TCFD Climate Risk Disclosures: Early Evidence on the "Gold Standard"*

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Abstract

Using the three years of data that are available since the introduction of the Task Force on Climate-related Financial Disclosures (TCFD) reporting framework (i.e., 2018-2020), we provide the first large sample evidence related to TCFD-compliant climate risk disclosures reported to the CDP. A detailed manual review of the company-furnished financial impact estimates reveals the CDP database to be strewn with errors. Focusing on usable observations for a global sample of firms from advanced economies plus South Africa, we investigate three voluntary disclosure decisions: i) whether to respond to the CDP survey questionnaire; ii) whether to identify and disclose physical and transition climate risks in accordance with the TCFD framework; and iii) whether to provide TCFD-solicited estimates of the financial impact of these climate risks on the firm. Although the observed propensities to disclose are declining with each successive decision, we find that all three are explained by similar factors. Specifically, larger and more tangible asset intensive firms, those with a higher proportion of institutional shareholders, as well as those evincing other indicators of their commitment to sustainability, are all more likely to provide disclosures, while industry and country controls are also important. In capital markets tests we find that there is little signalling value associated with the act of disclosure. The number of transition risks disclosed by the firm is negatively associated with firm value, consistent with the market treating these as credible and material threats to the firm's business model and future prospects (i.e., as unrecorded liabilities or impaired assets). Neither the number of physical risks nor the financial impact estimates are reflected in market values, however, and third party assurance of climate risk data does not enhance its association with market values in our setting. With the exception of the number of transition risks, our results suggest that market participants don't understand the firms' climate risk disclosures, that they are largely inattentive to corporate TCFD reporting, and/or that they don't view these disclosures as sufficiently credible, probable, or proximate to materially affect firm value.

1. Introduction

"Climate risk is investment risk." – Larry Fink, CEO of Blackrock, 2020 Letter to CEOs

Climate change is arguably the greatest existential threat to humanity (Attenborough, 2020; Oreskes & Conway, 2013).[1] Capital markets participants, standard setting bodies, and securities regulators have finally begun to acknowledge the extreme importance of climate change, and they're doing so with an increasing sense of urgency. Considering this widespread awakening, which has been several years in the making, it is surprising to hear allegations of continuing grossly unmet investor demand for corporate disclosures related to the business risks and opportunities that climate change poses to companies' prospects. Investors have been resoundingly and persistently complaining that they lack consistent, reliable firm-specific climate related data to help inform their investment decisions, a complaint that was recently echoed by U.S. Securities and Exchange Commissioner, Allison Herren Lee. Lee has stated that, despite much voluntary disclosure in the sustainability space, investors are still not getting the material climate-risk-related financial information that they need (Herren Lee, 2020). The mandating of climate risk disclosures has therefore been placed at the top of the SEC's agenda, following similar moves by other major regulatory and standard setting bodies around the world (CFTC, 2020; Herren Lee, 2021).

This alleged dearth of climate risk data is an oft-repeated but somewhat surprising claim given that the Task Force on Climate-Related Financial Disclosures (TCFD) has been established by the Financial Stability Board (FSB) since 2015 with a mandate to fill this gap.[2] The TCFD, a private-sector-led taskforce, published its recommendations on climate-risk-related financial disclosures in 2017, and a growing number of companies have been voluntarily reporting under its guidelines since 2018. Globally recognized as the "gold standard" for climate-related disclosures (Mooney & Nauman, 2020), the TCFD recommendations were born out of a market need for enhanced company-provided information when it became clear that markets were not adequately pricing in climate-related risks (CFTC, 2020). The distinguishing feature of the TCFD's climate-

[1] See also the IPCC Sixth Assessment Report (Masson-Delmotte et al., 2021), the declaration of the UN Secretary-General António Guterres on May 15th, 2018 (United Nations, 2018), and the call for action by the Nobel Prize Summit in April 2021 (Nobel Prize Summit Steering Committee, 2021).

[2] According to their website, the FSB, "through its members, seeks to strengthen financial systems and increase the stability of the international financial markets… The FSB promotes international financial stability; it does so by coordinating national financial authorities and international standard-setting bodies as they work toward developing strong regulatory, supervisory and other financial sector policies…" (Financial Stability Board, 2021).

related financial disclosure recommendations is that they are designed to elicit *company-provided* information about the risks and opportunities that the firm faces as a result of climate change - i.e., disclosures related to *the impact of climate change on the firm,* rather than information about *the firm's impact on the environment* such as the greenhouse gas emissions that have been the topic of considerable prior capital markets research (e.g., Matsumura, Prakash, & Vera-Muñoz, 2014, Jung, Herbohn, & Clarkson, 2018, Aswani, Raghunandan, & Rajgopal, 2021, amongst many others). Thus, although other stakeholders may also find the information to be of interest, the TCFD's specific mandate is to help to improve the quality and consistency of corporate disclosures related to climate information targeted at the firm's *financial stakeholders*, including lenders, shareholders, and insurers. Since its inception, the Michael Bloomberg-chaired TCFD has received an extremely high level of support. As of March 2021, the TCFD reports having more than 2,000 supporters from 78 countries, with a market capitalization of over $19.8 trillion, including 859 financial institutions responsible for assets of $175 trillion (TCFD, 2021b). Support for the TCFD continues to grow rapidly, with the framework having recently received strong endorsements from numerous influential players, including: Blackrock CEO, Larry Fink; U.S. Treasury Secretary, Janet Yellen; Mark Carney, the UN Special Envoy on Climate Action and Finance (and former Governor of the Bank of Canada and Bank of England); the UK's Financial Conduct Authority; the Sustainable Finance Action Council just established by the Government of Canada; as well as the IFRS Foundation in the context of its proposed establishment of a new set of global sustainability standards, amongst many others.[3]

To the best of our knowledge, ours is the first study to present large sample evidence related to voluntary disclosures made to the CDP in accordance with the TCFD reporting framework.[4] We

[3] In his 2020 and 2021 letters to CEOs, Blackrock's Larry Fink asked all companies to report in alignment with the recommendations of the TCFD (Fink, 2020, 2021). In a statement to the Institute of International Finance on April 22nd, 2021, Janet Yellen endorsed the TCFD climate reporting framework (Yellen, 2021). In February 2020, Mark Carney declared that "Every major systemic bank, the world's largest insurers, its biggest pension funds and top asset managers are calling for the disclosure of climate-related financial risk through their support of the TCFD." Following its pledge to cut emissions by 40%-45% by 2030 and its commitment to net zero by 2050, on May 13th, 2021, the Government of Canada established the Sustainable Finance Action Council, indicating that the Council's "early emphasis will be on enhancing climate-related disclosures in Canada's private and public sector, in alignment with the TCFD recommendations" (Segal, 2021). In December 2020, the UK's Financial Conduct Authority issued a policy statement requiring companies with a UK premium listing to include a statement in their annual financial report whether their disclosures are consistent with TCFD recommendations (FCA, 2020). This is part of a broader roadmap to make TCFD-aligned disclosures mandatory in the UK by 2025 (HM Treasury, 2020).

[4] As we explain in Section 2, the CDP (formerly known as the Carbon Disclosure Project) is an NGO that sends surveys to thousands of firms around the world every year, soliciting carbon emissions data and other firm-specific climate-related information.

focus on a sample of firms from advanced economies plus South Africa. The number of companies from around the world who are responding to the CDP's annual questionnaire has grown from 300 in 2004 to over 9600 in 2020, while those responding to the TCFD-related questions exhibit similarly increasing year-over-year trends (e.g., from over 1,538 in 2018, the first TCFD reporting year, to 1,937 in 2020).[5] Nevertheless, while new companies are joining each year, in contrast to the usual assumption that corporate voluntary disclosure practices are highly "sticky" and principally expanding over time, we also observe a non-trivial amount of attrition. For example, more than 162 firms that provided responses to TCFD-related climate risk questions in 2019 did not volunteer information related to climate risks in the 2020 survey. This large sample finding from the CDP database echoes anecdotal accounts documented elsewhere (e.g., Metzner & Mikes, 2021) that companies are disinclined to continue their participation in the surveys because the costs to complete them outweigh the benefits that they are expected to yield.

Prior to examining the determinants and market valuation implications of the TCFD disclosures, we begin with an examination of the raw data purchased from the CDP. This leads to some surprising revelations. Focusing our manual review on the disclosure of financial impacts of climate risk, a critical information item solicited by the TCFD framework, we observe that the CDP database is riddled with errors and irregularities. We note that there is no requirement that the data provided to the CDP be audited, although a high proportion of firms report receiving some level of assurance on their disclosures. Because there is no alternative authoritative source against which to validate the CDP data, our review is only able to definitively detect the most egregious of errors (i.e., those that are internally inconsistent), and to flag those that appear to be suspect (i.e., those that are likely to be erroneous, but for which the correctness cannot be fully confirmed or refuted), and therefore the documented cases of concern represent a lower bound on the potential irregularities in this database.[6] Notwithstanding the constrained nature of our review, we nevertheless estimate that at least 7% of financial impact disclosures are problematic and not suitable for use, and a further 9% are potentially suspect.[7] Although the number of definitively

[5] These figures are based upon the total responses to the questionnaire, not just those from the advanced economies that we focus on in our analyses.

[6] In response to private correspondence regarding the irregularities that we uncovered, as well as in their product offering descriptions, the CDP reports that they do some reasonableness checks on company responses, but that they do not certify the data's correctness.

[7] By way of example, the CDP requests that companies disclose the financial impacts of climate risks in plain numbers (e.g., 10,000,000), but some companies erroneously report their financial impacts as percentages. Similarly, the CDP allows firms to report in their home currency, however the system through which the questionnaire was administered in

problematic cases that we identify is declining over time (e.g., from 366 in 2018 to 220 in 2020), and the most egregious shortcomings of the questionnaire seem to have been remedied, the error rate is arguably still quite unacceptably high. Importantly, the CDP is the only authoritative body directly gathering company-provided climate information on a widescale basis, data that it solicits in a standardized format that should lend itself to regularity and tabulation, and as such it is currently the only prospect for the provision of global, consistent data, reported in accordance with a common framework. Yet despite the fact that companies responding to the TCFD-related questions are those that are likely to be amongst the most committed to identifying, monitoring, managing, and reporting climate-related risks, the CDP database containing this company-furnished data is not reliable without significant user intervention to attempt to purge the dataset of erroneous cases.[8] We conclude from this review that, while the TCFD reporting *framework* may well have considerable merit, the data that it generates via the single global repository for this company-provided data (i.e., the CDP) is certainly not of "gold standard" quality.

Our first set of investigations examine the determinants of the firms' respective decisions to: i) respond to the CDP questionnaire; ii) identify physical and/or transition risks in accordance with the TCFD framework; and iii) provide TCFD-solicited estimates of the financial impact of the identified climate risks. Consistent with the results from prior (typically single-country) studies of firms' other environmental disclosure decisions (e.g., GHG emissions), we find that firm size, capital expenditure intensity, and institutional ownership are each positively associated with the CDP response and TCFD disclosure decisions. Indicators of the firm's overall commitment to sustainability, such as having a sustainability sub-committee of the board of directors, the establishment of an environmental management system, the production of a sustainability report, and overall environmental performance are each also incrementally significant determinants of firms' disclosure propensities, and the firm's industry and the location of its headquarters are also important. The percentage of independent directors on the board increases the propensity for disclosure in the absence of controls for the firm's commitment to sustainability, but board independence reduces forthcomingness once commitment to sustainability has been controlled for.

2018 did not allow entry of numbers with more than 12 digits. This was particularly problematic for large South Korean companies reporting in Won (i.e., their figures inevitably exceeded the allowable digits).

[8] Because companies may not be publicly disclosing this information elsewhere, or they may be disclosing it only in part, in a non-standardized format, and/or in their home country language, it is not reasonably possible to correct the errors with a view to rendering all of the responses useful.

We next investigate whether the act of disclosure has signalling value, and separately whether the number of climate risks, or the estimated financial impacts of climate risks, are reflected in market prices. Firms that respond to the CDP survey, and especially those that provide the additional TCFD-compliant information, are evidently measuring and tracking this important data for internal decision-making purposes. As such, the mere act of disclosing these climate risks may provide a signal to the capital markets that disclosing firms are more focused on, and/or adept at, *managing* these risks. Our empirical tests indicate that, while the firm's decision to respond to the CDP questionnaire is positively associated with firm value, indicators capturing the decisions to furnish the more investor-specific TCFD disclosures are not. Overall, we conclude that the evidence does not strongly support the hypothesis that the provision of climate risk information is a credible signal of the firm's advanced level of measuring and managing climate risks, or at least that it is not a signal to which the market is attentive, on average across reporting firms.

We further examine whether the number of physical risks and transition risks disclosed by the firm in compliance with the TCFD framework are associated with firm value. Considering that managers primarily have incentives to talk up their firm's share price, the negative connotations implied by specific identification of material physical and transition risks should make these risk disclosures inherently credible (i.e., at least as a lower bound on the firm's risk exposures). Thus, *a priori,* the test of value relevance for these risk disclosures could be a "straw man," with the refutation of the risk counts' value relevance being highly improbable, particularly in light of the extremely high level of support for TCFD-compliant disclosures, in combination with the alleged investor demand for climate risk information. On the other hand, leading regulators, practitioners, and academics claim that climate risks are not being fully priced (Arnold, 2020; CFTC, 2020; International Monetary Fund, 2020a; Schnabel, 2020), and specifically that there is a lack of awareness of, or appreciation for, the TCFD framework (Hook & Vincent, 2021; OMB Research, 2021).

Our results lend support to each of these perspectives. First, we show that the number of transition risks disclosed by the firm are negatively associated with firm value, consistent with these risks being viewed by investors as credible threats to the firm's business model as the world transitions to a low carbon economy (i.e., as unrecorded liabilities or impaired assets). By contrast, physical risks are not significant in valuation regressions, nor are the allegedly coveted firm-provided estimates of the financial impacts of climate change. Our findings imply that investors

don't understand the TCFD disclosures that firms are voluntarily furnishing to the CDP, that they are inattentive to this information, and/or that they simply do not view the risks and estimates provided in the disclosures as credible, probable, proximate in time, and/or material to firm value.

Our analyses are important because the demand for sustainable investments has been exploding in recent years, with global sustainable investment estimated to be $35.3 trillion at the start of 2020, accounting for up to 35.9% of total assets under management (Global Sustainable Investment Alliance, 2021). Institutional investors are correspondingly clamoring for relevant, reliable, and consistently measured climate-related information, and regulators are stepping up practices to assist in the elicitation of what the providers of capital need. Notably, several countries have already begun to specifically mandate TCFD-compliant disclosures (e.g., the UK, New Zealand, Switzerland, and Canada under certain circumstances), while the U.S. SEC has confirmed that it plans to issue new climate-related disclosure rules before the end of the year, and pundits expect that these new rules may be largely based upon the TCFD framework (Johnson & Schroeder, 2021). Our findings from a large global sample suggest that, when voluntarily-provided, TCFD-compliant information is largely not being reflected in share prices, even when companies report that their climate risk disclosures have been assured. The potential net benefits from mandating TCFD disclosures, which will impose significant costs on reporting entities, are thus far from obvious.

The rest of this paper is organized as follows. Section 2 provides institutional background related to the CDP and the TCFD framework, while Section 3 reviews the literature and develops hypotheses. Section 4 describes our sample and data, Section 5 investigates the determinants of firms' climate risk disclosure decisions, and Section 6 examines the capital market implications of the disclosures. Section 7 concludes.

2. Institutional Background and Overview of CDP Data

2.1. Corporate Climate Risk Reporting

Similar to the rest of the ESG reporting landscape of which it is a part, corporate climate related reporting is the subject of numerous alternative frameworks and reporting standards.[9] To

[9] The Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB), the International Integrated Reporting Council (IIRC), the Climate Disclosure Standards Board (CDSB), as well as the UN Global Compact through its Principles for Responsible Investing initiative, all speak to climate risk disclosure issues in one way or another. The EU's Non-Financial Reporting Directive (NRFD), which is subject to a proposed replacement by an EU

address perceived weaknesses associated with existing all-purpose sustainability disclosure frameworks, a number of standard-setting organizations were established to focus on the most "pressing" element of the ESG agenda; namely, climate change (Barker & Eccles, 2020).

Founded in 2000, the Carbon Disclosure Project (later simply "CDP") was an early attempt to promote and gather corporate disclosures on climate-related issues. The CDP encourages companies to voluntarily disclose their impact on climate change, particularly by measuring, reporting, and setting reduction targets for their greenhouse gas (GHG) emissions. Focused on the company's *impact on the environment*, CDP disclosures are of interest to a wide variety of stakeholders, including shareholders.[10] Indeed, there is a significant body of academic research documenting the price-relevance of emissions disclosures for both equity (e.g., Clarkson, Fang, Li, & Richardson, 2013, Matsumura et al., 2014, Bolton & Kacperczyk, 2021, amongst many others) and debt markets (e.g., Herbohn, Gao, & Clarkson, 2019), although Aswani et al. (2021) question the validity of the inferences drawn from some of these studies.

From the perspective of analyzing the financial risks and opportunities that climate issues pose for a firm, however, such carbon emissions disclosures are necessary but not sufficient. A critical missing element from ESG-related corporate disclosure frameworks that focus on *the firm's impact on the environment* and/or society is the disclosure of information related to the *impact of climate change on the firm.* Consider that there are a multitude of climate-related issues over which the firm has no control or significant influence (e.g., global warming), which may nevertheless have material consequences for the company. For example, the CO_2e emissions of a real estate holding company with significant waterside assets in Miami may be miniscule (and in a state that is less likely than most to impose carbon taxes that would significantly impact profitability), however a 2-degree rise in global temperatures could render the firm's assets worthless. In such cases, the firm's own CO_2e emissions disclosures do not nearly adequately capture the existential threat that climate change poses to the entity. Absent additional information, corporate climate-related risks

Corporate Sustainability Reporting Directive (CSRD), is also important to this landscape, as is the Partnership for Carbon Accounting Financials for financial institutions. Barker and Eccles (2018) provide a more extensive review and discussion of the various ESG-related standard-setting agencies, although the landscape has evolved considerably since that time.

[10] Shareholders may be interested in the firm's CO_2e emissions because of the increase in carbon emissions tax and allowance schemes that may affect the firm's cost structure and viability, because of changing consumer preferences for more environmentally friendly products (affecting each producer in the supply chain), because of changing financial capital providers' tastes favoring more sustainable companies, or due to any number other similar reasons that result in the firm's own CO_2e emissions potentially influencing the firm's financial prospects.

(and opportunities) are therefore unlikely to be properly incorporated into corporate decision-making, or properly priced by the market.

As explained by Mark Carney, the UN Special Envoy on Climate Action and Finance, former Governor of the Bank of Canada and of the Bank of England, and former Chairman of the Financial Stability Board, any failure to incorporate climate risk into investment decisions is not only jeopardizing to business models, but also puts the entire financial system at risk (Carney, 2015). Recognizing the systemic risks associated with climate change, in 2015 the Financial Stability Board established the Taskforce on Climate-related Financial Disclosures (TCFD) "to develop recommendations for more effective climate-related disclosures that could promote more informed investment, credit, and insurance underwriting decisions" (TCFD, 2021a). The TCFD's reporting framework, which requests that firms *report on the impact of climate change on their business* (i.e., rather than their business' impact on the environment), is radically different from previous sustainability reporting models. Chaired by Michael Bloomberg, the TCFD is supported by more than 2,000 entities from around the world with a combined market capitalization of over $19.8 trillion, including financial institutions responsible for assets of $175 trillion (TCFD, 2021b, p. 32).

The TCFD's reporting guidelines divide risks into two major categories: i) risks related to the *transition* to a lower-carbon economy; and ii) risks related to the *physical* impacts of climate change (TCFD, 2017, p. 5). *Transition* risks include policy and legal risks, such as the financial impact of carbon taxes or climate-related litigation (e.g., PG&E's triggering of California wildfires that resulted, in part, from a prolonged drought). Also included in this category are market risks (e.g., related to the supply and demand for commodities); technology risks, such as the development of renewable energy, battery storage, and energy efficiency; as well as reputational risks related to consumer and societal preferences (or even tolerances) changing during the low carbon transition. *Physical risks* may be event driven (acute) or due to longer-term shifts (chronic) in climate patterns. An example of the latter is provided by the Miami real estate firm mentioned above, whereby an increase in global temperatures over time will result in a sea level rise that could eventually lead to asset submersion. Examples of acute risks include the increasing frequency and intensity of hurricanes affecting the Southeastern U.S., flooding in Bangladesh, Germany, China, and elsewhere, or wildfires engulfing Australia and California. The TCFD also recognizes that there are climate-related *opportunities* related to resource efficiency, alternative energy sources, new

low-emission products and services, new markets, and in developing resilience, and the framework explicitly attempts to elicit company-provided insights into these climate-related upsides as well.

It is expected that a firm's identification and description of the material physical and transition risks that it faces, as well as their estimates of the financial impacts of climate risk, if credibly conveyed, would be informative to a fundamental analyst of the firm. In addition to signalling the firm's active monitoring and management of these risks, which is of no trivial importance, the details provided by firm insiders should meaningfully inform analysts' own subjective evaluations of the climate-related risks and opportunities being faced by the firm, and particularly their expected financial impacts. When added to the emissions data that was previously being solicited by the CDP, it is easy to see why the TCFD became known as the "gold standard" of corporate climate-related reporting, as well as why it has the backing of the most influential players in global capital markets, including the IFRS Foundation that is expected to subsume it, as well as SEC Commissioners and other important members of IOSCO. However, under the heretofore voluntary disclosure regime of the TCFD in which the information furnished is not required to be audited, is apparently not meaningfully reviewed by the CDP for accuracy and comprehension, and that is therefore strewn with errors, we discuss in the next section why there is little shine and potentially not much utility associated with some aspects of these disclosures.

2.2. CDP Questionnaire and Data

The CDP surveys companies that are publicly traded, amongst the largest firms in their country of headquarters, have high GHG emissions, or if they have previously responded to the CDP survey.[11,12] Beginning in 2018, the CDP survey was expanded to include questions designed to elicit the information proposed by the TCFD framework. Survey participation is entirely voluntary, it is not directly tied to any country-specific legislation, and companies report that the survey is extremely time- and resource-intensive to complete. By way of example, the .pdf version of the full 2019 climate change questionnaire is 185 pages long. Corporate respondents complete the CDP survey via an online form that includes closed- and open-ended questions, and they can

[11] The CDP's investor request process for the most recent survey period of 2021 is available here: https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/comfy/cms/files/files/000/004/393/original/CDP_Climate_Change_Sample_Investor_Request_2021.pdf

[12] Further details related to the TCFD's survey procedures and our approach to replicating their sampling procedure are provided in Appendix A.

elect whether to make their responses available to the public. The closing deadlines for responding to the survey have varied over the years, but generally fall between June and August. The CDP consolidates responses by late fall, and it makes this data available (for companies that have elected to have it shared publicly) on its website. While an individual company's responses can be freely accessed on the CDP's website, the full dataset of consolidated responses is available only to CDP signatories for a small fee, and to other members of the public (e.g., academics) for a more substantial price. The data obtained from companies who elect not to have their responses made public is available to institutional level subscribers to the CDP, a relationship level that only seems to be available to institutional investors (CDP, 2021). The CDP claims to do some light review of the data, but none of the submitted data are required to be audited, nor are they apparently subject to serious scrutiny before being consolidated by the CDP and sold on to the public.

In the CDP questionnaire section related to information sought under the TCFD framework, companies are requested to provide financial impact estimates of climate risks. Our initial inspection of the financial impacts data for each of the three years for which it is available revealed some concerns, which led us to undertake a review of 100% of the 11,443 climate risk financial impact disclosure observations available for publicly-listed firms from advanced economies and South Africa.[13] Since the survey responses are the only available "source data", our review consisted of checks for internal consistency between the quantitative financial impact figures and the textual explanations contained in each company's responses. Based upon this reconciliation, 825 financial impact observations (7% of total) were deemed to be problematic due to the various issues summarized in Figure 1, a further 1,047 (9%) could not be verified either because no textual explanations were provided and/or because the text was in Japanese. The remaining 84% of observations did not exhibit obvious data integrity concerns, although we would emphasize that our 7% error rate is almost certainly a lower bound on the extent of potentially problematic cases.

As shown in Figure1, the most common errors were that the respondent replied at the wrong level of aggregation (e.g., they reported on a particular process or activity rather than at the

[13] The set of observations reviewed is consistent with those included in our sampling frame, as explained in Section 3 and Appendix A (i.e., companies from advanced economies plus South Africa), except for the following differences: First, the final sample used in our regression analyses excludes companies from the financial sector and companies with any missing data. Second, the unit of observation for the data verification is the climate risk financial impact disclosure, of which there may be several per firm per year (i.e., on average, companies disclosing financial impact estimates provided information related to 4.22 climate risks per year), whereas the unit of observation for our regression analyses is the firm-year.

aggregate company level), that the response was in the wrong units (e.g., financial impacts are disclosed as percentages instead of plain numbers in a specified currency), or that the same aggregated financial impact figure was provided for different individual climate risks (e.g., the same financial impact of weather-related events is supplied for both acute and chronic physical climate risks). While some of these errors could potentially be corrected with some painstaking effort, most of them cannot be adjusted with the information made available. Overall, considering that the TCFD-compliant information being gathered by the CDP is known as the "gold standard" of company-provided climate risk information, we were very surprised and disappointed by both the rate, and the nature, of the errors that we observed. Furthermore, we consider the confirmed and suspected errors to be a lower bound on the data concerns that are likely to be embedded in the CDP database. Accordingly, we include only a limited set of analyses using the detailed financial impact data, and we would recommend that other potential users of this aspect of the CDP database proceed with extreme caution.

3. Related Literature, Theory, and Hypothesis Development

A large body of extant research examines the determinants of firms' voluntary sustainability reporting decisions, as well as the implications of sustainability disclosures for the firm's cost of capital and/or firm value (Christensen, Hail, & Leuz, 2021).[14] Corporate social responsibility (CSR) reporting differs from traditional financial reporting in a number of important ways, including: i) the potential audience for CSR reporting is broader; ii) CSR is not sharply defined, it encompasses a broad range of topics; iii) CSR reporting has many objectives and responds to the preferences of numerous stakeholders beyond investors; iv) CSR activities are not necessarily measured in monetary terms, nor otherwise on a consistent basis across activities (or, in the current absence of agreed upon frameworks, across firms or even by the same firm across time); v) CSR disclosure has historically been largely voluntary, although this is changing rapidly in many jurisdictions; vi) CSR activities are often embedded in the firm's strategy, and are expected to yield benefits over longer-term horizons, which makes them difficult to measure and report upon over shorter intervals; and vii) externalities play a central role in CSR activities and reporting.[15]

[14] We use the terms "sustainability" and "CSR" interchangeably in the discussions that follow.
[15] This list is derived from Christensen, Hail, and Leuz (2021).

A considerable amount of the extant research related to voluntary CSR reporting focuses on climate-related disclosures, much of which specifically investigates carbon emissions. We discuss the literature related to the determinants of voluntary disclosures and the information content of the disclosures, respectively, in the following two sections.

3.1 Determinants of Voluntary Climate-Related Disclosures

Hahn et al. (2015) identify two complementary theoretical perspectives that explain disclosure decisions: sociopolitical theories of disclosure, and economic theories of (voluntary) disclosure. Sociopolitical theories (e.g., Gray, Kouhy, & Lavers, 1995) view disclosure as firms' response to social, political and stakeholder pressure, a perspective that suggests that climate-risk disclosure can be explained as a response to stakeholder demand for information about how climate change will be (is) impacting businesses. Previous studies that explain *climate-related disclosure* in these terms include Liesen, Hoepner, Patten, and Figge (2015) in a European setting, and Reid and Toffel (2009) in the U.S. context. Also consistent with the sociopolitical perspective, countries with higher corporate-governance and disclosure norms have been shown to exert higher pressure for carbon disclosure (Choi & Luo, 2021).

Economics-based theories of disclosure, while acknowledging the forces of institutional pressure, also argue that companies will undertake a cost-benefit analysis before opting for voluntary reporting (e.g., Verrecchia, 1983). This perspective recognizes that demand for discretionary disclosure of corporate information arises from the inevitable information asymmetry that exists between corporate insiders and the firm's other stakeholders, and suggests that firms will optimize their disclosure policy in a manner that maximizes firm *value* (Core, 2001).[16] This more narrow perspective fails to consider agents' broader mandate of maximizing shareholder *welfare*, which is not necessarily the same thing (Christensen et al., 2021; Hart & Zingales, 2017), and the differences are likely to be considerably more important in the context of sustainability-related disclosure decisions. Nevertheless, while it is still reasonable to assume that corporate environmental disclosure decisions will involve a rational cost-benefit analysis, the decisions about whether to disclose climate risk information are complicated by a lack of consensus (and knowledge) about how to measure these risks, and whether they are likely to be credible and

[16] Healy and Palepu (2001) and Beyer, Cohen, and Lys (2010) provide comprehensive and insightful summaries of the disclosure-related literature.

material to decision makers, given that climate change predictions are generally uncertain and involve very long time horizons (Christophers, 2019).

In the context of financial capital markets, the benefits from disclosure are expected to include a reduction in the information asymmetry component of the cost of capital. Signalling theory (e.g. Milgrom, 1981; Connelly, Certo, Ireland, & Reutzel, 2010) suggests further benefits in that financial markets, regulators, employees, customers, and/or other stakeholders may reward firm transparency in the form of reputational enhancements. With respect to environmental disclosures, in particular, reputational benefits may accrue in the form of cash flow gains from increased or premium-priced sales, from having access to more motivated and/or more talented employees, from being able to negotiate more favorable terms with suppliers, and/or from greater access to cheaper financial capital in markets that put a premium on sustainable investment opportunities. We hasten to emphasize that the potential signalling value of environmental risk disclosures to the providers of financial capital is not only expected to be driven by stakeholders' "green preferences." Rather, to the extent that stakeholders recognize that climate risk is a real threat to a company's prospects, the firm's disclosure acts as a signal of potential real risk reduction (or optimal risk management) at the firm level, as disclosing firms may be assumed to better monitor, measure, and manage these risks.

The costs of disclosure in general include the potential release of proprietary information, the establishment of a measurement, tracking, and reporting system, and perhaps the additional need to have the disclosures assured by an independent third party to render them more credible. In the environmental realm, foreseeable costs also include the potential negative reputational costs if the firm is not perceived to be performing in line with stakeholder expectations. The latter may lead to adverse consequences that are opposite to the previously listed benefits (e.g., loss of access to/retention of talented employees, loss of sales or higher costs to maintain the same level of sales, higher costs of financial capital, etc.), in addition to the possible costs that could arise from the firm being targeted by activist campaigns (shareholders, customers, or the general public).

In the following sections we discuss the specific firm characteristics that the prior literature has investigated, and summarize the extant results concerning the determinants of environmental disclosures.

3.1.1 Size, Financial Performance, and Asset-Liability Structures

Larger firms face heightened political pressure to disclose their emissions, they are better equipped to bear the costs associated with a carbon emissions tracking system, and they may be

better positioned to bear any proprietary costs that may ensue if the firm disappoints some of its constituents with its climate-related performance (Liesen et al., 2015). Consistent with this, numerous studies have documented that firm size is positively associated with the likelihood of carbon emissions disclosure (Clarkson, Li, Richardson, & Vasvari, 2008; Liesen et al., 2015; Matsumura et al., 2014).

Similarly, more profitable firms are expected to have the resources and managerial attention required to implement the management information systems to track environmental performance metrics. Consistent with this, the prior literature documents that profitability is positively related to the voluntary disclosure of carbon emissions (Choi & Luo, 2021; Liesen et al., 2015; Ott, Schiemann, & Günther, 2017).

Other firm financial characteristics that have been shown to be related to firms' environmental disclosures include their growth prospects (Matsumura et al., 2014), leverage (Matsumura et al., 2014), and capital intensity (Clarkson et al., 2008). Our analyses also consider the role of firms' investments in internally-generated intangible assets (e.g., Demers, Hendrikse, Joos, & Lev, 2021) as some pundits consider these to be intimately related (albeit in unspecified ways) to the firm's sustainability activities and/or performance.

3.1.2 Ownership and Governance Characteristics

Institutional investors have a higher demand for climate-related information and may even require this information as a condition for investment, resulting in documented higher levels of disclosure by firms with greater institutional ownership (Ilhan, Krueger, Sautner, & Starks, 2020; Krueger, Sautner, Starks, & Karolyi, 2020). On the other hand, Matsumura et al. (2014) assert that firms *seeking* a greater institutional shareholder base are those most likely to disclose, suggesting perhaps the opposite relation between disclosure and institutional ownership.

Blockholders have been found to have a disclosure-decreasing influence as firms with closely-held ownership are unlikely to be responsive to public investors' demands for information given that controlling shareholders already have access to the relevant data (Cormier & Magnan, 1999).

A greater presence of independent directors and the existence of a sustainability committee at the board level have each been found to result in a higher likelihood of disclosure (Jaggi, Allini, Macchioni, & Zagaria, 2018). Intuitively, the firm's establishment of an environmental management system that enables them to track, measure, and manage climate-related information has also been shown to be a determinant of environmental disclosures (Ott et al., 2017).

3.1.3 Environmental Performance and Attestation

Theory suggests that firms that are superior in terms of their environmental performance are more likely to disclose such performance metrics in order to reveal their type (Milgrom, 1981; Spence, 1973). Consistent with this, Clarkson et al. (2008) and Matsumara et al. (2014) provide empirical evidence using U.S. samples that firms with better environmental performance are more likely to provide voluntary environmental disclosures.

3.2 The Relevance of Climate-Related Disclosures to Financial Markets

3.2.1 Signalling and Information Asymmetry Reduction Through the Act of Disclosure

Disclosure of private information reduces information asymmetry between firm insiders and the providers of capital (Healy & Palepu, 2001). Whether it is good or bad news that is being released, the provision of information reduces uncertainty and is expected to lead to a lower cost of capital, ceteris paribus. Consistent with this, using a sample of U.S. firms, Dhaliwal, Li, Tsang, and Yang (2011) find that the initiation of CSR reporting results in a lower cost of capital.

With respect to carbon and climate risk disclosures, signalling theory would suggest that a firm that discloses its carbon emissions and/or climate risks is signalling not only its ability to measure these emissions and risk exposures, a prerequisite for managing them (Matsumura et al., 2014), but also its superior performance (Clarkson et al., 2008). Moreover, climate-related disclosures provide investors with information about potential future costs that firms may incur due to changes in regulations, consumer preferences, or market dynamics triggered by societal efforts to mitigate climate change. Being able to readily access this information, investors do not need to undertake costly information searches such as purchasing estimates of firms' carbon emissions from third party providers. In line with these arguments, prior research finds that firms disclosing their carbon emissions enjoy higher firm valuations and lower cost of capital relative to non-disclosing firms. Employing propensity score matching and doubly robust regressions, Matsumura et al. (2014) document that median firm value is $2.3 billion higher for S&P 500 firms with disclosed carbon emissions compared to firms without emissions disclosures. This is consistent with Bolton and Kacperczyk's (2020) finding that the voluntary disclosure of Scope 1 GHG emissions is associated with lower stock returns.

Recent studies have extended the scope of this research from considering the capital market implications of emissions disclosures to examining the consequences of providing information

about climate risk exposure more broadly. Studying a sample of 717 European companies, Schiemann and Sakhel (2019) document that the voluntary disclosure of firms' exposure to physical climate risks is associated with lower information asymmetry. Flammer, Toffel, and Viswanathan (2021) conduct an event study of U.S. S&P 500 companies disclosing climate risks through the CDP questionnaire after being targeted by environmental shareholder activism. Assessing the stock market response around the day on which the climate risk disclosure is released to the public, the study finds that companies disclosing climate risks achieve higher stock market valuations post-disclosure.

Following from both information asymmetry and signalling theories, as well as the prior empirical environmental disclosure literature, we similarly expect that in the context of our international sample of firms and their decisions related to CDP questionnaire response, as well as the disclosure of TCFD-solicited climate risk information, that voluntary disclosure will lead to a higher market value, ceteris paribus. Specifically, we hypothesize the following with respect to each of the disclosure decisions that we investigate:

H1A: Respondents to the CDP questionnaire have a higher firm value, ceteris paribus.

H1B: Firms disclosing physical and/or transition risks (collectively, climate risks) in accordance with the TCFD framework have a higher value, ceteris paribus.

H1C: Firms providing estimates of the financial impacts of climate risks in accordance with the TCFD framework have a higher value, ceteris paribus.

Notwithstanding the theoretical plausibility of such predictions, we note that these hypotheses are not without tension. Numerous reports suggest that TCFD disclosures have not meaningfully captured the attention of practitioners. For example, an HSBC survey of 2,000 investors found that just 10 per cent of respondents viewed TCFD disclosures as a relevant source of information, claiming, "[d]espite all the talk about TCFD, at the moment we don't see it being used in discussions with credit rating agencies, in discussion with mainstream investors — it is still a very niche agenda item" (Hook & Vincent, 2021). In the U.K., where legislation is now in place to *mandate* TCFD-compliant corporate climate risk disclosures by 2025, a recent survey of defined benefit (DB) pension plan managers prepared for The Pensions Regulator found that less than 50% of all DB schemes allocated time and resources to assessing any financial risks and opportunities associated with climate change (although the proportion was 70% for large schemes), and that fully

71% of respondents (including 59% of large DB scheme respondents) were not even aware of the TCFD (OMB Research, 2021).

3.2.2 Information Content of Climate Risk Disclosures

A considerable body of prior research has investigated the association between firm value and the levels, or amounts, of environmental issues disclosed in corporate communications. Beginning with Barth and McNichols (1994), the early literature examined the capital market implications of corporate environmental issues through the lens of unbooked liabilities, that is, firms' exposure to potential future costs arising from environmental regulations. This strand of literature has found that the exposures to such environmental liabilities are associated with lower firm value (Barth & McNichols, 1994; Cormier & Magnan, 1997; Hughes, 2000). Much of the subsequent literature examining the value-relevance of carbon emissions as a proxy for environmental obligations has adopted a similar framework, hypothesizing and finding that carbon emissions are negatively associated with firm value (Chapple, Clarkson, & Gold, 2013; Choi & Luo, 2021; Clarkson, Li, Pinnuck, & Richardson, 2015; Griffin, Lont, & Sun, 2017; Matsumura et al., 2014). Although the basic finding of a negative relation between emissions and firm value is consistent across most studies, the economic significance of this relation differs between geographies and time periods, and results are sensitive to how emissions are measured (Aswani et al., 2021). For example, Matsumura et al. (2014) use an unscaled measure of total Scope 1 and Scope 2 GHG emissions for a sample of U.S. firms and find that every additional ton of emitted carbon is associated with a $212 reduction in firm value for S&P 500 companies. Studying the same empirical setting, but scaling carbon emissions by shares, Griffin et al. (2017) report a market-implied equity discount of $78.8 per ton of carbon emissions for the median S&P 500 company in their sample. Using a sample of 58 Australian firms, Chapple et al. (2013) document a 6.57% valuation penalty for firms with high relative to low carbon intensity, defined as GHG emissions scaled by sales revenue.

All these findings of a negative association between emissions and firm value are consistent with the notion that carbon emissions disclosures capture imposing threats of regulation and/or other expected real costs as the economy transitions to a lower carbon reality. However, the heterogenous firm value discounts documented in prior studies indicate that the value relevance of carbon emissions is likely to differ across institutional and geographical contexts. Consistent with this, Clarkson et al. (2015) find that for firms that are subject to the European Emission Trading Scheme, only those carbon emissions that are not covered by free emission allowances are

associated with a valuation penalty, which they estimate to be €75 per ton of emissions. Similarly, using a global sample of 1,748 firm-year observations from 28 countries, Choi and Luo (2021) find that the negative association between carbon emissions and firm value is stronger in the presence of a national emissions trading scheme. Bolton and Kacperczyk (2021) also document some cross-country differences in the pricing of firms' carbon emissions, but overall they find a consistent, positive association between carbon emissions and stock returns for firms in all sectors across three continents (Asia, Europe, North America).

Notably, all the preceding studies examine the association of firm performance, returns, and/or value with a measure of *the firm's impact on the environment* (i.e., emissions), which is at best an indirect and incomplete measure of the potential cost to shareholder value associated with the environmental issues that firms face. Considering the body of evidence supporting the value relevance of such a weak proxy for the total climate risks being faced by the firm, it seems reasonable to expect that the "gold standard" TCFD disclosures that we examine, which are designed to measure the more shareholder relevant *impacts of climate risk on the firm*, would quite obviously be associated with firm value.

For several reasons, however, there is more tension related to this hypothesis than it might appear at first blush. First, Aswani et al. (2021) revisit the issue as to whether CO_2e emissions are associated with firm performance, and their results call into question the conclusions of earlier studies. These authors find that emissions levels are only associated with stock returns when the emissions are measured in metric tons of CO_2e, but not when they are measured in terms of carbon intensity (i.e., CO_2e emissions scaled by sales), which is the measure most used by practitioners. Furthermore, and of direct relevance to the TCFD-compliant disclosures that we investigate, Aswani et al. (2021) find that emissions are only associated with returns when emissions data are estimated by data purveyors, *not when the disclosures emanate from the firm*, and further that emissions are not associated with performance when the analyses incorporate industry effects.

Secondly, anecdotal accounts stemming from representatives of leading organizations around the world similarly suggest that climate risk more broadly (i.e., beyond CO_2e emissions) is not being adequately priced by the capital markets. For example, BNY Mellon (2019) reports that 93% of survey participants "regard climate change as an investment 'risk' that has yet to be priced in by all the key financial markets globally." The IMF similarly reports that climate change physical risk does not appear to be reflected in global equity valuations, leading the organization to call for

global mandatory disclosures on material climate change risk (International Monetary Fund, 2020a). The U.S. Commodity Futures Trading Commission (CFTC) has arrived at similar conclusions, claiming that, "in the case of climate risk, neither the expected impacts – nor the potential for extremely bad outcomes – is being priced appropriately" (CFTC, 2020). Christine Lagard, President of the European Central Bank, has expressed a similar opinion in the international arena (Arnold, 2020). Consistent with these mostly anecdotal perspectives, a recent survey of academics, professionals, and public sector regulators and policy economists reports that, "[b]y an overwhelming margin, respondents believe that asset prices underestimate climate risks" (Stroebel & Wurgler, 2021, p. 1). With respect to TCFD disclosures in particular, a GSIA (2019, p. 5) investor poll reports that "87% said they do not believe that markets are consistently and correctly pricing climate risks into company and sector valuations."

Despite this skepticism, a recent study by Koelbel, Leippold, Rillaerts, and Wang (2020) uses a textual analysis of U.S. firms' 10-K reports to investigate whether the corporate climate risks disclosed in these filings are priced by the credit default swap (CDS) market. Differentiating between physical and transition risks, as suggested by the TCFD framework, Koelbel et al. (2020) find that transition risks increase CDS spreads, especially after the Paris Climate Agreement of 2015, but they do not find any such significant effect for physical risks.

In summary, there is now even conflicting evidence related to the value-relevance of the more pervasive and generally well-understood corporate carbon emissions disclosures. Combined with the many anecdotes and survey evidence suggesting that TCFD disclosures are either not well understood or not being attended to by investors, and notwithstanding the unanimously strong support for the TCFD framework on the part of many regulatory bodies and other important players in the global capital markets, the extent to which this alleged "gold standard" of climate risk reporting will be reflected in market prices is far from obvious.

4. Data, Sample, and Descriptive Statistics

4.1 Sample

Data related to corporate voluntary reporting of climate related risks was purchased from the CDP for their reporting years 2018 through 2020.[17] Our analyses focus on companies

[17] The CDP labels their data based on the year in which the company *reports* the climate related information. The deadline by which companies are required to respond to the survey has varied from July 31st to August 26th, and thus for

headquartered in advanced economies plus South Africa, excluding financial firms.[18] Panel A of Table 1 reports the total number of publicly-traded CDP respondents by country for each of the three CDP reporting years for which we have data. On a country basis, the greatest number of respondents are from the U.S., followed by Japan, the U.K., and France. However, if considered as a bloc, the EU would rank first in terms of the absolute number of CDP survey responders. Together, companies from the EU, U.S., Canada, and Japan account for more than 80% of the total firm-year responses to the surveys for the years shown. Panel B provides the distribution of respondents by industry sector for each year, with the data indicating that firms in the industrial, consumer discretionary, and materials sectors together account for nearly 50% of firm-year responses.

In order to model firms' decisions about whether to disclose, we require a sample of firms that are expected to have been *invited* to respond to the CDP survey, not just those who have actually replied. As discussed in Section 2, although the CDP's corporate invitation list is not consistently disclosed, their survey methodology is sufficiently transparent as to permit its approximate replication. Appendix A describes in detail our approach to replicating the CDP's selection of surveyed firms. We use Refinitiv's EIKON database to implement the stated selection criteria. This process yields the samples summarized in Panels C and D on a country-by-country and sector-by-sector basis, respectively, for each year included in the sample.

Panels E and F of Table 1 show the rates of response to the CDP questionnaire by country and by sector for each year. As expected, many European countries exhibit relatively high response rates. This is far from homogeneous, however, as evidenced by the spread between, e.g., Cyprus, Iceland, and others at the lower end, and Norway and Finland at the higher end of the range. Within

most companies a "2018" CDP reporting year corresponds to the company's 2017 fiscal year. To align CDP data with financial data, we assume that companies with fiscal year end months of January through June that are reporting to the CDP in 2018, e.g., are reporting for their fiscal year 2018, while companies with year ends from July through December that are reporting in 2018 are reporting for their fiscal year ending in 2017. For the latter group (i.e., the majority of companies in the sample), we merge the 2018 CDP data to their 2017 financial data and refer to this as a "2018" observation because this is the year of the climate risk disclosure decision. Our results are not sensitive to alternatively assuming that only companies with year ends from January to March file CDP reports in the year that corresponds with their fiscal year end (which is not surprising given that relatively few firms in the sample have year ends from April through June, and also given that many of the explanatory variables are "sticky" from year to year).

[18] We identify advanced economies based upon the definition provided by the International Monetary Fund (International Monetary Fund, 2020b, p. 109). We include South Africa because integrated reporting has been mandatory for firms listed on the Johannesburg Stock Exchange for more than 10 years, which has led to an unusually high rate of climate risk disclosure for companies headquartered in South Africa. Our results are not sensitive to dropping the South African observations.

the Asia-Pacific region, Japan has the highest rate of response, whereas Hong Kong and Australia are relative laggards. Surprisingly, the U.S. has a higher response rate than most EU countries, whereas the UK and Canada fall around the middle of the pack. In terms of industry response rates, the highest by far is utilities, traditionally a sector about which GHG emissions concerns abound, followed by consumer staples.

Panels G and H show the country and industry response rates to TCFD-aligned climate-related questions. Since these are a subset of the CDP responses, the response rates are systematically lower, but they otherwise exhibit similar tendencies in terms of countries' and industries' propensities to respond.

4.2. Data Sources

Data related to climate risk disclosures was purchased from the CDP. Blockholder share ownership data is derived from S&P's Capital IQ, and all other corporate financial, ownership, share price, CDS spread, and ESG data are provided by the Refinitiv EIKON database.

4.3. Descriptive Statistics

Panel A of Table 2 provides descriptive information related to the firms in our sample, and for the sub-samples of responding/non-responding firms for each of: i) the CDP survey; ii) climate risk questions; and iii) the financial impact of climate risk questions. As shown, respondents to each type of information request are significantly larger in terms of sales, total assets, market capitalization, and analyst following relative to non-respondents. Respondents to each of the three sets of questions also tend to be more profitable, as evidenced by their higher ROA. Respondents spend less on each of R&D and SGA as a percentage of sales, and slightly more on CapEx as a percentage of total assets, and they are also more leveraged. For the subset of firms for which CO_2e emissions data are available, we find that firms with higher emissions are more likely to respond to each of the three dimensions of the survey.

Panel B of Table 2 provides descriptive statistics for our regression variables. *CDP*, a firm-year indicator set to one if the company responds to the CDP questionnaire, indicates a pooled average response rate of 36%. *CR* and *FI*, indicators set to one if companies respond to the TCFD-aligned climate risk and financial impact of climate risk questions, respectively, indicate pooled response rates of 31% and 24%, on average, for each of these aspects of the questionnaire. Although firms responding to the CDP questionnaire are likely to be those that are most attuned to,

and forthcoming about, climate-related disclosures, only 67% of CDP-responding firms provide the sought after financial impact information solicited under the TCFD framework. In untabulated analyses we also find that nearly (more than) 90% of firms providing climate risk (financial impact) information had previously responded to the CDP questionnaire, suggesting that it is very rare for firms to go from non-participation in the CDP survey to provided the more involved TCFD-compliant disclosures. Still, of those firms that had previously responded to the CDP questionnaire, approximately 12% and 29% don't provide climate and financial impact information, respectively, in the subsequent period. In other words, previously responding to the CDP questionnaire does not automatically lead to subsequent provision of the more complete and informative disclosures solicited by the TCFD, particularly with respect to the financial impact information that is potentially useful to investors. Firms that respond to the climate risk questions (i.e., those with *CR*=1), disclose, on average, 2.5 transition, 1.5 physical, and thus 4.0 climate risks in total.[19]

Over 59% of firms in our sample provide a sustainability report (*SustReport*), 49% have a formal sustainability committee (*SustCommittee*), 40% report having an environmental risk management system (*EMS*), and less than 17% of firms are signatories to the United Nations Global Compact (*UNsign*). For firms for which CO_2e data is available, we observe that there is immense variation in CO_2e emissions intensity across firms, and the ratio of CO_2e to revenues is extremely right-skewed. Accordingly, in value- and risk-relevance regressions that incorporate emissions, we use the natural log of (1+ CO_2e/Sales) as the explanatory variable.[20]

Table 3 presents the correlation matrix for the variables used in our regressions. Not surprisingly, size is correlated with the existence of a sustainability committee, the production of a sustainability report, and the establishment of an environmental management system, albeit to a less significant degree than might have been expected. Each of these three indicators of heightened attentiveness to, and management of, sustainability-related issues is also predictably highly correlated with the others. As previously established in sample comparisons, the pairwise correlations confirm that the decisions to respond to each of the three elements of the survey are correlated with various measures of size, performance, asset tangibility, and financial structure.

[19] For the sample as a whole, averaging across all firms including those that don't disclose any climate risk information, this implies the provision of .79 transition risks (*TransRisk*), .47 physical risks (*PhysRisk*), and thus a total 1.26 climate risks (*ClimateRisk*) as reflected in the averages shown in the table.

[20] We note that CO_2e intensity is a scaled variable (i.e., it is CO_2e emissions in tonnes scaled by revenues), so the variation and right-skewness in this raw ratio is not a simple manifestation of firm size.

5. Disclosure Decisions

In this section, we empirically investigate the determinants of three corporate disclosure decisions, including whether to respond to the CDP questionnaire, whether to disclose physical and transition risks in accordance with the TCFD framework, and whether to provide estimates of the TCFD-solicited financial impacts of climate risks, respectively.

5.1 Expected Determinants of Disclosure

Following from the prior literature, we expect that firm size, asset mix, and financial structure will impact the disclosure decisions, as will ownership and governance characteristics, the firm's industry and region of headquarters, as well as other indicators of the firm's commitment to sustainability and environmental performance. We discuss our empirical proxies for these variables each in turn.

5.1.1 Size, Financial Performance, and Asset-Liability Structures

Consistent with prior literature, we capture firm size using the natural log of sales (*logSales*), and we expect that it will be positively associated with the likelihood of disclosure (Clarkson et al., 2008; Liesen et al., 2015; Matsumura et al., 2014). Similarly, we expect that more profitable firms will have the requisite resources to respond to the CDP survey and to furnish the additional TCFD-related information, and we use net income scaled by total assets (*ROA*) as our proxy for profitability.[21]

We also consider that the firm's growth prospects (Matsumura et al., 2014), leverage (Matsumura et al., 2014), capital intensity (Clarkson et al., 2008), and its level of investment in internally created intangible assets (Demers et al., 2021) may influence their propensity to disclose climate risk information. Our proxies for each of these respective constructs are the book-to-market ratio (*BTM*), long-term debt scaled by total assets (*LEV*), capital expenditures scaled by total assets (*CapEx*), and the stock of unamortized investments in internally developed intangible assets (*IntangStock*).[22]

[21] In untabulated analyses, we use earnings before interest scaled by total assets and operating earnings scaled by total assets as alternative measures of profitability, and all of our key inferences remain unchanged.
[22] The calculation of *IntangStock*, as well as all other variables, are described in greater detail in Appendix B.

5.1.2 Ownership and Governance Characteristics

Following the prior literature (Ilhan et al., 2020; Matsumura et al., 2014), we capture institutional ownership using the percentage of common equity held by institutions (*InstOwn*), and we expect this to positively influence firms' propensities to disclose climate-related information.

We construct an indicator variable that is set to one if the firm has a shareholder owning 5% or more of the common stock, and zero otherwise (*Block),* and we expect that blockholders will have the opposite effect on disclosure (Cormier & Magnan, 1999).

We include the percentage of independent directors (*IndepDir*), an indicator set to one if the firm has a sustainability committee (*SustCommittee*), and an indicator set to one if the firm has an environmental management system in place (*EMS*), and we expect that each of these governance variables will be positively associated with the likelihood of disclosure.

5.1.3 Commitment to Sustainability

We include two additional variables that are designed to capture the firm's commitment to sustainability. *UNsign* is an indicator set to one if the firm is a signatory to the UN Global Compact, and is expected to be positively associated with the propensity for disclosure (Liesen et al., 2015). Firms that produce either a dedicated sustainability report, or that provide a section on sustainability in their annual reports, may be similarly signalling a higher commitment to environmental friendliness, and are therefore expected to be more likely to disclose. Given the propensity for greenwashing, however, it is possible that this variable will not be associated with the firm's decisions to disclose the detailed climate-related information requested by the CDP and the TCFD disclosure framework. We control for this using an indicator variable, *SustReport*.

5.1.4 Industry and Country

In addition to all of the preceding firm-specific attributes, we also expect that the sector in which the firm operates and the country or economic region in which it is headquartered will influence the firm's willingness to disclose climate-related information. We therefore include indicators for each of the 10 GICS sector classifications excluding the financial sector that was dropped from our sample (*industry*), as well as indicators capturing the firm's headquarters by country and/or region (*region*) using the following eight classifications: Canada, US, UK, EU+4, Australia, Japan + South Korea, South Africa, and HK+Taiwan+Singapore+Macau.

5.1.5 Additional Determinants

The firm's environmental performance is also expected to be an important determinant of their willingness to disclose environmental information (Clarkson et al., 2008; Matsumura et al., 2014). Unfortunately, the candidate control variables for this construct are only available for a subset of our sample, and therefore we include a control for environmental performance only in supplementary regressions. Our first proxy for this is the firm's industry decile ranking on the basis of GHG emissions intensity (i.e., CO_2e scaled by revenues), which we label *CO2eRank.* Given that prior value-relevance results are sensitive to emissions measurement, we also consider two additional alternatives: CO_2e scaled by revenues (i.e., emissions intensity without industry-adjustment, or *CO_2e*); and to address the skewness of emissions, *logC02e*. Finally, we alternatively use the firm's Refinitiv environmental pillar score to capture its environmental performance.

5.1.6 Voluntary Disclosure Decision Model

Following from the previous discussions, the regression model used to examine the determinants of firm's climate-related disclosure decisions is as follows:

$$\begin{aligned} Disclose_{it} = {} & \beta_0 + \beta_1 logSales_{it} + \beta_2 ROA_{it} + \beta_3 BTM_{it} + \beta_4 LEV_{it} + \beta_5 CapEx_{it} + \\ & \beta_6 IntangStock_{it} + \beta_7 InstOwn_{it} + \beta_8 Block_{it} + \beta_9 IndepDir_{it} + \\ & \beta_{10} SustCommittee_{it-1} + \beta_{11} EMS_{it} + \beta_{12} UNsign_{it} + \beta_{13} SustReport_{it} + \\ & \sum_{j=1}^{9} \delta_j industry_j + \sum_{k=1}^{7} \gamma_k region_k + \varepsilon_{it} \end{aligned} \quad (1)$$

where $Disclose_{it}$ is alternatively an indicator that is set to one if firm *i* in period *t* chooses to respond to the CDP questionnaire (CDP_{it}), to provide TCFD-compliant climate risk information (CR_{it}), or to provide the TCFD-solicited estimates of the financial impact of climate risks on the firm (FI_{it}), and zero otherwise, and all explanatory variables are as previously explained and as defined in greater detail in Appendix B. Standard errors are clustered by firm and year in all specifications.

5.2 CDP Questionnaire Response

The results from probit regressions of Equation (1) examining the determinants of firms' decisions to respond to the CDP questionnaire are reported in Table 4. In the first column, we report the results using only the financial, ownership, and independent director variables, in the second column we report the same regression with industry and region fixed effects, and in the third column we add variables capturing the firm's commitment to sustainability.

Consistent with findings in earlier U.S. and other single-country studies examining emissions disclosure decisions, firm size, institutional ownership, and profitability are significantly positively

associated with the firm's decision to respond to the CDP survey. The firm's stock of internally developed intangible assets (*IntangStock*) is a positive determinant of disclosure, as are capital expenditures, but the latter is only significant when variables capturing the firm's commitment to sustainability are excluded from the regression. A higher proportion of independent directors also increases the firm's propensity to respond to the questionnaire, but only when variables capturing the firm's commitment to sustainability are excluded from the regression. When the latter variables are included, the role of independent directors is to decrease the firm's propensity to respond to the CDP survey.[23] As expected, the establishment of a sustainability committee of the board of directors, the production of a sustainability report, the existence of an environmental management system, and being a UN Global Compact signatory all significantly increase the likelihood of firms responding to the CDP survey.

5.3 TCFD-Compliant Climate Risk and Financial Impacts Disclosure Decisions

In Table 5 we present the results of Equation (1) using the firm's decision to disclose physical risks and transition risks in accordance with the TCFD framework (collectively, climate risks, or *CR*) as the dependent variable. We find that most of the determinants of the firm's decision to provide this additional TCFD-compliant information are similar to those associated with the CDP survey response documented above. Specifically, firm size, institutional ownership, tangible asset intensity (*CapEx*), and the indicators capturing the firm's commitment to sustainability are all reliably associated with a higher likelihood of disclosure, and when the commitment to sustainability is controlled for, the coefficient on independent directors flips from positive to negative. The firm's capital structure (*LEV*) is now weakly significant, whereas neither *ROA* nor *IntangStock* are significant in explaining the firm's decision to identify their material climate risks.

In Table 6 we present the results from the same regressions using the firm's decision to provide quantitative estimates related to the financial impact of climate change as the dependent variable. Although only 24% of firms provide these disclosures (versus 36% and 31% responding to the CDP questionnaire and providing climate risk disclosures, respectively), the signs and

[23] This sign flipping is clearly suggestive of a potential multicollinearity problem, and the relatively high degree of pairwise correlation between *Indep_Dir* and some of the variables capturing the firm's commitment to sustainability heighten these concerns. Given that VIFs are not well-defined in probit analyses, in order to investigate the potential for multicollinearity amongst the variables, we rerun Equation (1) as an OLS regression. The VIFs calculated from this OLS regression are all well below traditional thresholds of concern, with the highest valued VIF being less than 3, suggesting that multicollinearity is not likely to have an undue effect on the reported probit coefficients.

significance of the coefficients on the explanatory variables are largely identical to those reported in the previous analyses.

5.4 Specifications Controlling for Environmental Performance

In Table 7 we present each of the fully specified decision model regressions using observations for which CO_2e emissions and the firm's overall environmental performance score are each respectively available. We first measure CO_2e emissions using the firm's sector decile ranking of CO_2e scaled by revenues (*CO2eRank*). As shown in Panel A, this variable is weakly significant in explaining the firm's decision to disclose climate risks, but it is not significantly associated with a higher likelihood of responding to the CDP survey or providing financial impacts information.[24] Panel B of Table 7 presents the results using the natural log of CO_2e emissions (*logCO2e*) to control for emissions performance. As shown, *logCO2e* is a significant determinant of the firms' decisions to disclose climate risk and financial impacts information, but it is not associated with the propensity to respond to the CDP questionnaire. Our inferences related to the other decision determinants are largely unaffected by the inclusion/exclusion of the emissions control variables, except that profitability (*ROA*) is now significant across the board when emissions performance is controlled for, and director independence (*IndepDir*).[25] We conclude from these tests that the role of CO_2e emissions as a determinant of TCFD disclosures is ambiguous as their significance is sensitive to how these emissions are measured.[26]

Panel C of Table 7 presents the results from each of the fully specified decision models after including Refinitiv's environmental pillar score (*EnvScore*) as the proxy for the firm's environmental performance. As shown, and consistent with prior research in the context of emissions disclosures (e.g., Clarkson et al., 2008), the firms' decisions to respond to the CDP questionnaire, to disclose climate risks, and to disclose the financial implications of climate risks, are all positively associated with their overall environmental performance. We conclude that the firm's overall environmental performance is a significant determinant of their propensity to disclose climate risk information.

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[24] For parsimony, we do not tabulate the similar results found for all three decisions using CO_2e scaled by sales (*CO_2e*).
[25] In untabulated tests, we rerun the decision models including/excluding the various CO_2e emissions variables using the constant sample for which these variables are available, and our inferences on the other determinants are not meaningfully different under the two alternative specifications.
[26] An alternative interpretation of the insignificance of the emissions variables is that the firms' emissions *are* an important consideration in their disclosure decisions, on average, but that the firm-level emissions data provided by the Refinitiv database are not reliably measured, resulting in attenuated coefficients.

5.5 Summary

To the best of our knowledge, ours is the first study to provide large scale global evidence related to firms' decisions to provide TCFD-compliant climate risk disclosures. Our evidence suggests that, although the rate of furnishing this information is considerably lower than that of the standard CDP responses, the determinants of these climate risk disclosures are generally similar. Firm size, institutional ownership, and indicators of the firm's commitment to sustainability, as well as industry membership and geographical region, are consistently significant determinants, whereas the firm's tangible asset intensity (captured by *CapEx* and *IntangStock*) and profitability (*ROA*) are not universally important. Director independence increases the likelihood of all three forms of disclosure in the absence of sustainability commitment variables and environmental performance variables, but its role changes when these variables are controlled for. Finally, for the subset of firms for which data is available, we confirm that overall environmental performance is important to all three climate risk disclosure decisions, whereas the role of CO_2e emissions varies depending upon how emissions are measured.

6. Capital Market Implications of Disclosure Decisions

We next consider whether the market assesses any relevance to corporate climate risk disclosures by examining whether any of the three decisions to disclose, the number of risk factors disclosed, or the estimated financial impact disclosures are associated with firm value.

6.1 Signalling Value of Disclosure Decisions

In order to assess the signalling value of the climate risk disclosure decisions, we run the following pooled regression using Tobin's Q, defined as the market value of common equity plus the book value of debt, all scaled by the book value total assets, as the dependent variable:

$$Q_{it} = \theta_0 + \theta_1 logSales_{it} + \theta_2 ROA_{it} + \theta_3 LEV_{it} + \theta_4 IntangStock_{it} + \theta_5 CapEx_{it} + \theta_6 SalesGrowth_{it} + \theta_7 Cash/Assets_{it} + \theta_8 Disclosure_{it} + \sum_{j=1}^{11} \delta_j\, industry_j + \sum_{k=1}^{7} \gamma_k region_k + \varepsilon_{it} \quad (2)$$

where *Disclosure* is alternatively defined as *CDP*, *CR*, and *FI* (i.e., indicators set to one when each respective disclosure has been provided), and all other explanatory variables are as previously explained and defined in detail in Appendix B. Standard errors are clustered by firm and year in all pooled specifications.

The results from this regression using all available firms in our sample are reported Table 8. As shown, only the *CDP* decision indicator is significant. The positive coefficient on *CDP* is

consistent with the prediction that voluntary disclosure of climate risk information will lead to reduced information risk and serve as a credible signal of the firm's commitment to measuring and managing these risks, which in turn results in higher firm value. However, when the result for *CDP* is considered together with the insignificance of the climate risk and financial impact decision indicators, the combined findings suggest that there is little information content conveyed by the firms' decisions to provide detailed climate risk information. This finding may result from the market's assessment that the act of disclosure alone is not a sufficiently credible signal of the firm's commitment to, or success in, measuring and managing climate risks (i.e., a substantial number of disclosing firms may be greenwashing). Alternatively, the results are also consistent with market participants not responding to the information contained in the disclosure decisions either because investors are unable to process the information signal being conveyed, or because they are simply not attentive to the disclosures. The latter interpretation is supported by anecdotal accounts and practitioner survey reports, as previously discussed in Section 3.

6.2 Value-Relevance of Physical and Transition Risks

We next investigate whether the *number* of disclosed transition and physical risks, respectively, are reflected in the firm's market value using the following regression:

$$Q_{it} = \theta_0 + \theta_1 logSales_{it} + \theta_2 ROA_{it} + \theta_3 LEV_{it} + \theta_4 IntangStock_{it} + \theta_5 CapEx_{it} + \theta_6 SalesGrowth_{it} + \theta_7 Cash/Assets + \theta_8 PhysRisk_{it} + \theta_9 TransnRisk_{it} + \theta_{10} IMR\_CR_{it} + \sum_{j=1}^{11} \delta_j\, industry_j + \sum_{k=1}^{7} \gamma_k region_k + \varepsilon_{it} \quad (3)$$

where *IMR_CR* is the inverse Mills ratio from the first stage (i.e., Equation (1)) regression capturing the firm's fitted propensity to disclose climate risks (i.e., either physical and/or transition risks or both), and *PhysRisk* and *TransnRisk* are the counts of the number of physical risks and transition risks disclosed by the firm, respectively. The use of counts of the number risks disclosed as a credible proxy for the extent of risk being faced by the firm is supported by prior studies in the IPO literature (e.g., Beatty & Welch, 1996), as well as studies examining the information content of firms' 10-K risk disclosures (e.g., Campbell, Chen, Dhaliwal, Lu, & Steele, 2014).

The results from these regressions are reported in Panel A of Table 9. In the first column, both the estimated likelihood that the firm will choose to disclose climate risk related information and the industry and region fixed effects are omitted. The second column incrementally includes the

fixed effects, and the third column additionally includes the inverse Mills' ratio (IMR) from the first stage regression modeling the firms' decisions to disclose climate risks (*IMR_CR*).[27]

As shown, the number of transition risks (*TransnRisk*) disclosed by the firm is negatively associated with firm value, whereas neither the number of physical risks (*PhysRisk*) nor the propensity to disclose climate risks (*IMR_CR*) is significant in explaining *Q*. The significant negative coefficient on *TransnRisk* suggests that the number of disclosed transition risks is being priced by the equity markets as a form of unrecorded liability or unrecognized asset impairment. Alternatively stated, the transition risks identified by the firm credibly convey value-destroying threats to the firm's business model that investors assess as having a sufficiently high probability and proximity as to have a material effect on firm value. By contrast, the identified physical risks are apparently viewed by the market as not credible, improbable, remote, or immaterial, on average, as they are not significantly associated with firm value.

We undertake a number of untabulated specification checks related to the results reported in Panel A of Table 9. First, we sum the number of transition risks and physical risks into a single variable capturing the total number of climate risks disclosed (*ClimateRisk*). The combined count variable is not significant, consistent with the market viewing the credibility and/or materiality of each type of risk differently (as was also suggested by the opposite-signed coefficients in the previous baseline regression), and with their aggregation therefore creating a noisy measure of the material climate risks being faced by the firm. Second, we create an indicator that is set to one for firms with higher than median institutional ownership (*HighInst*), and we rerun the Equation (3) regressions including an interaction of *HighInst* with each of the physical and transition risk count variables, respectively, as well as the *HighInst* main effect. Neither the main effect nor the interaction terms are significant, suggesting that the number of disclosed risks are not differentially valued by the market for firms with higher levels of more sophisticated shareholders.

In a final specification check, presented in Panel B, we consider whether independent assurance enhances the information content of the disclosed risks. Prior studies have shown that the

[27] Following Matsumura et al (2014), who in turn cite Lennox, Francis, and Wang (2012) concerning the importance of imposing ''exclusion restrictions'' when using the Heckman procedure, we also exclude some of the explanatory variables of the first-stage disclosure decision from the second stage valuation model in order to avoid a multicollinearity problem at the second stage that could potentially bias the valuation model coefficients. Specifically, we exclude institutional ownership, the percentage of independent directors, and the various indicators capturing the firm's commitment to sustainability. In untabulated regressions, we rerun various specifications that include subsets of these variables. None of the variables is individually significant, and all of our key results are unchanged when the other variables are included.

cost of capital reduction induced by CSR disclosures is increased when companies provide assurance on their CSR disclosures (e.g., Casey & Grenier, 2014; Dhaliwal et al., 2011), that high-quality assurance statements on sustainability reports significantly reduce bid-ask spreads (Fuhrmann, Ott, Looks, & Guenther, 2017), and that analysts perceive the credibility of assured CSR reports to be greater in certain contexts (Pflugrath, Roebuck, & Simnett, 2011). To investigate the role of assurance in our setting, we create an indicator that is set to one if the firm's response to the CDP questionnaire indicates that climate-related information other than carbon emissions has been verified by an independent third party (*Attest*, and we include each of the *Attest* main effect, as well as the interaction of *Attest* with *TransnRisk* and *PhysRisk,* respectively, in the valuation regression. As shown, none of the three *Attest* variables are significant, suggesting that third party certification does not enhance the information content of climate risk disclosures in our setting.

In Table 10, we present year-by-year results of the Equation (3) valuation regressions.[28] The 2018 CDP survey was the first to include requests that firms disclose information in accordance with the TCFD framework, and thus 2018 disclosing firms may be considered "disclosure leaders" in the sense that they are the first to be forthcoming with the requested risk information. The number of physical risks disclosed *(PhysRisk)* is positively and significantly associated with firm value for 2018, suggesting that the provision of this risk information reduces the financial capital providers' information risk about the firm's physical climate exposures and/or that the disclosures signal the firm's more active monitoring and management of these risks (i.e., either of which would manifest in the observed higher enterprise valuation). By contrast, the number of transition risks disclosed by the firm (*TransnRisk*) is negatively associated with value, suggesting that the reduced information risk stemming from the firm's forthcomingness about these threats is insufficient to overcome the implications of the extent of climate-related challenges to the firm's fundamental business model (i.e., real operating risks). In other words, the reduced information risk is more than offset by the negative valuation implications of real climate risks to which the firm is admitting vulnerability as the world transitions to a lower carbon economy.

The results for each of 2019 and 2020 in the subsequent two columns are similar to those for 2018 except that the number of physical risks is no longer associated with firm value in either year. Thus, after the first year in which the number of physical risks disclosed under the TCFD

[28] Because these annual regressions include only one observation per firm and are all from the same year, the standard errors are not clustered.

framework was positively perceived by financial market participants, there appears to have been a change in sentiment regarding the valuation implications of these disclosures in subsequent years. The results suggest that the risk reduction premium enjoyed by firms offering voluntary physical risk disclosures is no longer greater than the market's perception of the real effects that these risks pose to firm value, such that the net effect on value is zero. Alternatively, the insignificant coefficient may result from the market's assessment, after a year of learning, that the physical risk disclosures are not reliable and/or that the likelihood of their occurrence is too small or too distant on the horizon, and/or that the expected impacts are, on average, otherwise immaterial.

Overall, our results suggest that transition risks disclosed under the TCFD reporting framework have been consistently negatively valued by the market since the inception of TCFD reporting to the CDP. By contrast, physical risk disclosures were taken as a positive signal by the market in the initial year of this new reporting regime, but the apparent significance of this information to market participants has dissipated over time.

6.3 Value-Relevance of the Estimated Financial Impacts of Climate Risks

We rerun the valuation regressions including the estimated financial impacts of climate risks (*FinImpact*), instead of the counts of the number of physical and transition risks identified by the firm, using all available firm-years for which the *FinImpact* disclosure was provided and was not deemed to be erroneous or suspect.[29] As in the previous analyses, we control for the firm's propensity to disclose using the IMR from a first-stage probit model of the *FinImpact* disclosure decision (*IMR_FI*), and we cluster standard errors by firm and year.

The results, shown in Table 11, indicate that firm-provided estimates of the financial impacts of climate change are negatively, but not significantly, associated with firm value. These findings suggest that the equity markets deem these estimates to be broadly unreliable, on average, or alternatively that too many observations containing problematic estimates may remain in our sample (i.e., such that the noisy data causes the coefficients on *FinImpact* to attenuate to zero). Alternatively, market participants may view the firms' estimated financial impacts to be credible, but that the likelihood and/or timing of their occurrence is too remote to have a material effect on value, or perhaps that the equity market adopts a more complex assessment of the value-relevance

[29] We rerun these regressions including cases that are suspect, but not definitively erroneous, and the results are unsurprisingly unchanged in that *FinImpact* remains insignificant.

of the disclosures than is implied by our model.[30] Finally, the results are also consistent with market participants simply not understanding or not being attentive to these TCFD-compliant disclosures.

We run several untabulated specification checks related to these results. First, we enter the financial impacts of transition and physical risks separately, and we find that neither variable is significant. Second, we investigate the impact of attestation on the value relevance of financial impact estimates by including the interaction of *Attest* and *FinImpact,* together with the *Attest* main effect, and we find that attestation does not render the estimated financial impacts value-relevant at standard levels of significance. Finally, we run annual regressions and find that *FinImpact* is insignificant in each of the three years for which this TCFD-solicited information has been voluntarily reported, suggesting that the insignificance of the cross-temporally pooled results are not being driven by learning in later periods.

In summary, even after removing observations containing erroneous or suspect financial impact data, considering the influence of attestation, allowing financial and physical financial impacts to be valued separately, and considering each reporting year separately, TCFD-compliant corporate disclosures of the potential financial impacts of climate risk as provided to the CDP exhibit no significant association with firm values. Considering the extent of support for the TCFD reporting framework amongst regulators and other important players in the global capital markets, as well as the associated increasing propensity to mandate these disclosures in numerous jurisdictions around the world, it's somewhat surprising to find that, when voluntarily provided, TCFD-solicited estimates of the financial impact of firm-identified material climate risks have no apparent relevance to equity market participants. On the other hand, given that the data being furnished to the CDP is strewn with errors (some easily identifiable, others perhaps less so), that the CDP seems to engage in very minimal validation of the data, and that the CDP expressly does not guarantee its reliability, perhaps it is reasonable that, despite the conceptual soundness of the TCFD framework itself, market participants deem the data being disclosed to the CDP under this framework to lack reliability. Alternatively, investors may consider the estimates to be reliable but the likelihood or timing of their occurrence to be too remote to materially impact firm value. Yet

[30] Recall that our *FinImpact* measure is a simple linear aggregation of all the financial impacts disclosed by the firm in a given year. It is conceivable, however, that fundamental analysts assess some of the firm's disclosed impacts to be sufficiently credible, material, probable and not too remote in time to be relevant for firm value, while they discount or dismiss entirely other disclosed financial impacts. If so, then the equal weighting scheme implied by our mechanical *FinImpact* summation may lead to a noisy proxy for the financial impacts that market participants consider to actually be relevant for firm value, attenuating the coefficients on our *FinImpact* measure towards zero.

another alternative explanation is that market participants are either simply inattentive to, or don't understand, the TCFD disclosures. Considering that our sample consists of large publicly-traded firms from advanced economies (i.e., the most likely setting for the assumption of equity market efficiency to hold), this explanation might seem improbable. Nevertheless, it is consistent with anecdotal claims made by some of the most influential players in the global capital markets, as well as with recent academic survey evidence, that the TCFD reporting framework is being ignored by investors and that climate risk is generally being under- (or not) priced.

7. Conclusion

The TCFD framework is purported to be the "gold standard" for corporate climate risk reporting and is poised to become mandatory in numerous jurisdictions, yet to the best of our knowledge there is no prior large sample evidence related to the TCFD-compliant disclosures that firms have been submitting to the CDP since the framework's introduction. Ours is thus the first study to contribute insights related to these widely touted disclosures that have the backing of many of the most prominent voices in the global capital markets.

Our investigations reveal that the TCFD-compliant financial impact disclosures are riddled with errors. The CDP is the single authoritative organization with whom this data is currently being filed (although nothing precludes firms from additionally or alternatively disclosing it elsewhere), they have a standardized online template for gathering the data, it is a significant resource-consuming effort for firms to complete the survey questionnaire (i.e., responding firms must be motivated as they are making a costly decision to respond and disclose the financial impacts and other data to the CDP), approximately 53% of firms providing financial impact estimates indicate that their climate-related information beyond carbon emissions data is subject to (costly) third party assurance, and yet despite all of this we estimate that a *minimum* of 7% of the financial impact estimates in the CDP database are erroneous. As such, the TCFD-related financial impacts data purveyed by the CDP is not suitable for use in quantitative investment strategies or any other large sample based policy- or decision-making contexts. Even after a detailed review of each entry, only the most egregious financial impact errors may be identifiable, and these may not be easily correctible if the information has not been publicly disclosed through other channels (and in an accessible language).

Our analyses of the usable data focus on a global sample of firms from advanced economies plus South Africa. Using data from 2018-2020, the three years for which TCFD-compliant disclosures are available, we document that the determinants of firms' decisions to respond to the CDP questionnaire, to disclose TCFD-compliant physical and transition risks, and to provide TCFD-solicited estimates of the financial impacts of climate risk, are generally similar to previously documented determinants of other corporate climate-related disclosures (e.g., such as carbon emissions). Specifically, larger firms, those with a larger institutional shareholder base, firms that are more tangible-asset intensive, and those evincing other indicators of their commitment to sustainability, including their overall environmental performance, are all more likely to respond to the CDP and to provide the solicited TCFD-compliant disclosures.

The results from our value-relevance tests are somewhat more surprising, especially in light of the very vocal and unanimous support being expressed for the TCFD reporting framework by influential capital markets participants and regulators around the world. We find that the number of firm-disclosed transition risks is reliably negatively associated with Tobin's Q, consistent with the market treating these as legitimate threats to the firm's business model and future prospects (i.e., as an unrecorded liability or unrecognized asset impairment). However, the physical risks identified by the firm as material are generally not associated with share prices, except in the first year of TCFD-compliant reporting when they were apparently being priced as a positive signal. Company-provided estimates of the financial impacts of their identified climate risks are not associated with market value in any one year, nor when pooled across time, and contrary to prior results in the general CSR literature, third party assurance does not enhance the value-relevance of TCFD-compliant climate risk disclosures. All of our reported results are robust to battery of additional robustness checks.

In summary, the CDP-provided TCFD disclosures leave much to be desired in terms of data integrity, and market values exhibit only a modest association with one aspect of TCFD disclosures, the total number of transition risks disclosed by the firm. We conclude that investors don't consider physical risk disclosures or the firm's estimates of the financial impacts of climate risk to represent credible, material, imminent threats to firm prospects, that investors don't understand or fully process the information contained in the disclosures, and/or that investors are simply inattentive to the TCFD disclosures. While the latter explanation seems improbable in efficient capital markets, particularly for our sample of relatively large firms from advanced economies, it is nevertheless

consistent with widespread anecdotal accounts, as well as practitioner and academic survey evidence. Although caution should be exercised when attempting to draw inferences about proposed *mandatory* TCFD disclosures on the basis of empirical evidence derived from their *voluntary* provision (Christensen et al., 2021), our findings should nevertheless be informative to policy makers and regulators, as well as to investors who are apparently ignoring potentially materially information.

Appendix A
Description of Sample Selection Procedure

In order to model the voluntary reporting decisions, we require a sample of firms that are expected to have been *invited* to respond to the CDP survey, not just those who have actually replied. Although the CDP's corporate invitation list is not consistently disclosed, we could access the list of companies that the CDP requested to respond to the climate change questionnaire in 2019 and 2021. The former is outlined in the document *CDP's List of Official Samples 2019* (link) and the latter is disclosed on the CDP website (link). The CDP requested 6,100 companies to respond to the Climate Change Questionnaire in 2019 and 6,900 companies were invited to respond in 2021. Focusing on companies that were included in *both* the 2019 and 2021 list, we then applied our sampling criteria to the resulting pool of companies to construct our final sample. We used Refinitiv's EIKON database to implement the screening criteria outlined below.

Our sample determination process is summarized in Table A1 below. We began by selecting companies headquartered in advanced economies plus South Africa. The former were identified based upon the listing of advanced economies provided by the IMF (International Monetary Fund, 2020b). We included South Africa in our sampling frame because integrated reporting has been mandatory for firms listed on the Johannesburg Stock Exchange for more than 10 years, which has led to an unusually high rate of climate risk disclosure for companies headquartered in that country. This yielded an initial sample of 4,749 firms. We added 89 companies from these geographies that were not specifically invited to the CDP Climate Change questionnaire but that nonetheless voluntarily submitted at least one response in the period 2018-2020. We removed 301 companies that were no longer publicly listed as of May 21st, 2021, 531 companies operating in the financial sector, and we lose 150 companies due to missing data, resulting in a final sample of 3,856 firms.

TABLE A1: Sample determination

Sampling Step	Number of Firms
Companies from advanced economies & South Africa requested to respond to CDP Climate Change Questionnaire in 2019 and 2021	4,749
Companies from Advanced Economies & South Africa that responded to CDP Climate Change Questionnaire without request	+89
Private companies	-301
Financial firms (based upon GICS classification)	-531
Missing data	-150
Number of sample firms	3,856

Appendix B
Variable Definitions

Variable	Definition
Analysts Follow	Number of sell-side analysts covering the firm.
Assets	Total assets of the firm (in $ million).
Attest	Indicator variable that equals one if the firm's response to the CDP questionnaire indicates that climate-related information other than carbon emissions has been verified by an independent third party.
Block	Indicator variable that equals one if the firm has a shareholder owning 5% or more of the common stock, and zero otherwise
BTM	Book-to-market ratio calculated as book value of common equity divided by market value
CapEx	Capital intensity calculated as capital expenditures divided by total assets.
Cash/Assets	Cash and short-term investments divided by total assets.
CDP	Indicator variable that equals one if a firm responds to the CDP questionnaire in given year
ClimateRisk	The total number of transition and physical climate risks disclosed by the firm.
CO2eRank	The firm's sector decile ranking on the basis of CO2 emissions intensity (i.e., CO2 emissions scaled by sales).
CR	Indicator variable that equals one if a firm provides climate risk related information in its response to the CDP questionnaire.
EMS	Indicator variable that equals one if a firm has an environmental management system with ISO 14001 certification.
EnvScore	Environmental pillar score retrieved from Refinitiv EIKON database: "The environmental pillar measures a company's impact on living and non-living natural system, including the air, land and water, as well as complete ecosystems. It reflects how well a company uses best management practices to avoid environmental risks and capitalize on environmental opportunities in order to generate long-term shareholder value."
FI	Indicator variable that equals one if a firm provides information related to the financial impacts of climate risks in its response to the CDP questionnaire.
FinImpact	Financial impact estimates of climate risks divided by sales.
IMR CR	Inverse Mills ratio calculated from the first stage probit regression modeling firms' decisions to disclose climate risks.
IMR FI	Inverse Mills ratio calculated from the first stage probit regression modeling firms' decisions to disclose estimates of the financial impacts of climate risks.
IndepDir	Ratio of independent directors in relation to the total number of directors on the board. Expressed as percentage.
industry	Indicators for each of the 10 GICS sector classifications excluding the financial sector.
InstHigh	Indicator that equals one for firms with higher than median institutional ownership.
InstOwn	Percentage of traded shares held by institutional investors. Truncated at 100%. Shares held by institutional investors as percentage of total shares outstanding. Truncated at 100%. Set to zero if missing.
IntangStock	Stock of R&D+⅓*SG&A investments scaled by adjusted total assets using 5-year amortization. For example, RD&SGAstock for fiscal 2019 = (FY2019 (R&D+⅓SGA)*100% + FY2018 (R&D+⅓SGA)*80% + FY2017 (R&D+⅓SGA)*60% + FY2016 (R&D+⅓SGA)*40% + FY2015 (R&D+⅓SGA)*20%) divided by total assets adjusted to include remaining notionally capitalized intangibles investments.
LEV	Leverage calculated as long-term debt divided by total assets.
logCO2e	Natural logarithm of (1+ CO2e/Sales), where CO2e is emission intensity calculated as the sum of scope 1 and scope 2 emissions (tons CO2) divided by sales.
logSales	Natural logarithm of sales.
Market Cap	Market capitalization of the firm (in $ million).

PhysRisk	The number of physical climate risks disclosed by the firm.
Q	Tobins Q calculated as (total assets + market value of equity - book value of equity) / total assets.
R&D/Sales	R&D expenses divided by sales.
region	Indicators capturing the firm's headquarters by country and/or region (*region*) using the following eight classifications: Canada, US, UK, EU+4 (Iceland, Israel, Norway, Switzerland), Australia, Japan + South Korea, South Africa, and HK+Taiwan+Singapore+Macau.
ROA	Return on assets calculated as income after taxes divided by total assets. Expressed as percentage.
Sales	Total sales of the firm (in $ million)
SalesGrowth	Three-year annualized average sales growth.
SGA/Sales	Selling, General & Administrative expenses divided by sales.
SustCommittee	Indicator variable that equals one if a firm has a CSR committee or team at board level.
SustReport	Indicator variable that equals one if a firm publishes a sustainability report or a section in its annual report on sustainability.
TransnRisk	The number of transition climate risks disclosed by the firm.
UNsign	Indicator variable that equals one if a firm is a signatory of the UN Global Compact.

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Figure 1: Summary of problematic climate risk financial impact disclosures

Figure 1 presents the number of problematic climate risk financial impact disclosures, of which there may be several per firm per year (i.e., on average, companies disclosing financial impact estimates provided information related to 3.5 climate risks per year). The problematic disclosures are clustered into six categories: **(1) Entity**: Respondent replied at the wrong level of aggregation, e.g., they reported on a particular process or activity rather than at the aggregate company level. **(2) Unit:** Financial impacts were disclosed in the wrong unit, e.g., financial impacts are disclosed as percentages instead of plain numbers in a specified currency. **(3) Aggregate:** The same aggregated financial impact figure was provided for different individual climate risks, e.g. the same financial impact of weather-related events is supplied for both acute and chronic physical climate risks. **(4) Placeholder:** Respondents provided quantitative disclosure as a mere placeholder (e.g. the value 1), stating in the accompanying textual explanation that they were unable to quantitatively assess the financial impacts of climate risks. **(5) Currency:** Financial impacts were disclosed in a different currency then the one in which companies stated they would disclose financial figures throughout the CDP questionnaire. **(6) Double counting:** Financial impacts were disclosed as both point estimates and as minimum/maximum estimates, when companies were asked to provide one or the other.

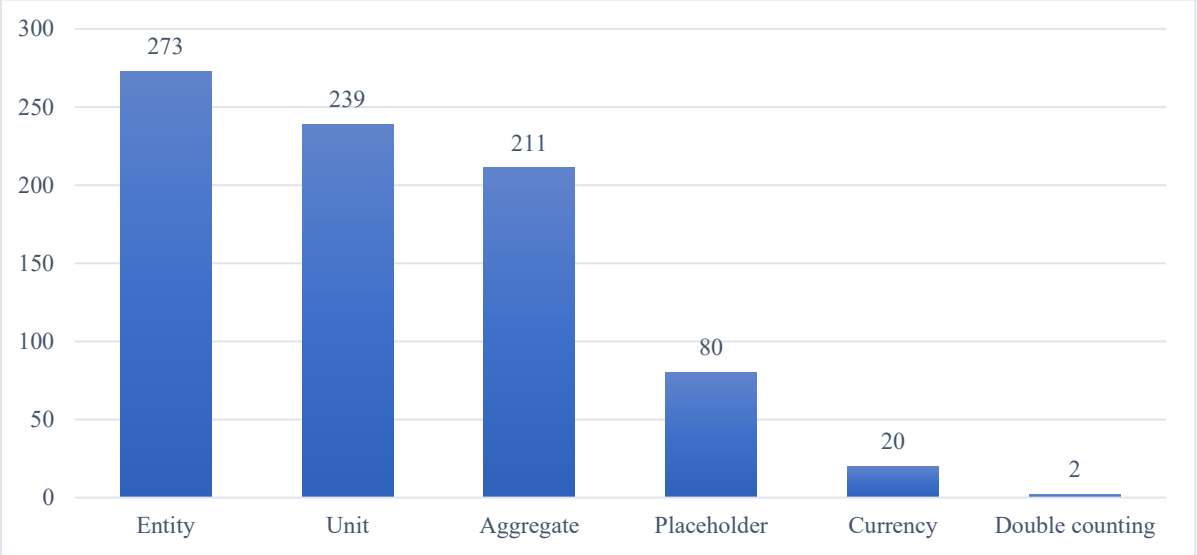

Table 1

Panel A: Number of CDP respondents by country

	Year			
Country	2018	2019	2020	Total
Australia	30	27	28	85
Austria	9	10	11	30
Belgium	10	11	13	34
Canada	56	67	71	194
Czech Republic	0	1	1	2
Denmark	14	16	18	48
Finland	29	32	35	96
France	61	70	76	207
Germany	55	56	56	167
Greece	1	1	1	3
Hong Kong	7	13	12	32
Ireland	15	15	21	51
Israel	2	2	2	6
Italy	24	25	32	81
Japan	211	246	281	738
Luxembourg	1	2	3	6
Netherlands	17	21	21	59
New Zealand	9	12	15	36
Norway	23	26	29	78
Portugal	7	8	8	23
Singapore	8	9	9	26
South Africa	46	45	45	136
South Korea	38	38	44	120
Spain	28	32	33	93
Sweden	35	45	51	131
Switzerland	32	38	35	105
Taiwan	27	28	39	94
UK	121	132	143	396
USA	282	328	365	975
Total	1198	1356	1498	4052

Panel B: Number of CDP respondents by industry sector

	Year			
Sector	2018	2019	2020	Total
Communication Services	65	67	81	213
Consumer Discretionary	161	184	206	551
Consumer Staples	122	139	146	407
Energy	50	58	66	174
Health Care	83	96	103	282
Industrials	289	324	356	969
Information Technology	135	159	177	471
Materials	157	171	196	524
Real Estate	54	69	75	198
Utilities	82	89	92	263
Total	1198	1356	1498	4052

Panel C: Sample companies by country

	Year			
Country	2018	2019	2020	Total
Australia	158	160	165	483
Austria	25	25	25	75
Belgium	64	62	62	188
Canada	172	173	177	522
Cyprus	2	2	2	6
Czech Republic	5	5	5	15
Denmark	35	36	37	108
Estonia	8	9	9	26
Finland	41	43	43	127
France	226	229	220	675
Germany	178	181	184	543
Greece	7	6	6	19
Hong Kong	102	103	107	312
Iceland	2	2	2	6
Ireland	41	41	44	126
Israel	16	16	16	48
Italy	68	71	73	212
Japan	527	531	533	1591
Latvia	2	2	2	6
Lithuania	7	7	7	21
Luxembourg	24	27	27	78
Macau	3	3	3	9
Malta	2	2	2	6
Netherlands	59	60	59	178
New Zealand	78	75	81	234
Norway	40	43	44	127
Portugal	32	32	30	94
Singapore	36	37	37	110
Slovak Republic	1	1	1	3
South Africa	75	76	77	228
South Korea	202	214	222	638
Spain	72	75	74	221
Sweden	102	104	105	311
Switzerland	112	115	120	347
Taiwan	107	108	109	324
UK	336	340	340	1016
USA	717	727	735	2179
Total	3684	3743	3785	11212

Panel D: Sample companies by industry sector

	Year			
Sector	2018	2019	2020	Total
Communication Services	217	222	225	664
Consumer Discretionary	547	554	559	1660
Consumer Staples	312	319	320	951
Energy	186	191	190	567
Health Care	336	345	350	1031
Industrials	803	811	813	2427
Information Technology	427	433	445	1305
Materials	432	439	447	1318
Real Estate	256	258	265	779
Utilities	168	171	171	510
Total	3684	3743	3785	11212

Panel E: CDP response rate by country

	Year		
Country	2018	2019	2020
Australia	18.99	16.88	16.97
Austria	36.00	40.00	44.00
Belgium	15.63	17.74	20.97
Canada	32.56	38.73	40.11
Cyprus	0.00	0.00	0.00
Czech Republic	0.00	20.00	20.00
Denmark	40.00	44.44	48.65
Estonia	0.00	0.00	0.00
Finland	70.73	74.42	81.40
France	26.99	30.57	34.55
Germany	30.90	30.94	30.43
Greece	14.29	16.67	16.67
Hong Kong	6.86	12.62	11.21
Iceland	0.00	0.00	0.00
Ireland	36.59	36.59	47.73
Israel	12.50	12.50	12.50
Italy	35.29	35.21	43.84
Japan	40.04	46.33	52.72
Latvia	0.00	0.00	0.00
Lithuania	0.00	0.00	0.00
Luxembourg	4.17	7.41	11.11
Macau	0.00	0.00	0.00
Malta	0.00	0.00	0.00
Netherlands	28.81	35.00	35.59
New Zealand	11.54	16.00	18.52
Norway	57.50	60.47	65.91
Portugal	21.88	25.00	26.67
Singapore	22.22	24.32	24.32
Slovak Republic	0.00	0.00	0.00
South Africa	61.33	59.21	58.44
South Korea	18.81	17.76	19.82
Spain	38.89	42.67	44.59
Sweden	34.31	43.27	48.57
Switzerland	28.57	33.04	29.17
Taiwan	25.23	25.93	35.78
UK	36.01	38.82	42.06
USA	39.33	45.12	49.66

Panel F: CDP response rate by sector

	Year		
Sector	2018	2019	2020
Communication Services	29.95	30.18	36.00
Consumer Discretionary	29.43	33.21	36.85
Consumer Staples	39.10	43.57	45.63
Energy	26.88	30.37	34.74
Health Care	24.70	27.83	29.43
Industrials	35.99	39.95	43.79
Information Technology	31.62	36.72	39.78
Materials	36.34	38.95	43.85
Real Estate	21.09	26.74	28.30
Utilities	48.81	52.05	53.80

Panel G: Climate risk disclosure rate by country

	Year		
Country	2018	2019	2020
Australia	13.92	14.38	12.73
Austria	36.00	36.00	40.00
Belgium	14.06	16.13	19.35
Canada	26.74	28.90	33.90
Cyprus	0.00	0.00	0.00
Czech Republic	0.00	20.00	20.00
Denmark	28.57	41.67	43.24
Estonia	0.00	0.00	0.00
Finland	51.22	55.81	67.44
France	23.89	26.64	29.09
Germany	19.66	21.55	21.74
Greece	14.29	16.67	16.67
Hong Kong	6.86	9.71	11.21
Iceland	0.00	0.00	0.00
Ireland	34.15	34.15	40.91
Israel	12.50	12.50	12.50
Italy	33.82	32.39	39.73
Japan	37.57	43.88	48.22
Latvia	0.00	0.00	0.00
Lithuania	0.00	0.00	0.00
Luxembourg	4.17	3.70	7.41
Macau	0.00	0.00	0.00
Malta	0.00	0.00	0.00
Netherlands	28.81	33.33	35.59
New Zealand	11.54	16.00	16.05
Norway	52.50	51.16	59.09
Portugal	21.88	21.88	26.67
Singapore	16.67	24.32	21.62
Slovak Republic	0.00	0.00	0.00
South Africa	60.00	57.89	54.55
South Korea	18.81	17.29	19.37
Spain	36.11	40.00	40.54
Sweden	25.49	32.69	40.95
Switzerland	19.64	23.48	19.17
Taiwan	24.30	25.93	33.94
UK	29.46	33.24	36.18
USA	33.47	37.69	42.72

Panel H: Climate risk disclosure rate by sector

	Year		
Sector	2018	2019	2020
Communication Services	24.42	24.77	29.33
Consumer Discretionary	26.69	30.51	34.17
Consumer Staples	35.90	40.44	41.88
Energy	24.73	26.18	32.11
Health Care	19.35	22.32	22.86
Industrials	28.89	32.68	36.41
Information Technology	25.76	29.79	31.69
Materials	32.41	34.85	39.60
Real Estate	19.92	24.03	25.66
Utilities	47.02	49.12	53.22

Table 2

Panel A: Company Descriptive Statistics (Mean)

	Sample	CDP	No CDP	Diff	Climate Risk	No Climate Risk	Diff	Financial Impact	No Financial Impact	Diff
Sales	7330.39	13348.28	3924.74	9423.5***	13827.43	4367.07	9460.4***	14369.25	5064.88	9304.4***
Assets	11730.15	20989.26	6490.21	14499.0***	22070.71	7013.78	15056.9***	23477	7949.33	15527.7***
Market Cap	10240.1	18391.14	5627.24	12763.9***	18495.68	6474.69	12021.0***	18884.18	7457.93	11426.3***
ROA	4.57	5.25	4.18	1.076***	5.09	4.33	0.765***	5.05	4.41	0.634***
CapEx	.04	.04	.04	0.00223**	.04	.04	0.00357***	.04	.04	0.00289***
R&D/Sales	.03	.02	.04	-0.0181***	.02	.04	-0.0195***	.02	.04	-0.0176***
SGA/Sales	.22	.19	.24	-0.0517***	.18	.24	-0.0567***	.19	.23	-0.0463***
LEV	.21	.22	.2	0.0230***	.23	.2	0.0248***	.22	.2	0.0154***
Analysts Follow	10	13.33	8.11	5.219***	13.4	8.44	4.957***	13.74	8.79	4.950***
Number of obs.	11212	4052	7160		3512	7700		2730	8482	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2

Panel B: Regression Descriptive Statistics

	Mean	Std. Dev.	min	p25	Median	p75	max	N
Q	1.974	1.759	.626	1.041	1.355	2.106	11.38	11212
CDP	.361	.48	0	0	0	1	1	11212
CR	.313	.464	0	0	0	1	1	11212
FI	.243	.429	0	0	0	0	1	11212
TransnRisk	.788	1.456	0	0	0	1	7	11212
PhysRisk	.472	.902	0	0	0	1	4	11212
ClimateRisk	1.262	2.181	0	0	0	3	10	11212
FinImpact	.017	.07	0	0	0	0	.53	11212
logSales	7.593	1.804	2.161	6.498	7.722	8.804	11.483	11212
ROA	4.566	8.02	-31.085	1.974	4.524	7.93	28.537	11212
BTM	.629	.538	-.155	.255	.49	.851	2.912	11212
LEV	.208	.164	0	.071	.186	.315	.699	11212
CapEx	.042	.039	0	.015	.032	.057	.21	11212
SalesGrowth	9.617	20.07	-27.748	1.34	6.038	12.542	136.353	11212
Cash/Assets	.134	.14	.001	.039	.089	.174	.721	11212
IntangStock	.191	.193	0	.049	.136	.272	.971	11212
InstOwn	61.616	24.733	2.631	44.943	63.559	81.108	100	11212
Block	.958	.201	0	1	1	1	1	11212
IndepDir	46.011	34.382	0	0	50	77.778	100	11212
SustCommittee	.496	.5	0	0	0	1	1	11212
EMS	.401	.49	0	0	0	1	1	11212
UNsign	.166	.372	0	0	0	0	1	11212
SustReport	.593	.491	0	0	1	1	1	11212
Attest	.153	.36	0	0	0	0	1	11212

All variables are defined in detail in Appendix B. Institutional ownership (*InstOwn*) is truncated at 100% and all other continuous variables are winsorized at the 1% and 99% level.

Table 3: Correlation Matrix

Panel A: Regression Variables used in Disclosure Choice Models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) CDP	1.00															
(2) CR	0.90*	1.00														
(3) FI	0.75*	0.84*	1.00													
(4) logSales	0.43*	0.41*	0.36*	1.00												
(5) ROA	0.06*	0.04*	0.03*	0.17*	1.00											
(6) BTM	-0.02*	0.01	0.03*	0.03*	-0.21*	1.00										
(7) LEV	0.07*	0.07*	0.04*	0.12*	-0.13*	-0.09*	1.00									
(8) CapEx	0.03*	0.04*	0.03*	0.04*	0.03*	-0.02*	0.08*	1.00								
(9) IntangStock	-0.04*	-0.06*	-0.05*	-0.12*	-0.02*	-0.29*	-0.23*	-0.07*	1.00							
(10) InstOwn	0.13*	0.11*	0.06*	0.22*	0.07*	-0.13*	0.20*	0.01	-0.06*	1.00						
(11) Block	0.01	-0.00	-0.01	-0.01	0.04*	-0.04*	-0.01	-0.01	0.02*	0.17*	1.00					
(12) IndepDir	0.25*	0.20*	0.14*	0.33*	0.05*	-0.16*	0.24*	0.04*	-0.07*	0.34*	0.05*	1.00				
(13) SustCommittee	0.42*	0.41*	0.38*	0.43*	0.05*	0.04*	0.09*	0.07*	-0.13*	0.09*	0.00	0.42*	1.00			
(14) EMS	0.35*	0.33*	0.31*	0.39*	0.06*	0.05*	-0.03*	0.02	-0.07*	0.04*	-0.00	0.26*	0.50*	1.00		
(15) UNsign	0.34*	0.32*	0.30*	0.32*	0.02*	0.00	0.01	-0.00	-0.02*	-0.01	-0.00	0.19*	0.34*	0.36*	1.00	
(16) SustReport	0.41*	0.38*	0.34*	0.42*	0.09*	-0.00	0.10*	0.05*	-0.11*	0.12*	0.03*	0.48*	0.69*	0.55*	0.34*	1.00

* p<0.05

Panel B: Regression Variables used in Value Relevance Models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Q	1.00														
(2) CDP	-0.09*	1.00													
(3) CR	-0.12*	0.89*	1.00												
(4) FI	-0.12*	0.74*	0.83*	1.00											
(5) TransnRisk	-0.12*	0.70*	0.79*	0.67*	1.00										
(6) PhysRisk	-0.09*	0.68*	0.76*	0.65*	0.67*	1.00									
(7) FinImpact	-0.07*	0.30*	0.33*	0.40*	0.33*	0.30*	1.00								
(8) logSales	-0.22*	0.39*	0.38*	0.34*	0.30*	0.27*	0.10*	1.00							
(9) ROA	0.28*	0.04*	0.02*	0.01	0.00	0.02	-0.02*	0.08*	1.00						
(10) LEV	-0.12*	0.04*	0.04*	0.01	0.03*	0.05*	-0.00	0.07*	-0.16*	1.00					
(11) IntangStock	0.38*	-0.02	-0.05*	-0.04*	-0.05*	-0.07*	-0.03*	-0.05*	0.07*	-0.23*	1.00				
(12) CapEx	-0.05*	0.02	0.04*	0.03*	0.03*	0.03*	0.02*	0.02	0.01	0.07*	-0.07*	1.00			
(13) SalesGrowth	0.25*	-0.16*	-0.15*	-0.14*	-0.13*	-0.13*	-0.04*	-0.20*	-0.02	-0.04*	0.01	0.01	1.00		
(14) Cash/Assets	0.41*	-0.12*	-0.13*	-0.10*	-0.12*	-0.12*	-0.05*	-0.17*	0.05*	-0.34*	0.36*	-0.12*	0.19*	1.00	
(15) Attest	-0.09*	0.55*	0.55*	0.58*	0.47*	0.46*	0.24*	0.32*	0.01	0.02	-0.02	-0.00	-0.10*	-0.08*	1.00

* p<0.05

Table 4: CDP Questionnaire Disclosure Decision

Table 4 presents the results from probit regressions examining the determinants of firms' decisions to respond to the CDP questionnaire. In column (1), we regress *CDP* on financial, ownership, and independent director variables; in column (2) we add industry and region fixed effects; in column (3) we add variables capturing the firm's commitment to sustainability. Robust standard errors are reported in parentheses. Standard errors are clustered by firm and year. Institutional ownership (*InstOwn*) is truncated at 100 and all other continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

VARIABLES	(1) CDP	(2) CDP	(3) CDP
logSales	0.359***	0.417***	0.270***
	(0.0138)	(0.0169)	(0.0185)
ROA	0.00336*	0.00459**	0.00511***
	(0.00177)	(0.00184)	(0.00175)
BTM	-3.41e-05	-0.0180	0.00125
	(0.0374)	(0.0387)	(0.0398)
LEV	-0.0459	0.0733	0.109
	(0.130)	(0.126)	(0.131)
CapEx	0.500	1.304***	0.548
	(0.383)	(0.402)	(0.387)
IntangStock	0.0754	0.173*	0.208**
	(0.0881)	(0.0977)	(0.0974)
InstOwn	0.000986	0.00381***	0.00356***
	(0.00115)	(0.00109)	(0.00105)
Block	0.0111	0.000210	-0.0379
	(0.0819)	(0.0895)	(0.0878)
IndepDir	0.00536***	0.00675***	-0.00222**
	(0.000924)	(0.00131)	(0.00112)
SustCommittee			0.462***
			(0.0468)
EMS			0.175***
			(0.0564)
UNsign			0.455***
			(0.0478)
SustReport			0.528***
			(0.0684)
Industry controls	no	yes	yes
Region controls	no	yes	yes
Constant	-3.547***	-4.936***	-3.483***
	(0.149)	(0.262)	(0.198)
Log likelihood	-6057	-5780	-5292
Wald χ^2	864.2	1016	1507
McFadden R^2	0.174	0.212	0.278
% of correct predictions	68.96	70.99	75.35
Observations	11,212	11,212	11,212

The cut-off point for determining the percentage of correct predictions is 0.36.
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Climate Risk Disclosure Decision

Table 5 presents the results from probit regressions examining the determinants of firms' decisions to provide information related to climate risks . In column (1), we regress *CR* on financial, ownership, and independent director variables; in column (2) we add industry and region fixed effects; in column (3) we add variables capturing the firm's commitment to sustainability. Robust standard errors are reported in parentheses. Standard errors are clustered by firm and year. Institutional ownership (*InstOwn*) is truncated at 100 and all other continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

VARIABLES	(1) CR	(2) CR	(3) CR
logSales	0.363***	0.414***	0.270***
	(0.0126)	(0.0142)	(0.0188)
ROA	0.00113	0.00216	0.00266
	(0.00192)	(0.00207)	(0.00212)
BTM	0.0481	0.0117	0.0339
	(0.0426)	(0.0419)	(0.0448)
LEV	0.0265	0.144	0.198*
	(0.105)	(0.109)	(0.109)
CapEx	1.204***	1.811***	1.161***
	(0.383)	(0.435)	(0.418)
IntangStock	-0.148	-0.00895	0.00825
	(0.114)	(0.135)	(0.137)
InstOwn	0.00116	0.00387***	0.00358***
	(0.00102)	(0.00105)	(0.000982)
Block	-0.0334	-0.0595	-0.0972
	(0.0819)	(0.0854)	(0.0927)
IndepDir	0.00355***	0.00516***	-0.00398***
	(0.000696)	(0.000961)	(0.000904)
SustCommittee			0.514***
			(0.0498)
EMS			0.219***
			(0.0678)
UNsign			0.401***
			(0.0454)
SustReport			0.473***
			(0.0682)
Industry controls	no	yes	yes
Region controls	no	yes	yes
Constant	-3.638***	-4.995***	-3.581***
	(0.165)	(0.235)	(0.202)
Log likelihood	-5812	-5560	-5091
Wald χ^2	769.1	903.1	1374
McFadden R^2	0.166	0.202	0.270
% of correct predictions	68.36	70.39	74.77
Observations	11,212	11,212	11,212

The cut-off point for determining the percentage of correct predictions is 0.31.
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Financial Impact Disclosure Decision

Table 6 presents the results from probit regressions examining the determinants of firms' decisions to provide quantitative estimates related to the financial impact of climate risks on the firm. In column (1), we regress *FI* on financial, ownership, and independent director variables; in column (2) we add industry and region fixed effects; in column (3) we add variables capturing the firm's commitment to sustainability. Robust standard errors are reported in parentheses. Standard errors are clustered by firm and year. Institutional ownership (*InstOwn*) is truncated at 100 and all other continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

	(1)	(2)	(3)
VARIABLES	FI	FI	FI
logSales	0.343***	0.411***	0.278***
	(0.0121)	(0.0138)	(0.0189)
ROA	0.00122	0.00192	0.00217
	(0.00212)	(0.00260)	(0.00231)
BTM	0.0883*	0.0228	0.0419
	(0.0485)	(0.0458)	(0.0488)
LEV	-0.0372	0.0879	0.129
	(0.112)	(0.130)	(0.126)
CapEx	0.907*	1.780***	1.153**
	(0.507)	(0.522)	(0.489)
IntangStock	-0.0849	0.117	0.142
	(0.153)	(0.170)	(0.163)
InstOwn	0.000217	0.00397***	0.00371***
	(0.000819)	(0.000867)	(0.000880)
Block	-0.0160	-0.0658	-0.0938
	(0.0905)	(0.0922)	(0.0968)
IndepDir	0.00181***	0.00416***	-0.00416***
	(0.000616)	(0.000933)	(0.000893)
SustCommittee			0.566***
			(0.0415)
EMS			0.205***
			(0.0540)
UNsign			0.331***
			(0.0527)
SustReport			0.359***
			(0.0876)
Industry controls	no	yes	yes
Region controls	no	yes	yes
Constant	-3.596***	-5.287***	-4.034***
	(0.153)	(0.248)	(0.211)
Log likelihood	-5342	-5012	-4645
Wald χ^2	607.3	762.5	1149
McFadden R^2	0.142	0.195	0.254
% of correct predictions	66.78	70.49	73.50
Observations	11,212	11,212	11,212

The cut-off point for determining the percentage of correct predictions is 0.24.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Disclosure Choice Model Controlling for Environmental Performance

Table 7 presents results from the fully specified disclosure choice model regressions using the available observations after controlling for carbon emissions and the overall environmental performance score, respectively. In Panel A, carbon emissions are measured using the firm's sector decile ranking of CO_2e scaled by revenues (*CO2eRank*). Panel B presents the results using the natural log of CO_2e emissions to control for carbon emissions performance. Panel C presents the results from each of the fully specified decision models after including Refinitiv's environmental pillar score as the proxy for the firm's environmental performance. Robust standard errors are reported in parentheses. Standard errors are clustered by firm and year. Institutional ownership (*InstOwn*) is truncated at 100 and all other continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

Panel A: Carbon emissions measured as *CO2eRank*

	(1)	(2)	(3)
VARIABLES	CDP	CR	FI
logSales	0.254***	0.253***	0.265***
	(0.0153)	(0.0155)	(0.0165)
ROA	0.00754***	0.00614**	0.00560**
	(0.00255)	(0.00293)	(0.00253)
BTM	-0.0611	-0.0226	-0.00349
	(0.0415)	(0.0467)	(0.0570)
LEV	0.116	0.196	0.115
	(0.153)	(0.124)	(0.149)
CapEx	0.622	1.040**	1.018
	(0.471)	(0.507)	(0.629)
IntangStock	0.0685	-0.194	-0.00911
	(0.110)	(0.139)	(0.173)
InstOwn	0.00292**	0.00299***	0.00314***
	(0.00139)	(0.00110)	(0.00117)
Block	-0.0821	-0.151	-0.160
	(0.111)	(0.139)	(0.121)
IndepDir	0.00407***	0.00193*	0.000563
	(0.000979)	(0.00113)	(0.00106)
SustCommittee	0.527***	0.581***	0.620***
	(0.0528)	(0.0489)	(0.0451)
EMS	0.283***	0.315***	0.268***
	(0.0535)	(0.0725)	(0.0653)
CO2eRank	0.00426	0.0134*	0.0153
	(0.00800)	(0.00697)	(0.0117)
UNsign	0.428***	0.375***	0.314***
	(0.0592)	(0.0511)	(0.0612)
SustReport	0.815***	0.772***	0.631***
	(0.0517)	(0.0495)	(0.0693)
Industry controls	yes	yes	yes
Region controls	yes	yes	yes
Constant	-3.981***	-4.123***	-4.524***
	(0.218)	(0.245)	(0.249)
Log likelihood	-4249	-4152	-3886
Wald χ^2	1157	1100	898.2
McFadden R^2	0.265	0.259	0.242
% of correct predictions	74.12	73.37	70.86
Observations	8,444	8,444	8,444

The cut-off point for determining the percentage of correct predictions is 0.43 in column (1), 0.37 in column (2), and 0.29 in column (3).
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Disclosure Choice Model Controlling for Environmental Performance

Panel B: Carbon emissions measured as *logCO2e*

VARIABLES	(1) CDP	(2) CR	(3) FI
logSales	0.254***	0.252***	0.265***
	(0.0153)	(0.0156)	(0.0164)
ROA	0.00751***	0.00618**	0.00564**
	(0.00250)	(0.00290)	(0.00250)
BTM	-0.0608	-0.0278	-0.0108
	(0.0411)	(0.0449)	(0.0553)
LEV	0.117	0.181	0.0934
	(0.159)	(0.124)	(0.144)
CapEx	0.629	0.880*	0.792
	(0.465)	(0.496)	(0.682)
IntangStock	0.0675	-0.181	0.00926
	(0.109)	(0.141)	(0.178)
InstOwn	0.00292**	0.00299***	0.00313***
	(0.00139)	(0.00110)	(0.00117)
Block	-0.0821	-0.148	-0.157
	(0.111)	(0.140)	(0.122)
IndepDir	0.00407***	0.00192*	0.000548
	(0.000979)	(0.00113)	(0.00107)
SustCommittee	0.527***	0.578***	0.615***
	(0.0527)	(0.0485)	(0.0456)
EMS	0.284***	0.315***	0.268***
	(0.0548)	(0.0736)	(0.0657)
logCO2e	0.00750	0.0388***	0.0469**
	(0.0132)	(0.0135)	(0.0211)
UNsign	0.428***	0.375***	0.314***
	(0.0597)	(0.0516)	(0.0618)
SustReport	0.815***	0.771***	0.629***
	(0.0518)	(0.0496)	(0.0689)
Industry controls	yes	yes	yes
Region controls	yes	yes	yes
Constant	-3.976***	-4.135***	-4.542***
	(0.216)	(0.249)	(0.254)
Log likelihood	-4249	-4150	-3882
Wald χ^2	1157	1103	900.5
McFadden R^2	0.265	0.259	0.242
% of correct predictions	74.10	73.39	71.34
Observations	8,444	8,444	8,444

Robust standard errors are in parentheses. Standard errors are clustered by firm and year.
The cut-off point for determining the percentage of correct predictions is 0.43 in column (1), 0.37 in column (2), and 0.29 in column (3).
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Disclosure Choice Model Controlling for Environmental Performance

Panel C: Environmental pillar score (*EnvScore*)

VARIABLES	(1) CDP	(2) CR	(3) FI
logSales	0.168***	0.166***	0.180***
	(0.0167)	(0.0176)	(0.0168)
ROA	0.00669***	0.00481*	0.00425
	(0.00216)	(0.00257)	(0.00269)
BTM	-0.0689	-0.0214	0.00298
	(0.0438)	(0.0453)	(0.0489)
LEV	0.124	0.231*	0.161
	(0.164)	(0.125)	(0.144)
CapEx	0.552	1.200**	1.204*
	(0.452)	(0.497)	(0.665)
IntangStock	-0.00915	-0.299**	-0.0962
	(0.106)	(0.135)	(0.182)
InstOwn	0.00271**	0.00286***	0.00320***
	(0.00138)	(0.00109)	(0.00116)
Block	-0.0762	-0.152	-0.163
	(0.112)	(0.139)	(0.126)
IndepDir	0.00323***	0.00111	-0.000293
	(0.000961)	(0.00120)	(0.00116)
SustCommittee	0.315***	0.371***	0.412***
	(0.0503)	(0.0480)	(0.0480)
EMS	0.181***	0.223***	0.176***
	(0.0535)	(0.0699)	(0.0669)
EnvScore	0.0174***	0.0173***	0.0175***
	(0.000962)	(0.00100)	(0.00111)
UNsign	0.311***	0.255***	0.190***
	(0.0538)	(0.0476)	(0.0555)
SustReport	0.406***	0.367***	0.204**
	(0.0620)	(0.0565)	(0.0917)
Industry controls	yes	yes	yes
Region controls	yes	yes	yes
Constant	-3.375***	-3.490***	-3.925***
	(0.217)	(0.259)	(0.279)
Log likelihood	-4090	-3999	-3739
Wald χ^2	1260	1196	993.6
McFadden R^2	0.299	0.291	0.275
% of correct predictions	75.70	75.01	73.68
Observations	8,530	8,530	8,530

Robust standard errors are in parentheses. Standard errors are clustered by firm and year.
The cut-off point for determining the percentage of correct predictions is 0.43 in column (1), 0.37 in column (2), and 0.29 in column (3).
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Value Relevance of Climate-related Disclosure Decision

Table 8 presents the results from regressing Tobin's Q on firms' decisions to provide climate-related disclosures. In column (1) we regress *Q* on the firms' decision to respond to the CDP questionnaire (*CDP*); in column (2) we regress Q on the firms' decision to provide information related to climate risks (*CR*); in column (3) we regress Q on the firms' decision to provide estimates of the financial impact of identified climate risks (*FI*). Robust standard errors are reported in parentheses. Standard errors are clustered by firm and year. Institutional ownership (*InstOwn*) is truncated at 100 and all other continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

	(1)	(2)	(3)
VARIABLES	Q	Q	Q
logSales	-0.173***	-0.168***	-0.165***
	(0.0151)	(0.0147)	(0.0156)
ROA	0.0551**	0.0552**	0.0552**
	(0.00561)	(0.00560)	(0.00560)
LEV	0.450*	0.449*	0.450*
	(0.123)	(0.123)	(0.123)
IntangStock	1.485***	1.490***	1.488***
	(0.131)	(0.130)	(0.130)
CapEx	0.578	0.582	0.588
	(0.413)	(0.416)	(0.416)
SalesGrowth	0.0101**	0.0101**	0.0100**
	(0.00230)	(0.00228)	(0.00228)
Cash/Assets	3.366**	3.366**	3.363**
	(0.390)	(0.388)	(0.388)
CDP	0.122**		
	(0.0283)		
CR		0.0823	
		(0.0380)	
FI			0.0693
			(0.0457)
Industry controls	yes	yes	yes
Region controls	yes	yes	yes
Constant	2.717***	2.689***	2.681***
	(0.183)	(0.179)	(0.184)
Observations	11,212	11,212	11,212
R-squared	0.369	0.368	0.368

*** p<0.01, ** p<0.05, * p<0.1

TABLE 9: Value Relevance of Physical and Transition Risks

Table 9 presents the results from regressing Tobin's Q on the number of physical risks and transition risks disclosed by the firm, respectively. Panel A presents the results using the the sample of firms for which CR=1 (i.e., firms that either disclose transition risks, physical risks, or both). In column (1) both the inverse mills ratio and the industry and region fixed effects are omitted; column (2) incrementally includes the industry and region fixed effects; and column (3) additionally includes the inverse Mills' ratio from the first stage regression modeling the firms' decisions to disclose climate risks (*IMR_CR*). Panel B presents the results from the same regression after including the indicator *Attest*, as well as the interaction of *Attest* with each of *TransnRisk* and *PhysRisk*. Robust standard errors are reported in parentheses. Standard errors clustered by firm and year. All continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

Panel A: Firm-Value Effect of Number of Disclosed Risks

	(1)	(2)	(3)
VARIABLES	Q	Q	Q
logSales	-0.0455	-0.0777*	-0.108**
	(0.0225)	(0.0191)	(0.0170)
ROA	0.111***	0.102***	0.102***
	(0.0106)	(0.00916)	(0.00923)
LEV	1.479**	0.987**	0.970**
	(0.199)	(0.196)	(0.191)
IntangStock	1.637**	1.158**	1.162**
	(0.198)	(0.216)	(0.216)
CapEx	-0.186	0.357	0.259
	(0.941)	(1.009)	(1.039)
SalesGrowth	0.00143	0.00149	0.00158
	(0.00131)	(0.00189)	(0.00194)
Cash/Assets	1.607	1.640	1.637
	(0.614)	(0.659)	(0.668)
PhysRisk	0.0425	0.0273	0.0271
	(0.0186)	(0.0181)	(0.0179)
TransnRisk	-0.0475**	-0.0377*	-0.0383*
	(0.0103)	(0.00964)	(0.00948)
IMR_CR			-0.123
			(0.0562)
Industry controls	no	yes	yes
Region controls	no	yes	yes
Constant	0.822*	1.554**	1.957***
	(0.232)	(0.207)	(0.191)
Observations	3,512	3,512	3,512
R-squared	0.414	0.461	0.462

*** p<0.01, ** p<0.05, * p<0.1

TABLE 9: Value Relevance of Physical and Transition Risks

Panel B: Assurance Effect on Information Content of Disclosed Risks

VARIABLES	(1) Q	(2) Q	(3) Q
logSales	-0.0386	-0.0722*	-0.105**
	(0.0230)	(0.0201)	(0.0175)
ROA	0.111***	0.102***	0.102***
	(0.0105)	(0.00915)	(0.00921)
LEV	1.477**	0.992**	0.975**
	(0.198)	(0.198)	(0.193)
IntangStock	1.633**	1.164**	1.170**
	(0.196)	(0.217)	(0.217)
CapEx	-0.241	0.359	0.249
	(0.940)	(1.005)	(1.036)
SalesGrowth	0.00146	0.00150	0.00160
	(0.00128)	(0.00184)	(0.00188)
Cash/Assets	1.589	1.635	1.632
	(0.614)	(0.659)	(0.669)
PhysRisk	0.0528	0.0372	0.0385
	(0.0204)	(0.0202)	(0.0201)
TransnRisk	-0.0496*	-0.0436*	-0.0451*
	(0.0127)	(0.0126)	(0.0124)
Attest	-0.111	-0.0577	-0.0692
	(0.0547)	(0.0506)	(0.0520)
Attest x PhysRisk	-0.0157	-0.0187	-0.0215
	(0.0298)	(0.0264)	(0.0266)
Attest x TransnRisk	0.0105	0.0150	0.0174
	(0.0172)	(0.0162)	(0.0164)
IMR_CR			-0.138
			(0.0587)
Industry controls	no	yes	yes
Region controls	no	yes	yes
Constant	0.805*	1.512**	1.955***
	(0.233)	(0.218)	(0.196)
Observations	3,512	3,512	3,512
R-squared	0.416	0.462	0.463

Robust standard errors in parentheses. Standard errors clustered by firm and year.
*** p<0.01, ** p<0.05, * p<0.1

TABLE 10: Year-by-Year Value Relevance of Physical and Transition Risks

Table 10 presents the year-by-year results from regressing Tobin's Q on the number of physical risks and transition risks disclosed by the firm, respectively, using the the sample of firms for which CR=1 (i.e., firms that either disclose transition risks, physical risks, or both). The results for 2018 are presented in column (1), the results for 2019, in column (2), and the results for 2020 in column (3). Standard errors are reported in parentheses and all continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

VARIABLES	(1) Q 2018	(2) Q 2019	(3) Q 2020
logSales	-0.0759***	-0.115***	-0.116***
	(0.0280)	(0.0296)	(0.0349)
ROA	0.0914***	0.106***	0.113***
	(0.00453)	(0.00479)	(0.00531)
LEV	1.141***	1.012***	0.684***
	(0.192)	(0.206)	(0.222)
IntangStock	1.361***	1.303***	0.938***
	(0.165)	(0.184)	(0.211)
CapEx	-1.260*	-0.255	2.066**
	(0.721)	(0.724)	(0.860)
SalesGrowth	0.00321	-0.000203	-0.00123
	(0.00228)	(0.00284)	(0.00258)
Cash/Assets	0.893***	1.289***	2.780***
	(0.273)	(0.332)	(0.366)
PhysRisk	0.0523**	0.0156	0.0146
	(0.0226)	(0.0263)	(0.0301)
TransnRisk	-0.0342**	-0.0313*	-0.0398**
	(0.0141)	(0.0174)	(0.0202)
IMR_CR_2018	-0.154**		
	(0.0782)		
IMR_CR_2019		-0.159*	
		(0.0892)	
IMR_CR_2020			-0.106
			(0.113)
Industry controls	yes	yes	yes
Region controls	yes	yes	yes
Constant	1.686***	2.029***	2.031***
	(0.368)	(0.398)	(0.455)
Observations	1,034	1,173	1,305
R-squared	0.520	0.496	0.463

*** p<0.01, ** p<0.05, * p<0.1

TABLE 11: Value Relevance of Financial Impacts of Climate Risks

Table 11 presents the results from regressing Tobin's Q on the estimates of the financial impacts of climate risks, using all available firm-years for which the *FinImpact* disclosure was provided and was not deemed to be erroneous or suspect. In column (1) both the inverse mills ration and the industry and region fixed effects are omitted; column (2) incrementally includes the industry and region fixed effects; and column (3) additionally includes the inverse Mills' ratio from the first stage regression modeling the firms' decisions to disclose financial impacts information (*IMR_FI*). Robust standard errors are reported in parentheses and all continuous variables are winsorized at the 1% and 99% levels. All variables are defined in detail in Appendix B.

	(1)	(2)	(3)
VARIABLES	Q	Q	Q
logSales	-0.0292	-0.0533*	-0.0798*
	(0.0205)	(0.0146)	(0.0242)
ROA	0.108***	0.0998***	0.0995***
	(0.00814)	(0.00722)	(0.00734)
LEV	1.069	0.612	0.608
	(0.388)	(0.356)	(0.351)
IntangStock	1.438**	1.123**	1.119**
	(0.290)	(0.252)	(0.250)
CapEx	0.662	1.677	1.586
	(0.906)	(0.862)	(0.892)
SalesGrowth	0.00125	0.00154	0.00171
	(0.00188)	(0.00196)	(0.00205)
Cash/Assets	1.404	1.621	1.611
	(0.647)	(0.704)	(0.717)
FinImpact	-0.422*	-0.179	-0.183
	(0.124)	(0.137)	(0.140)
IMR_FI			-0.105
			(0.0943)
Industry controls	no	yes	yes
Region controls	no	yes	yes
Constant	0.759	1.189**	1.567**
	(0.278)	(0.168)	(0.337)
Observations	2,038	2,038	2,038
R-squared	0.422	0.472	0.472

Robust standard errors in parentheses. Standard errors clustered by firm and year.
*** p<0.01, ** p<0.05, * p<0.1