GHG inventories in that country, so even suppliers whose GHG emissions are not regulated have superior access to such services. In addition, institutional theory predicts that regulations legitimize certain norms and preferences (Scott 1995). In our context, a country's GHG regulations legitimize (a) the management of climate change impacts and (b) being transparent about these efforts, while also lowering the cost of doing so, both of which would tend to delegitimize a supplier's refusal to disclose climate change information. We therefore propose:

Hypothesis 5 (H5). *Sharing climate change information with buyers is more likely among suppliers in countries with GHG emissions regulation.*

4. Data and Measures

4.1. Data and Sample

We tested our hypotheses in the context of the Carbon Disclosure Project's Supply Chain Program, which involves a group of multinational corporations (buyers) interested in learning about their key suppliers' vulnerabilities to climate change, strategies to address these vulnerabilities, and GHG emission levels. Participating buyers have included financial companies such as National Australia Bank, high-technology firms including Dell and IBM from the United States, consumer product firms such as France's L'Oréal and the United Kingdom's Unilever, and energy service firms such as Italy's Enel. Each buyer provided CDP with a list of the suppliers from whom it sought data. Buyers typically selected a subset of their suppliers that accounted for a significant portion of the buyer's spending (Cremmins 2011). CDP, a UK-based NGO that maintains the world's largest database of corporate climate change information (Carbon Disclosure Project 2011b), surveyed these suppliers on behalf of the buyers using an online questionnaire. Although the online questionnaire was administered through CDP, buyers also communicated directly with their suppliers to inform them about this request and to encourage them to share the information (Carbon Disclosure Project 2012).

Our empirical context offers a unique opportunity to examine how suppliers in different industries around the world respond to an identical set of questions asked simultaneously by a variety of buyers. Each year, all of the suppliers surveyed receive an email from CDP on the same date, explaining the online questionnaire and inviting them, on behalf of their particular buyer(s), to complete it. Each supplier, upon accessing the online questionnaire using a custom URL, immediately sees a list of its buyers that are requesting this information. Suppliers can respond privately or publicly. CDP shares private responses only with those buyers that had requested the information. (Suppliers can not, however, instruct CDP to share their responses with only a subset of their requesting buyers.) Public responses are shared with the requesting buyers and are also posted on CDP's public website (http://www.cdproject.net).

The CDP Supply Chain Program is an extension of CDP's primary program that sends similar questionnaires to predominantly large, publicly traded companies on behalf of their institutional investors. Prior studies have examined the content of information disclosed to CDP (Kolk and Pinkse 2007) and stock market reactions to these disclosures (Kim and Lyon 2011). Other studies found that companies' decisions of whether or not to publicly disclose climate change information to the Investor CDP Program were associated with the company's size, environmental performance, media visibility, reliance on foreign sales, the threat of climate change regulation, and having been targeted by environment-related shareholder resolutions (Stanny and Ely 2008, Reid and Toffel 2009, Luo et al. 2012). Our research differs from these studies because we examine factors related to supply chain relationships, we exploit institutional variation across firms located in many countries, and the suppliers in our sample are significantly more heterogeneous in size and include both privately held and publicly owned companies, compared to those who receive the Investor CDP questionnaire.

CDP provided us with proprietary data from its Supply Chain Program surveys conducted in 2009 and 2010 on the condition that we maintain the confidentiality of nonpublic information. Each year, the response deadline was July 31. For the 2009 survey, 44 buyers from 11 countries asked CDP to survey 1,402 of their suppliers in 42 countries. For the 2010 survey, these numbers grew to 57 buyers from 15 countries requesting information from 1,853 suppliers in 45 countries. We linked the CDP data to the Capital IQ and Worldscope databases and to information from the United Nations Framework Convention on Climate Change, the World Economic Forum, Trucost, and the U.S. Department of Agriculture's Economic Research Service. Of the questionnaires sent in 2009 and 2010, totaling 3,255, we were able to link the CDP data to other variables of interest for 3,226 questionnaires (99%) from 2,490 suppliers in 49 countries (the supplier's country is almost always its headquarters country); 1,376 questionnaires for 2009, and 1,850 for 2010. The geographic and industry distribution of these suppliers is reported in the online supplement (available at http://dx.doi.org/10.1287/msom.1120.0420). Our unit of analysis is the supplier-year.

4.2. Measures

4.2.1. Dependent Variable. We created a dichotomous variable, *shared climate change information*, coded 1 when a supplier shared climate change information (publicly or privately) by responding to the CDP Supply Chain Program questionnaire in a given year and 0 otherwise. We created this variable based on proprietary data obtained from CDP for survey years 2009 and 2010. Of the 1,376 suppliers that were sent the questionnaire in 2009, 726 (52.8%) shared climate change information. In 2010, 995 of the 1,850 surveyed suppliers (53.8%) did so. Although this measure considers even those suppliers that responded to a single question to have shared climate change information, alternative approaches to coding with different comprehensiveness thresholds yielded nearly identical results. In particular, as robustness tests, we employed four alternative approaches to coding this dichotomous variable as 1 based on whether the supplier answered at least 2, at least 4, at least 8, or at least 12 of 19 core survey questions.

4.2.2. Independent Variables. We captured the degree to which buyer requests were indicative of a social movement rather than being idiosyncratic via *number of buyer requests*—the number of buyers that asked a particular supplier to share climate change information through the CDP questionnaire in a given year. We obtained data for this measure from CDP. To reduce skew, we use the logged value in our models.

To capture the extent to which suppliers perceived their buyers to be more committed to actually using the requested information, we obtained data from CDP Supply Chain Program staff about each buyer's formal mechanism (if any) to incorporate suppliers' responses into future procurement decisions. For example, as mentioned earlier, Dell warns its suppliers that failure to respond can reduce their future business prospects (Way 2010). We created *climate change as a buying criterion* as a dichotomous variable coded 1 for suppliers that faced at least one requesting buyer whose supplier scorecard, RFP process, or other supplier evaluation scheme incorporated responses to the CDP Supply Chain questionnaire, and 0 if the supplier had no such buyer. This measure differentiates suppliers facing buyers portraying a commitment to use the requested information from suppliers whose buyers do not portray such a commitment.

Because numerous suppliers in our sample are privately held companies located around the world, we were unable to obtain firm-level profit margin data for most of the suppliers in our sample. We instead measure the profitability of each supplier's industry based on the *median profit margin* of that industry in the supplier's country. We calculated the profit margin (net income divided by sales) of all companies in the Worldscope database, which includes more than 95% of the world's publicly traded companies. Finding large variation across countries in the profit margins of companies within the same industry (four-digit Global Industry Classification Standard (GICS) code), we calculated the *median profit margin* within each industry–country dyad to capture the prevailing profitability of each supplier's industry. We chose median rather than mean to avoid contamination by outliers. We used one-year lagged values in our models, but using the average of one- and two-year lags instead yielded very similar results.

We gauge a supplier's vulnerability to climate change regulations by the GHG intensity of its industry. Using data obtained from Trucost, we measure *industry's GHG intensity* in metric tons of GHG per million U.S. dollars of revenue in 2009 for each six-digit GICS code. We linked this to our sample based on six-digit GICS codes obtained from Capital IQ. We recoded the 569 cases for which we could not obtain these data from "missing" to "0." To reduce skew, we logged this variable (after adding 1). We also included in our models a corresponding dichotomous variable coded 1 for observations for which such recoding had been conducted and 0 otherwise.

To identify whether there were climate change regulations in a supplier's country, we created a dichotomous variable, *Kyoto Annex I country*, coded 1

for suppliers in countries that were listed in the Kyoto Protocol's Annex I and that, by September 2010, had ratified, approved, accepted, or accessed the protocol, thereby agreeing to promulgate national regulations imposing binding GHG emission limits, and coded 0 otherwise. We coded this variable based on data obtained from the United Nations Framework Convention on Climate Change website (United Nations Framework Convention on Climate Change 2010).

4.2.3. Control Variables. We measured whether a supplier was simultaneously asked to respond to the two other primary questionnaires that CDP administered on behalf of institutional investors and government agencies by creating two dichotomous variables: *received CDP Investor questionnaire* and *received CDP Public Procurement questionnaire*. We obtained data for these measures from CDP. Also, to account for instances in which suppliers in 2010 had also received the CDP Supply Chain Program questionnaire in 2009, we created a dichotomous variable, *received CDP Supply Chain questionnaire in previous year*, coded 1 in such instances and 0 otherwise.

We measure buyer power as each supplier's *largest buyer's revenue* (in U.S. dollars), which we obtained by combining data from CDP and Capital IQ. Because of Capital IQ's limited coverage, we could only obtain this measure for 92% of our sample (2,964 of the 3,226 supplier-year observations) and recoded missing values to 0. We also obtained data for *supplier's revenue* (in U.S. dollars) from Capital IQ, but only for 36% of our sample (1,163 of 3,226 supplier-year observations). We recoded the missing values to 0. In our models, we used one-year lagged values of both variables and logged each of them (after adding 1) to reduce skew. We also included in our models corresponding dichotomous variables coded 1 to denote observations for which recoding-to-zero had been conducted and coded 0 otherwise.

Our model controls for several country-level factors. We measure *country's environmental governance* in each supplier's country based on executives' perceptions of (1) that country's pollution levels, (2) the extent to which environmental challenges negatively impact business operations in that country, and (3) the stringency of that country's environmental regulations and enforcement. We obtained these data from the World Economic Forum's annual Executive Opinion Surveys, in which executives scored each of these dimensions using a seven-point Likert scale ranging from 1 for "extremely weak" to 7 for "extremely strong—the best in the world." Because this set of questions changed slightly during our sample period, we calculated annual country averages (rather than relying on factor-analysis scores) to avoid having our measure be overly dependent on our particular sample (Wainer 1976). In our models, we use responses lagged one year to capture the circumstances prevailing when the CDP questionnaire was administered.

We measure activist pressure and scrutiny in the supplier's country as *environmental NGOs per million population*, which reflects the number of the International Union for Conservation of Nature (IUCN) member organizations (in 2004) per million population (in 2003). IUCN is an international environmental organization whose members include the most significant international environmental NGOs, such as Conservation International, the National Geographic Society, and the Sierra Club. This ratio, which we obtained from Esty et al. (2005), has been used for similar purposes by others (e.g., Hafner-Burton and Tsutsui 2005). To reduce skew, we logged this variable after adding 1.

We also obtained data for each supplier *country's per capita GDP* in real 2005 U.S. dollars from the U.S. Department of Agriculture's Economic Research Service. We logged this variable to reduce skew and used one-year lagged values.

We control for the potential for management decisions to be influenced by industry norms and trends (Meyer and Rowan 1977, Reid and Toffel 2009). We created a set of supplier *industry dummies* based on their two-digit GICS codes, using information from Capital IQ whenever available or else from supplier responses to CDP. The industry dummies also control for potential measurement error issues, such as the possibility that there are unobserved buyer requests that are not managed through CDP and the number of which varies by industry. Our industry dummies had to be fairly coarse to afford ample variation of our hypothesized industry measures (GHG intensity and profit margins) within these categories. We created an *unknown industry* dummy to denote the 506 observations for which we could not obtain industry information from either of our sources. While industry dummies control for time-invariant industry characteristics, managers might interpret the number of CDP Supply Chain information requests they receive in light of industry trends. We therefore also control for the log (after adding 1) of *mean buyer requests* each year within each supplier's industry (two-digit GICS code). We also performed a robustness test using the unlogged version of this variable, which yielded largely similar results.

Tables 1 and 2 report summary statistics and correlations for all of these variables. The distribution of industries are reported in the online supplement.

5. Method and Results

5.1. Model Specification

We test our hypotheses by estimating the following model:

$$Y_{ijct} = F(\beta_1 \mathbf{X}_{ijct} + \beta_2 \gamma_{it} + \beta_3 \phi_{ct} + \beta_4 \eta_j + \beta_5 \tau_t + \beta_6 u_{jt} + v_{ijct}),$$

Table 1 Summary Statistics

Variable	Mean	SD	Min	Max
Shared climate change information	0.53	0.50	0	1
Number of questions answered (out of 19)	7.95	7.84	0	19
Number of buyer requests	1.31	0.92	1	10
Number of buyer requests (log)	0.16	0.40	0	2.30
Climate change as a buying criterion	0.41	0.49	0	1
Median profit margin by industry-country (%)[a]	0.01	0.07	−0.48	0.55
Industry's GHG intensity	240.60	468.99	0	6,433.14
Industry's GHG intensity (log)	3.98	2.21	0	8.77
Kyoto Annex I country	0.50	0.50	0	1
Mean buyer requests per industry-year	1.31	0.23	1	1.67
Mean buyer requests per industry-year (log)	0.83	0.10	0.69	0.98
Received CDP Investor questionnaire	0.21	0.41	0	1
Received CDP Public Procurement questionnaire	0.05	0.22	0	1
Received CDP Supply Chain questionnaire in previous year	0.24	0.43	0	1
Largest buyer's revenue (million USD)[a]	32,842.11	26,475.76	0	122,748.50
Largest buyer's revenue (USD) (log)[a]	22.03	6.61	0	25.53
Supplier's revenue (million USD)[a]	5,282.88	21,684.17	0	458,361.00
Supplier's revenue (USD) (log)[a]	7.88	10.60	0	26.85
Country's environmental governance[a]	4.84	0.56	0	6.24
County's environmental NGOs per million population	0.49	0.41	0	3.65
County's environmental NGOs per million population (log)	0.37	0.26	0	1.54
Country's per capita GDP (real 2005 USD)[a]	32,538.47	12,945.12	850.28	68,544.08
Country's per capita GDP (real 2005 USD) (log)[a]	10.20	0.79	6.75	11.14
Year 2010 dummy	0.57	0.49	0	1

Note. $N = 3{,}226$ company-year observations from 2,490 companies in 49 countries.
[a]Variable is lagged one year.

where Y_{ijct} refers to whether supplier i in industry j located in country c *shared climate change information* in year t. The function $F(\cdot)$ refers to the logistic function; $\mathbf{X}_{ijct}$ refers to our hypothesized variables *number of buyer requests*, *climate change as a buying criterion*, *median profit margin*, *industry's GHG intensity*, and *Kyoto Annex I country*; and v_{ijct} is the error term.

The term γ_{it} includes several control variables coded at the supplier-year level. Because repeated requests and information demands from other stakeholders can increase the propensity to share environmental information, we controlled for whether suppliers simultaneously received requests for similar information from CDP on behalf of public procurement agencies (*received CDP Public Procurement questionnaire*) and whether suppliers surveyed in 2010 had also been surveyed in 2009 (*received CDP Supply Chain questionnaire in previous year*). The term γ_{it} also includes a dichotomous variable designating whether the supplier also faced investor pressure to share climate change information, as indicated by its having also *received CDP Investor questionnaire*. Suppliers receiving these additional requests might feel increased pressure to respond and would face lower costs of responding per questionnaire because the questions are largely identical and because responses can be submitted simultaneously through CDP's online system.

Because prior studies have found suppliers to be especially likely to comply with buyers' requests to adopt environmental and labor management practices when the buyers had more market power (Barrientos and Smith 2006, Weil and Mallo 2007), γ_{it} also includes each supplier's *largest buyer's revenue* (among its requesting buyers). The term γ_{it} also includes *supplier's revenue*, because supplier size can affect environmental disclosure (Patten 1991, Cormier and Magnan 2003, Stanny and Ely 2008) and the adoption of environmental and social practices in supply chains (Locke et al. 2007, Weil and Mallo 2007).

The term ϕ_{ct} refers to several institutional variables corresponding to the supplier's country. Because environmental disclosure is more likely among organizations subjected to heightened environmental regulatory scrutiny (Short and Toffel 2008), ϕ_{ct} includes the supplier *country's environmental governance*. It also includes a measure of activist pressure, *environmental NGOs per million population*, because activist pressure and scrutiny have been shown to affect organizations' disclosure decisions (Lyon and Maxwell 2011). The term ϕ_{ct} also includes the supplier *country's per capita GDP* because environmental preferences are sometimes viewed as a luxury good, and the environmental interests of stakeholders in the supplier's country might be correlated with economic development.

Because research has shown that firms in different industries exhibit distinct environmental disclosure patterns (Patten 1991, Cormier and Magnan 2003, Reid and Toffel 2009), we include η_j to account for

Table 2 Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) *Shared climate change information*	1.00														
(2) *Number of buyer requests* (log)	0.27	1.00													
(3) *Climate change as a buying criterion*	0.32	0.28	1.00												
(4) *Median profit margin by industry-country*[a]	0.03	−0.01	0.00	1.00											
(5) *Industry's GHG intensity* (log)	0.36	0.17	0.18	0.06	1.00										
(6) *Kyoto Annex I country*	−0.01	−0.05	−0.03	−0.05	−0.08	1.00									
(7) *Mean buyer requests per industry-year* (log)	0.31	0.26	0.27	0.04	0.50	−0.17	1.00								
(8) *Received CDP Investor questionnaire*	0.27	0.40	0.17	−0.03	0.21	0.05	0.18	1.00							
(9) *Received CDP Public Procurement questionnaire*	0.18	0.25	0.12	0.03	0.04	0.14	−0.01	0.23	1.00						
(10) *Received CDP Supply Chain questionnaire in previous year*	0.25	0.26	0.26	−0.04	0.19	−0.06	0.27	0.18	0.14	1.00					
(11) *Largest buyer's revenue* (log)[a]	−0.05	0.15	−0.04	0.00	−0.12	0.15	−0.09	0.03	0.05	−0.09	1.00				
(12) *Supplier's revenue* (log)[a]	0.28	0.37	0.24	−0.03	0.25	−0.05	0.25	0.68	0.18	0.20	−0.02	1.00			
(13) *Country's environmental governance*[a]	0.16	0.14	0.03	−0.13	0.24	0.20	0.14	0.23	0.07	0.07	−0.02	0.21	1.00		
(14) *Country's environmental NGOs per million population* (log)	−0.05	−0.03	−0.06	−0.07	−0.08	0.74	−0.17	0.03	0.16	−0.05	0.06	−0.07	0.29	1.00	
(15) *Country's per capita GDP* (log)[a]	0.11	0.10	0.11	−0.19	0.15	0.25	0.05	0.11	0.11	0.06	0.00	0.12	0.63	0.43	1.00
(16) *Year 2010 dummy*	−0.01	0.01	0.06	−0.01	−0.02	0.02	0.08	−0.00	0.00	0.48	−0.09	−0.06	−0.17	0.04	−0.11

Note. $N = 3{,}226$ company-year observations from 2,490 companies in 49 countries.
[a]Variable is lagged one year.

general differences between industries by including the set of suppliers' *industry dummies*. To account for a general increase in awareness of climate change, τ_t refers to a *year 2010* dummy variable to distinguish supplier responses to the 2010 questionnaire from responses to the 2009 questionnaire. Also, because managers might decide whether or not to share climate change information in light of industry trends, we include u_{jt}, which captures the annual *mean buyer requests* in each supplier's industry.

5.2. Results

We use logistic regression to estimate our model that predicts a dichotomous dependent variable, but estimating the model as a linear probability model (using ordinary least squares regression) yields the same inferences. Because our data set includes some suppliers that were surveyed in both 2009 and 2010, we report robust standard errors clustered by supplier, which accommodates heteroskedasticity as well as the nonindependence of these suppliers' responses over the two-year sample period.

We begin by estimating a baseline model that includes only attributes of the supplier and its institutional environment—which have been the focus of the environmental information disclosure literature so far—and omitting all supply-chain-related variables. We find that being located in a country with GHG emissions regulation ($\beta = 0.50$; $p < 0.01$) and having also received a CDP Investor questionnaire ($\beta = 0.88$; $p < 0.01$) are positive and significant predictors of suppliers sharing climate change information, but find no evidence of a significant influence from being in an industry more vulnerable to climate change. Moreover, the supplier country's number of environmental NGOs per million population ($\beta = -0.93$; $p < 0.01$) is a negative and significant predictor of suppliers sharing climate change information.

Columns (2a) and (2b) of Table 3 report results of our primary model, with coefficients in column (2a) and average marginal effects in column (2b). Examining our control variables, we find that requests by CDP on behalf of other parties and previous buyer requests for climate change information made it more likely that suppliers would share that information with their buyers. Specifically, having simultaneously received a CDP Investor questionnaire ($\beta = 0.73$; $p < 0.01$) or a CDP Public Procurement questionnaire ($\beta = 1.46$; $p < 0.01$) significantly increased suppliers' probability of sharing climate change information, as did the supplier's having received the CDP Supply Chain questionnaire in both 2009 and 2010 ($\beta = 0.68$; $p < 0.01$). The coefficient on *mean buyer requests per industry-year* is also positive and significant ($\beta = 10.82$; $p < 0.01$), signifying that more requests increase the likelihood of a supplier responding to the questionnaire. The negative

Table 3 Regression Results

	Model:	(1)	(2a)	(2b)	(3a)	(3b)
	Dependent variable:	*Shared climate change information*			*No. of questions answered*	
	Functional form:	Logistic			Negative binomial	
	Sample:	All firms	All firms		All firms	
		Coefficients	Coefficients	AME	Coefficients	AME
H1	*Number of buyer requests* (log)		0.794***	0.14	0.095**	0.82
			[0.185]		[0.045]	
H2A/H2B	*Climate change as a buying criterion*		0.840***	0.15	0.462***	4.00
			[0.103]		[0.049]	
H3	*Median profit margin by industry-country*[a]		1.453**	0.25	0.844**	7.31
			[0.698]		[0.362]	
H4	*Industry's GHG intensity* (log)	0.083	0.034	0.01	0.044	0.38
		[0.060]	[0.062]		[0.035]	
H5	*Kyoto Annex I country*	0.500***	0.459***	0.08	0.270***	2.34
		[0.144]	[0.146]		[0.069]	
	Mean buyer requests per industry-year (log)		10.815***	1.89	6.520***	56.45
			[2.397]		[1.155]	
	Received CDP Investor questionnaire	0.880***	0.733***	0.13	0.297***	2.57
		[0.184]	[0.191]		[0.075]	
	Received CDP Public Procurement questionnaire		1.455***	0.25	0.267***	2.31
			[0.337]		[0.080]	
	Received CDP Supply Chain questionnaire in previous year		0.683***	0.12	0.532***	4.61
			[0.126]		[0.053]	
	Largest buyer's revenue (log)[a]		0.064	0.01	−0.031	−0.27
			[0.059]		[0.030]	
	Supplier's revenue (log)[a]	0.066	0.026	0.00	0.021	0.18
		[0.041]	[0.039]		[0.020]	
	Country's environmental governance[a]	0.010	0.155	0.03	−0.047	−0.41
		[0.124]	[0.123]		[0.065]	
	Country's environmental NGOs per million population (log)	−0.925***	−0.915***	−0.16	−0.260*	−2.25
		[0.304]	[0.305]		[0.133]	
	Country's per capita GDP (log)[a]	0.118	−0.023	−0.00	−0.042	−0.36
		[0.081]	[0.086]		[0.049]	
	Observations	3,226	3,226		3,226	
	Companies	2,490	2,490		2,490	
	Countries	49	49		49	
	Log likelihood	−1,803	−1,667		−8,858	
	Mean dependent variable	0.53	0.53		7.95	
	McFadden's adjusted R^2	0.18	0.24		0.04	

Notes. Brackets contain robust standard errors clustered by supplier. AME, average marginal effect. All models also include dummies for *year 2010*, industry dummy variables and dummy variables denoting instances in which the following variables were recoded from missing to zero: *industry's GHG intensity* ($N = 569$), *supplier's revenue* ($N = 2{,}063$), and *country's environmental governance* ($N = 4$). Models 2 and 3 also include dummy variables to denote instances in which *largest buyer's revenue* ($N = 262$) and *median profit margin* ($N = 540$) were recoded from missing to zero.

[a]Variable is lagged one year.

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$.

and significant coefficient on supplier *country's environmental NGOs per million population* ($\beta = -0.92$; $p < 0.01$) suggests that the higher pressure and scrutiny associated with higher NGO density leads to suppliers being less likely to respond to the questionnaire. In contrast, *largest buyer's revenue*, *supplier's revenue*, the supplier *country's environmental governance*, and the supplier *country's per capita GDP* were not significant contributors to the likelihood of a supplier sharing climate change information with its buyers.

Turning to our independent variables, the results yield support for both of our hypothesized demand-side factors. A significant positive coefficient on *number of buyer requests* ($\beta = 0.79$; $p < 0.01$) indicates that the greater the number of buyers requesting climate change information from a supplier, the more likely that supplier is to provide it, which supports H1. The average marginal effect indicates that a one-log-unit increase in the number of requesting buyers is associated with a 14.0-percentage-point increase in

the probability of sharing climate change information. Estimating the model after substituting the unlogged number of requesting buyers for the logged value also yielded a significant positive coefficient.

The significant positive coefficient on *climate change as a buying criterion* ($\beta = 0.84$; $p < 0.01$) indicates that a buyer's apparent commitment to use its suppliers' climate change information in future procurement decisions increases, rather than decreases, the probability that suppliers will share that information. This supports H2A rather than H2B. The average marginal effect indicates that having at least one requesting buyer using climate change as a buying criterion boosts the probability of a supplier sharing that information by 15 percentage points, increasing the average predicted probability from 47.0% to 62.2%. This finding is robust to several alternatives to our dichotomous measure, including the proportion of requesting buyers using climate change as a buying criterion, the number of requests from buyers using climate change as a buying criterion, and the largest revenue of a requesting buyer using climate change as a buying criterion.

From the supplier's side, the significant and positive coefficients on *median profit margin* ($\beta = 1.45$; $p < 0.05$) and *Kyoto Annex I country* ($\beta = 0.46$; $p < 0.01$) lend support to H3 and H5. Average marginal effects indicate that (a) a one-standard-deviation increase in *median profit margin* increases the probability that a supplier shares climate change information by 1.75 percentage points, and (b) being located in a country with GHG emissions regulation increases the probability of sharing climate change information by 8 percentage points (increasing the average predicted probability from 49.5% to 57.4%).

The nonsignificant coefficient on *industry's GHG intensity* yields no support for H4. Exploring several alternative measures of GHG intensity, such as the log of total GHG emissions associated with each supplier's industry (based on estimates of U.S. industries obtained from the National Center for Manufacturing Sciences' Environmental Roadmapping Initiative) and a dichotomous *environmentally sensitive industry* variable (Cho and Patten 2007, p. 643), we continued to find no evidence that suppliers in industries more vulnerable to climate change regulation were more likely to share climate change information. Finding no evidence of a direct effect of *industry's GHG intensity*, we explored whether it had an indirect effect. Additional analyses described in the online supplement revealed that buyer requests have a larger impact on the likelihood of sharing climate change information for suppliers in low-GHG-intensity industries than they do for suppliers in high-GHG-intensity industries.

Comparing results of the baseline model (column (1)) with those of the more comprehensive primary model (columns (2a) and (2b)) yields an important insight: A likelihood ratio test indicates that our primary model significantly improves the model fit compared with that of our simpler baseline model ($\chi^2 = 271$; $p < 0.01$). This implies that supply chain factors do significantly improve our understanding of a supplier's decision of whether or not to share climate change information with its buyers.

The online supplement reports additional analyses that indicate that the results of our analysis are robust to additional controls, including environmental governance in buyers' countries and the market power of buyers and suppliers relative to each other. Additional analyses in the online supplement also suggest that our results are generalizable to other buyers—including those less committed to disclosing their own climate change information—and to the additional suppliers from whom the buyers did not request climate change information.

6. Response Comprehensiveness and Transparency

The analyses in the previous section examine a supplier's decision whether or not to share climate change information, considering such sharing to be a binary activity. In this section, we extend our analysis to explore variation in the comprehensiveness of the information shared—both in terms of the raw amount of information shared and whether key information was shared. We also identify circumstances under which suppliers share information particularly transparently by providing access to the public as well as to their buyers.

6.1. Response Comprehensiveness

The comprehensiveness of the information suppliers shared with buyers via the CDP Supply Chain Program differed substantially. Our dichotomous primary dependent variable, *shared climate change information*, does not differentiate between suppliers that answered every question in the questionnaire and those that answered only one. It also does not differentiate between suppliers that provided meaningful answers to core questions and those that provided uninformative responses such as "not applicable."

To better capture different levels of response comprehensiveness, we coded an alternative dependent variable: the *number of questions answered* meaningfully by the supplier. We identified 19 core questions that were asked in both the 2009 and 2010 versions of the CDP questionnaire. These include questions about the supplier's risks and opportunities associated with climate change (six questions), GHG emissions levels (five), reductions in its GHG emissions and energy usage (three), governance of climate change issues

(two), and engagement in climate change issues in its own supply chain (three). For each supplier, we counted how many of these 19 questions were answered, excluding responses such as "not applicable" and those that were left blank. Among questionnaires that were at least partially completed, the median response included answers to 16 questions, with a mean of 14.9 questions. Among all questionnaires, including the 1,506 in which none of the questions were answered, the median survey included answers to 9 of the 19 questions, with a mean of 7.95 questions.

We predicted *number of questions answered*, a count dependent variable, with the same set of independent and control variables used in our primary model. We use negative binomial regression because this count variable exhibits overdispersion (with variance 61.5 and mean 7.95). As before, the unit of analysis is the supplier-year. We report standard errors clustered by supplier, so our results are robust to heteroskedasticity and to nonindependence among the responses by those suppliers that responded in both 2009 and 2010.

Results from the negative binomial regression are reported in Table 3, column (3a), with average marginal effects reported in column (3b). All of the hypothesized variables that our primary model (columns (2a) and (2b)) indicated were significant determinants of sharing climate change information were also significant determinants of response comprehensiveness. For example, average marginal effects indicate that a one-log-point increase in *number of buyer requests* increases the number of questions answered by 0.82. A one-standard-deviation increase in *median profit margin* is associated with an increase in the number of questions answered by 0.51. The use of *climate change as a buying criterion* and being located in a *Kyoto Annex I country* (changes in values from 0 to 1) are associated with an average of 4.0 and 2.3 additional questions answered, respectively. These results indicate that the factors that significantly increase the likelihood of suppliers sharing *any* climate change information with their buyers also predict the comprehensiveness of the information they share.

6.2. Sharing Key Metrics

The analyses above have explored the determinants of (a) the supplier's decision to share climate change information with its buyers and (b) the comprehensiveness of the supplier's response, but have not distinguished whether or not the shared information included the metrics of greatest interest to many buyers. Both the CDP reports and our own interviews indicate that many buyers in our sample were motivated by the ultimate objective of reducing their extended carbon footprints (Carbon Disclosure Project 2010, 2011a). These buyers had requested climate information to learn whether or not their suppliers had begun measuring their GHG emissions and whether they had begun planning to reduce them. For example, approximately one-third of Walmart's supplier sustainability assessment focuses on GHG emissions levels and reduction targets (Walmart 2009). GHG emissions levels and trends are also among the most common environment, health, and safety metrics reported to senior management, and are commonly used by stock analysts to evaluate corporate performance along environmental, social, and governance dimensions (Soyka and Bateman 2012).

With all this in mind, we extended our analysis to explore whether the determinants we hypothesized to influence suppliers to share climate change information with their buyers also motivated them to share quantitative GHG emissions data and GHG or energy reduction targets in particular. Although the CDP questionnaire requested but did not require suppliers to include these (or any other) elements, suppliers that chose to do so demonstrated that they had invested in calculating their GHG emissions and had given some thought to reduction goals.

We created *shared reduction target* as an ordinal variable, coded 0 when a supplier did not share climate change information in a given year, 1 when it shared climate change information but not a quantitative GHG or energy reduction target, and 2 when the shared information included a quantitative GHG or energy reduction target. Among the 1,721 supplier-year observations with shared climate change information, 696 included a quantitative reduction target and 1,025 did not. Similarly, we created *shared GHG emissions data* as an ordinal variable, coded 0 when a supplier did not share climate change information in a given year, 1 when it shared climate change information but not quantitative GHG emissions data, and 2 when the shared information included quantitative GHG emissions data. Among the 1,721 supplier-year observations with shared climate change information, 1,267 included quantitative GHG emissions data, and 454 did not. Our primary approach to coding this variable 2 considered only direct GHG emissions, referred to as "Scope 1" emissions in both the CDP questionnaire and the Greenhouse Gas Protocol (2012), a widely used GHG reporting standard.

We predicted *shared reduction target* and *shared GHG emissions data* with the same set of independent and control variables used in our primary model (columns (2a) and (2b) of Table 3). Because both of these dependent variables are ordered variables, we used ordered logistic regression. The simplest form of ordered logistic regression is appropriate only to data that meet the proportional-odds assumption

(that the relationship between any pair of outcome groups is statistically indistinguishable), which can be assessed using the Brant test. Brant tests rejected the proportional-odds assumption for the models predicting *shared reduction target* and *shared GHG emissions data*, which led us to estimate these models instead with generalized ordered logistic regression. To create the most parsimonious model, given our data, we used an iterative process to identify the partial proportional-odds model that best fit the data, relaxing the proportional-odds assumption only for those variables for which the coefficient estimates statistically varied across levels (evaluated at $\alpha = 0.05$) (Williams 2006). The iterative process described above yielded approximately 2% of observations with negative predicted probability values, which we resolved, as advised by Williams (2012), by imposing more parallel-line restrictions. Specifically, we impose the parallel-line restriction on all control variables, while continuing to relax it on all hypothesized variables. Results were very similar when we used the iterative process described above and, separately, when we relaxed the parallel-lines assumption for all variables, indicating that results are not sensitive to the particular specification of the parallel-lines assumptions. As before, our unit of analysis is the supplier-year. Because we report standard errors clustered by supplier, our results are robust to heteroskedasticity and to nonindependence of the observations from those suppliers that responded in both 2009 and 2010.

Results of the generalized ordered logistic regression model predicting *shared reduction target* are reported in columns (1a)–(1c) of Table 4. Column (1a) reports the extent to which the predictor variables shift the dependent variable from not sharing any information (*shared reduction target* equals 0) to sharing information (*shared reduction target* equals 1 or 2). Column (1b) reports the extent to which the predictor variables shift the dependent variable from not sharing a GHG reduction target (*shared reduction target* equals 0 or 1) to doing so (*shared reduction target* equals 2). Column (1c) reports Wald test statistics comparing the coefficients between columns (1a) and (1b) (when applicable). Because the results reported in column (1a) closely match (mechanically) those of our primary model (column (2a) of Table 3), we focus here on whether and how our hypothesized variables influence suppliers' sharing of their reduction targets (column (1b)).

The positive and significant coefficients on *number of buyer requests*, *climate change as a buying criterion*, *median profit margin*, and *Kyoto Annex I country* indicate that the breadth of buyer pressure, the buyer's commitment to use shared information for future procurement decisions, the profitability of the supplier's competitive environment, and the GHG emissions regulation in the supplier's country are positively associated with sharing a GHG or energy reduction target. These results comport with those from the primary model, which predicts sharing any climate change information. Being in a *Kyoto Annex I country* has a significantly greater impact on sharing reduction targets than on sharing any climate change information per se (a Wald test comparing this coefficient between columns (1a) and (1b), as shown in column (1c), yields $\chi^2 = 3.86$; $p < 0.05$). Suppliers in countries with GHG emission regulations were more likely to share GHG or energy reduction targets, perhaps because they were more likely to have already invested in developing a GHG emissions inventory and to have begun formulating reduction targets. In contrast, *climate change as a buying criterion* had a significantly greater impact on a supplier's decision to share climate change information than on its decision to share reduction targets (a Wald test comparing this coefficient between columns (1a) and (1b), as shown in column (1c), yields $\chi^2 = 9.77$; $p < 0.01$). This could suggest that buyers are still in the early stages of encouraging their suppliers to reveal the most critical elements for assessing and reducing the supply chain's carbon footprint.

Results for the model predicting *shared GHG emissions data* are reported in columns (2a)–(2c) of Table 4. Column (2a) reports the extent to which the predictor variables shift the dependent variable from not sharing any climate change information (*shared GHG emissions data* equals 0) to sharing information (*shared GHG emissions data* equals 1 or 2), whereas column (2b) reports the extent to which the predictor variables shift the dependent variable from not sharing GHG emissions data (*shared GHG emissions data* equals 0 or 1) to doing so (*shared GHG emissions data* equals 2). Column (2c) shows the Wald test statistics. As above, we focus on results associated with column (2b).

The positive significant coefficients on *number of buyer requests*, *climate change as a buying criterion*, and *Kyoto Annex I country* comport with the results from the primary model (column (2a) of Table 3). Also, as with the results on *shared reduction target*, *climate change as a buying criterion* has a significantly stronger impact on suppliers' decisions to share climate change information per se than on sharing GHG emissions data (a Wald test comparing columns (2a) to (2b), shown in column (2c), yields $\chi^2 = 4.34$; $p < 0.05$).

Interestingly, being in a more profitable competitive environment has a significantly larger impact on suppliers' propensity to share climate change information per se than on their propensity to share GHG emissions data (a Wald test comparing this coefficient between columns (2a) and (2b), shown

Table 4 Generalized Ordered Logistic Regression Results

	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)
Dependent variable:	*Shared reduction target*			*Shared GHG emissions data*		
Coefficients:	Response (with or without reduction target)	Response with reduction target	Wald test statistics	Response (with or without GHG emissions data)	Response with GHG emissions data	Wald test statistics
Number of buyer requests (log)	0.554***	0.638***	0.24	0.795***	0.845***	0.17
	[0.177]	[0.143]		[0.180]	[0.157]	
Climate change as a buying criterion	0.866***	0.508***	9.77***	0.797***	0.641***	4.34**
	[0.103]	[0.112]		[0.100]	[0.098]	
Median profit margin by industry-country[a]	1.462**	1.289*	0.06	1.139*	0.318	5.86**
	[0.662]	[0.749]		[0.640]	[0.617]	
Industry's GHG intensity (log)	0.047	0.084	0.88	0.042	0.098*	5.33**
	[0.058]	[0.062]		[0.059]	[0.059]	
Kyoto Annex I country	0.481***	0.709***	3.86**	0.395***	0.400***	0.01
	[0.140]	[0.145]		[0.135]	[0.134]	
Mean buyer requests per industry-year (log)	6.716***	6.716***	n/a	9.913***	9.913***	n/a
	[2.066]	[2.066]		[2.235]	[2.235]	
Received CDP Investor questionnaire	0.815***	0.815***	n/a	0.820***	0.820***	n/a
	[0.167]	[0.167]		[0.171]	[0.171]	
Received CDP Public Procurement questionnaire	1.360***	1.360***	n/a	1.278***	1.278***	n/a
	[0.235]	[0.235]		[0.253]	[0.253]	
Received CDP Supply Chain questionnaire in previous year	0.617***	0.617***	n/a	0.737***	0.737***	n/a
	[0.104]	[0.104]		[0.119]	[0.119]	
Largest buyer's revenue (log)[a]	0.094*	0.094*	n/a	0.047	0.047	n/a
	[0.052]	[0.052]		[0.055]	[0.055]	
Supplier's revenue (log)[a]	0.137***	0.137***	n/a	0.054	0.054	n/a
	[0.044]	[0.044]		[0.039]	[0.039]	
Country's environmental governance[a]	0.207*	0.207*	n/a	0.151	0.151	n/a
	[0.107]	[0.107]		[0.112]	[0.112]	
Country's environmental NGOs per million population (log)	−0.931***	−0.931***	n/a	−0.691**	−0.691**	n/a
	[0.278]	[0.278]		[0.275]	[0.275]	
Country's per capita GDP (log)[a]	−0.118	−0.118	n/a	−0.034	−0.034	n/a
	[0.083]	[0.083]		[0.078]	[0.078]	
Log pseudolikelihood	−2,678			−2,556		
McFadden's adjusted R^2	0.19			0.19		

Notes. $N = 3{,}226$ supplier-year observations from 2,490 distinct suppliers in 49 countries. Brackets contain robust standard errors clustered by supplier; "n/a" indicates the Wald test statistic is not applicable when the parallel-lines assumption is imposed and thus the compared coefficients are identical by construction. All models also include dummies for *year 2010*, industry dummies, and dummy variables to denote instances in which the following variables were recoded from missing to zero: *industry's GHG intensity* ($N = 569$), *largest buyer's revenue* ($N = 262$), *supplier's revenue* ($N = 2{,}063$), *country's environmental governance* ($N = 4$), and *median profit margin* ($N = 540$). Column (1a) reports the extent to which the predictor variables shift the dependent variable from not sharing any information to sharing information (shifting *shared reduction target* from 0 to 1 or 2), whereas column (1b) reports the extent to which the predictor variables shift the dependent variable from not sharing a reduction target to doing so (shifting *shared reduction target* from 0 or 1 to 2). Column (2a) reports the extent to which the predictor variables shift the dependent variable from not sharing any information to sharing information (shifting *shared GHG emissions data* from 0 to 1 or 2), whereas column (2b) reports the extent to which the predictor variables shift the dependent variable from not sharing GHG emissions data to doing so (shifting *shared GHG emissions data* from 0 or 1 to 2).

[a]Variable is lagged one year.

***$p < 0.01$; **$p < 0.05$; *$p < 0.10$.

in column (2c), yields $\chi^2 = 5.86$; $p < 0.05$). In contrast, the GHG intensity of the supplier's industry is a significantly stronger predictor of sharing GHG emissions data than of sharing climate change information per se (a Wald test comparing this coefficient between columns (2a) and (2b), shown in column (2c), yields $\chi^2 = 5.33$; $p < 0.05$), owing perhaps to the greater likelihood that suppliers in more GHG-intensive industries had already conducted a GHG inventory.

To summarize, the prevalence of buyer requests, the commitment of buyers to use the shared climate

change information in their future procurement decisions, and being in a country with GHG emissions regulation increased suppliers' propensity to share GHG emissions data and reduction targets.

6.3. Public Disclosure

Suppliers that choose to respond to the CDP Supply Chain Program questionnaire are given the choice of having CDP either share their climate change information only with the requesting buyers or also post the information on its public website. In analyses reported in the online supplement, we find that the same hypothesized variables that have significant positive effects on sharing climate change information in our primary model also have significant positive effects on suppliers sharing this information publicly. Moreover, both indicators of buyer pressure (*number of buyer requests* and *climate change as a buying criterion*) have a significantly greater impact on suppliers' decisions to share climate change information per se than on sharing this information publicly, perhaps due to the fear that publicly disclosed information would leak to competitors. This reveals a potential limitation of supply chain initiatives to generate publicly available data.

7. Discussion

Our research connects the operations management information-sharing literature to the environmental information disclosure literature more typically explored in the field of strategy. Prior research had already identified some organization-, industry-, and country-level factors associated with greater environmental information disclosure. We build on this by revealing supply chain factors, including the number of and the commitment of requesting buyers, that appear to bolster an organization's willingness to disclose information. This suggests that researchers using institutional theory to predict organizational conformity to institutional pressures should also consider supply chain influences.

Our work also extends the operations management literature on using information sharing to mitigate supply chain risk. In contrast to that literature's typical focus on mitigating "known–unknown" operational risks (Simchi-Levi 2010) about which supply chain members have insights on the distribution of uncertainty, we focus on a supply chain risk of greater uncertainty—climate change. Despite mounting evidence supporting the link between GHG emissions and climate change (Fitzpatrick 2006, Intergovernmental Panel on Climate Change 2007), the extent to which suppliers are vulnerable to climate change is particularly uncertain because the physical impacts of climate change and the business effects of GHG regulation are especially difficult to predict. Our results also provide empirical evidence that suppliers' decisions on whether to share information—and if so, how much—are influenced by regulatory mandates that can reduce the costs of voluntary disclosures.

Our work also contributes insights to the literature on the diffusion of social and environmental practices through supply chains. While institutional (namely, industry and country) factors have been shown to predict the adoption of particular management practices, little research prior to ours has simultaneously examined institutional and organizational factors to predict suppliers' adoption of standards or practices promoted by buyers. Although ours is not the very first study to do so, the other studies that have done so have focused on suppliers meeting buyer requests to adopt operational standards (Locke et al. 2007, Delmas and Montiel 2009) rather than to share information.

Our work also advances theory regarding how buyers pressure suppliers to adopt particular standards and practices. Prior studies have predicted suppliers' adoption and compliance behaviors based on transaction cost economics, market power arguments, signaling theory, and institutional theory (Barrientos and Smith 2006, Delmas and Toffel 2008, Delmas and Montiel 2009). By capturing the prevalence of buyer requests, we apply social movement theory to portray how firms seek to cascade practices through their supply chains. Whereas the social movement literature typically examines how activist groups use boycotts, strikes, media campaigns, and shareholder resolutions to try to catalyze changes in organizational behavior (Davis et al. 2005, Reid and Toffel 2009), we explore a novel social movement tactic and instigator by examining how companies are using procurement preferences to catalyze behavioral changes in their suppliers. We also theoretically distinguish between several forms of buyer pressure: (1) the breadth of buyer pressure, indicative of a social movement, (2) the depth of buyer pressure that represents buyer intentions, and (3) market power. Our findings suggest that considering the breadth and depth of buyer pressure and not merely market power presents a more complete picture of the determinants of suppliers' adoption of practices and standards.

Our research also offers managerial insights, especially as growing awareness of climate change makes collaboration between suppliers and buyers increasingly important. For buyers, our finding that both buyer commitment and the number of buyer requests affect a supplier's likelihood of sharing information suggests that buyers can obtain more information from suppliers not only by investing in activities to convince suppliers of the importance of this information, but also by collaborating with other buyers to send this message collectively.

Understanding how the profitability and GHG intensity of a supplier's industry influences the supplier's willingness to share climate change information is relevant to buyers and to policy makers. For a buyer, knowing better how to differentiate its efforts to encourage suppliers to respond allows it to allocate its resources more efficiently. Policymakers, increasingly interested in fostering disclosure of GHG emissions, can better gauge where to target disclosure regulations and enforcement efforts. Firms in more profitable industries are particularly likely to publicly disclose climate change information irrespective of GHG regulatory requirements, which suggests that governments can more readily rely on market-driven requests for firm-level supply chain information (e.g., Obama 2009, Gunther 2010) to obtain this information from firms in more profitable industries, but that mandatory information disclosure regulations (e.g., U.S. Environmental Protection Agency 2012b) might be needed to compel disclosure by firms in less profitable industries.

There are some limitations to our work. The number of buyer requests could be subject to measurement error if suppliers in our sample receive similar buyer requests to share climate change information through channels other than CDP and if this affects their responsiveness to the frequency of requests they receive from buyers through CDP. It also remains unclear to what extent our results generalize to sharing information in the contexts of emerging social movements other than climate change and to more conventional contexts in which buyers seek supply chain data such as workplace conditions and quality management practices.

Future field research could pursue a deeper analysis of how information disclosure decisions are influenced by the particular staff function and the seniority of the staff members who issue or receive information requests. Moreover, future research could explore the role of third-party verification of the accuracy of information shared among supply chain partners and could investigate temporal dynamics that we were unable to explore in a data set spanning only two years.

Electronic Companion

An electronic companion to this paper is available as part of the online version at http://dx.doi.org/10.1287/msom.1120.0420.

Acknowledgments

The authors thank Carbon Disclosure Project (CDP) staff members Frances Way, Betty Cremmins, Dexter Galvin, Kirstin Hill, and Sonya Bhonsle, who provided them with data and interviews; several (anonymous) buyers and suppliers engaged in the CDP Supply Chain Program who allowed the authors to interview them; James Salo of Trucost Plc for providing greenhouse gas intensity data; Chris Allen, Kathleen Ryan, Christine Rivera, and Bill Simpson for statistical and research support; Jay Swaminathan, William Schmidt, and Nathan Craig for helpful comments; and Harvard Business School for financial support.

References

Akerlof GA (1970) The market for "lemons": Quality uncertainty and the market mechanism. *Quart. J. Econom.* 84(3):488–500.

Anderson SW, Daly JD, Johnson MF (1999) Why firms seek ISO 9000 certification: Regulatory compliance or competitive advantage? *Production Oper. Management* 8(1):28–43.

Baier P (2012) 5 lessons from Walmart on making supplier scorecards work for you. Accessed August 18, 2012, http://www.greenbiz.com/blog/2012/05/24/5-lessons-walmart-making-supplier-scorecards-work-your-business.

Barrientos S, Smith S (2006) Do workers benefit from ethical trade? Assessing codes of labour practice in global production systems. *Third World Quart.* 28(4):713–729.

Baxter International (2009) Carbon Disclosure Project supply chain response, 2009. Accessed May 2012, https://www.cdproject.net/en-US/Results/Pages/Company-Responses.aspx?company=1574.

Bolton RN, Lemon KN, Bramlett MD (2006) The effect of service experiences over time on a supplier's retention of business customers. *Management Sci.* 52(12):1811–1823.

Brown N, Deegan C (1998) The public disclosure of environmental performance information—A dual test of media agenda setting theory and legitimacy theory. *Accounting Bus. Res.* 29(1):21–41.

Cachon GP, Fisher M (2000) Supply chain inventory management and the value of shared information. *Management Sci.* 46(8):1032–1048.

Carbon Disclosure Project (2010) Carbon Disclosure Project supply chain report 2010. Carbon Disclosure Project, London.

Carbon Disclosure Project (2011a) Carbon Disclosure Project supply chain report 2011: Migrating to a low carbon economy through leadership and collaboration. Carbon Disclosure Project, London.

Carbon Disclosure Project (2011b) Carbon Disclosure Project home page. Accessed September 2011, https://www.cdproject.net/en-US/Pages/HomePage.aspx.

Carbon Disclosure Project (2012) CDP Supply Chain: Overview for procurement teams. Carbon Disclosure Project, London.

Chatterji A, Levine DI (2006) Breaking down the wall of codes: Evaluating non-financial performance measurement. *California Management Rev.* 48(2):29–51.

Chen F (2003) Information sharing and supply chain coordination. de Kok AG, Graves SC, eds. *Handbooks in Operations Research and Management Science, Vol. 11: Supply Chain Management: Design, Coordination, and Operation* (Elsevier, Amsterdam), 341–421.

Cho CH, Patten DM (2007) The role of environmental disclosures as tools of legitimacy: A research note. *Accounting, Organ. Soc.* 32(7–8):639–647.

Corbett CJ (2006) Global diffusion of ISO 9000 certification through supply chains. *Manufacturing Service Oper. Management* 8(4):330–350.

Cormier D, Magnan M (2003) Environmental reporting management: A continental European perspective. *J. Accounting Public Policy* 22(1):43–62.

Cremmins B (2011) (Manager, CDP Supply Chain) Personal communication with Chonnikarn Jira, September 6.

Davis GF, McAdam D, Scott WR, Zald MN (2005) *Social Movements and Organizational Theory* (Cambridge University Press, Cambridge, UK).

Delmas MA (2002) The diffusion of environmental management standards in Europe and in the United States: An institutional perspective. *Policy Sci.* 35(1):91–119.

Delmas MA, Montiel I (2009) Greening the supply chain: When is customer pressure effective? *J. Econom. Management Strategy* 18(1):171–201.

Delmas MA, Toffel MW (2008) Organizational responses to environmental demands: Opening the black box. *Strategic Management J.* 29(10):1027–1055.

Denend L, Plambeck E (2010) Walmart's sustainability strategy (B): 2010 update. Case OIT-71B, Stanford Graduate School of Business, Stanford, CA.

Esty DC, Levy M, Srebotnjak T, de Sherbinin A (2005) 2005 Environmental Sustainability Index: Benchmarking national environmental stewardship. Yale Center for Environmental Law and Policy, New Haven, CT.

Fitzpatrick M (2006) Global warming facts: Human fingerprints. Union of Concerned Scientists, Cambridge, MA.

Greenhouse Gas Protocol (2012) Calculation tools: FAQ. Accessed August 2012, http://www.ghgprotocol.org/calculation-tools/faq.

Gunther M (2010) U.S. government to ask 600K suppliers for greenhouse gas data. *GreenBiz.com* (July 14), http://www.greenbiz.com/blog/2010/07/14/united-states-government-asks-600K-suppliers-greenhouse-gas-data.

Hafner-Burton EM, Tsutsui K (2005) Human rights in a globalizing world: The paradox of empty promises. *Amer. J. Sociol.* 110(5):1373–1411.

Halldórsson Á, Kovács G (2010) The sustainable agenda and energy efficiency, logistics solutions and supply chains in times of climate change. *Internat. J. Physical Distribution Logist. Management* 40(1/2):5–13.

Hopkins MS (2010) The four-point supply chain checklist: How sustainability creates new opportunity. *MIT Sloan Management Rev.* 51(4):65–69.

Intergovernmental Panel on Climate Change (2007) Climate change 2007: Synthesis report. Intergovernmental Panel on Climate Change, Geneva.

Kim E, Lyon T (2011) When does institutional investor activism increase shareholder value? The Carbon Disclosure Project. *B.E. J. Econom. Anal. Policy* 11(1):Article 50, http://www.bepress.com/bejeap/vol11/iss1/art50.

Klungle R, Maluchnik J (1997) The role of simulation in call center management. *Proc. 1997 Michigan Simulation User Group Conf.*, 1–10.

Kolk A, Pinkse J (2007) Multinationals' political activities on climate change. *Bus. Soc.* 46(2):201–228.

Kurtuluş M, Ulku S, Toktay LB (2012) The value of collaborative forecasting in supply chains. *Manufacturing Service Oper. Management* 14(1):82–98.

Lee S (2008) Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. *Supply Chain Management: An Internat. J.* 13(3):185–198.

Lee H, Whang S (2000) Information sharing in a supply chain. *Internat. J. Manufacturing Tech. Management* 1(1):79–93.

Levine DI, Toffel MW (2010) Quality management and job quality: How the ISO 9001 standard for quality management systems affects employees and employers. *Management Sci.* 56(6):978–996.

Li L (2002) Information sharing in a supply chain with horizontal competition. *Management Sci.* 48(9):1196–1212.

Li L, Zhang H (2008) Confidentiality and information sharing in supply chain coordination. *Management Sci.* 54(8):1467–1481.

Li S, Lin B (2006) Accessing information sharing and information quality in supply chain management. *Decision Support Systems* 42(3):1641–1656.

Locke RM, Qin F, Brause A (2007) Does monitoring improve labor standards? Lessons from Nike. *Indust. Labor Relations Rev.* 61(1):3–31.

Luo L, Lan YC, Tang QL (2012) Corporate incentives to disclose carbon information: Evidence from the CDP Global 500 report. *J. Internat. Financial Management Accounting* 23(2):93–120.

Lyon TP, Maxwell JW (2011) Greenwash: Environmental disclosure under threat of audit. *J. Econom. Management Strategy* 20(1): 3–41.

Meyer JW, Rowan B (1977) Institutionalized organizations: Formal structure as myth and ceremony. *Amer. J. Sociol.* 83(2):340–363.

Naveh E, Marcus A (2007) Financial performance, ISO 9000 standard, and safe driving practices effects on accident rate in the U.S. motor carrier industry. *Accident Anal. Prevention* 39(4):731–742.

Neu D, Warsame H, Pedwell K (1998) Managing public impressions: Environmental disclosures in annual reports. *Accounting, Organ. Soc.* 23(3):265–282.

Newton M (2007) Climate action: A lifecycle approach to supply chain leadership. Presentation, U.S. Environmental Protection Agency's Climate Leaders Meeting, December 5. http://www.epa.gov/climateleadership/documents/events/dec2007/Mark_Newton.pdf.

Obama B (2009) Executive order 13514—Federal leadership in environmental, energy, and economic performance. *Federal Register* 74(194):52117–52127.

Özer O, Zheng Y, Chen K (2011) Trust in forecast information sharing. *Management Sci.* 57(6):1111–1137.

Patten DM (1991) Exposure, legitimacy, and social disclosure. *J. Accounting Public Policy* 10(4):297–308.

Porteus EL (1990) Stochastic inventory theory. Heyman DP, Sobel MJ, eds. *Stochastic Models*, Handbooks in Operations Research and Management Science, Vol. 2 (Elsevier, Amsterdam), 605–652.

Reichheld F (1996) *The Loyalty Effect: The Hidden Force Behind Growth, Profits, and Lasting Value* (Harvard Business School Press, Boston).

Reid EM, Toffel MW (2009) Responding to public and private politics: Corporate disclosure of climate change strategies. *Strategic Management J.* 30(11):1157–1178.

Schloetzer JD (2012) Process integration and information sharing in supply chains. *Accounting Rev.* 87(3):1005–1032.

Schneider SH, Semenov S, Patwardhan A, Burton I, Magadza CHD, Oppenheimer M, Pittock AB, et al. (2007) Assessing key vulnerabilities and the risk from climate change. Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, UK), 779–810.

Scott WR (1995) *Institutions and Organizations* (Sage, Thousand Oaks, CA).

Short JL, Toffel MW (2008) Coerced confessions: Self-policing in the shadow of the regulator. *J. Law, Econom. Organ.* 24(1):45–71.

Simchi-Levi D (2010) *Operations Rule: Delivering Customer Value Through Flexible Operations* (MIT Press, Cambridge, MA).

Soyka PA, Bateman ME (2012) *Finding Common Ground on Metrics That Matter* (IRRC Institute, New York).

Stanny E (2013) Voluntary disclosures of emissions by US firms. *Bus. Strategy Environment* 22(3):145–158.

Stanny E, Ely K (2008) Corporate environmental disclosures about the effects of climate change. *Corporate Soc. Responsibility Environ. Management* 15(6):338–348.

Terwiesch C, Ren ZJ, Ho T, Cohen M (2004) An empirical analysis of forecast sharing in the semiconductor equipment industry. *Management Sci.* 51(2):208–220.

Toffel MW, Short JL, Ouellet M (2012) Reinforcing regulatory regimes: How states, civil society, and codes of conduct promote adherence to global labor standards. Working Paper 13-045, Harvard Business School, Boston.

United Nations Framework Convention on Climate Change (2010) Status of the ratification of Kyoto Protocol. Accessed September 2010, http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php.

U.S. Environmental Protection Agency (2012a) Agency information collection activities; submission to OMB for review and approval; comment request; federal supplier (small business) greenhouse gas inventory pilot (renewal). *Federal Register* 77(56):16831–16832.

U.S. Environmental Protection Agency (2012b) Greenhouse Gas Reporting Program. Accessed June 2012, http://www.epa.gov/climatechange/emissions/ghgrulemaking.html.

U.S. General Services Administration (2010) Executive Order 13514 Section 13: Recommendations for vendor and contractor emissions. U.S. General Services Administration, Washington, DC.

U.S. Securities and Exchange Commission (2010) SEC issues interpretive guidance on disclosure related to business or legal development regarding climate change. Press release, January 27, http://www.sec.gov/news/press/2010/2010-15.htm.

Van Bergen B, Soonawal L, Wälzholz G (2008) *Climate Change and Your Business* (KPMG International, Amstelveen, The Netherlands).

Verrecchia RE (2001) Essays on disclosure. *J. Accounting Econom.* 32(1–3):97–180.

Vodafone (2009) Carbon Disclosure Project supply chain response, 2009. Accessed May 2012, https://www.cdproject.net/en-US/Results/Pages/Company-Responses.aspx?company=20316.

Wagner D (2006) Throttling the customer. *MIT Sloan Management Rev.* 47(4):10–11.

Wainer H (1976) Estimating coefficients in linear models: It don't make no nevermind. *Psych. Bull.* 83(2):213–217.

Walmart (2009) Supplier sustainability assessment: 15 questions for suppliers. Accessed June 2012, http://az204679.vo.msecnd.net/media/documents/r_3863.pdf.

Way F (2010) Leading firms set industry standards for emissions management, CDP report finds. *GreenBiz.com* (February 2), http://www.greenbiz.com/blog/2010/02/02/leading-firms-set-industry-standards-emissions-management-cdp-report-finds?page=full.

Weil D, Mallo C (2007) Regulating labour standards via supply chains: Combining public/private interventions to improve workplace compliance. *British J. Indust. Relations* 45(4):791–814.

Williams R (2006) Generalized ordered logit/partial proportional odds models for ordinal dependent variables. *Stata J.* 6(1):58–82.

Williams R (2012) gologit2/oglm Troubleshooting. Accessed August 20, 2012, http://www3.nd.edu/~rwilliam/gologit2/tsfaq.html.

Zhou H, Benton WC (2007) Supply chain practices and information sharing. *J. Oper. Management* 25(6):1348–1365.